

MINIMISING SAPSTAIN IN HARVESTING OPERATIONS

**ALASTAIR RIDDLE/TONY EVANSON
DAVE PALMER/MIKE McCONCHIE**



PROPERTY OF
**NATIONAL FORESTRY
LIBRARY**

Project Report

PR.62

LIRO Limited,
P.O. Box 2244,
Rotorua,
NEW ZEALAND

MINIMISING SAPSTAIN IN HARVESTING OPERATIONS

P.R. 62

1997

Prepared by:

Alastair Riddle
Tony Evanson
Dave Palmer
Mike McConchie

LIRO Limited

February, 1997.

Copyright © 1997 by LIRO Limited

The form and content of this Project Report are copyright. No material, information or inclusions appearing in this Project Report may be used for advertising or other sales promotion purposes without prior written permission.

This Project Report is confidential to members and may not be communicated to non-members except with written permission of the Chief Executive Officer of LIRO Limited.

For information, please contact LIRO Limited, P.O. Box 2244, Rotorua, New Zealand.

TABLE OF CONTENTS

	Page
List of Figures	4
Executive Summary	5
Minimising Sapstain - Introduction	6
Factors Which Influence Turnover Time	6
Reducing Turnover Times - Strategies for Ground-based Contractors	10
Reducing Turnover Times - Strategies for Hauler Operations	13
Reducing Turnover Times - Strategies for Forest Owners	16
Log Turnover Auditing	17

LIST OF FIGURES/TABLES

	Page
<i>Figure 1 - Felled wood is extracted at a later date, dependent on buffer and weekends</i>	7
<i>Figure 2 - Age of wood (in days) arriving at landing using one or two day buffer</i>	7
<i>Figure 3 - Time taken to fell, process and load fifty trees</i>	8
<i>Table 1 - Fell to extract time (days) for an operation with a two day buffer</i>	10
<i>Table 2 - Fell to extract time (days) for an operation with a one day buffer</i>	11

EXECUTIVE SUMMARY

Sapstain degradation is a problem for the New Zealand industry. To control the severity of sapstain attack, chemical, biological and physical (milling and drying) control methods are used or are under investigation. The severity of sapstain degrade also depends in part on the time between felling trees and either milling or debarking and sapstain spraying logs (turnover time).

This report identifies the factors which influence turnover times in New Zealand harvesting operations and gives a range of strategies which can be used to reduce that time. There are already enough of these logging strategies in use in New Zealand to show that reducing turnover time is quite feasible in both ground-based and hauler operations.

Many of these strategies will increase logging costs. They can only be costed into operations after a careful analysis of the trade-off between higher logging costs and higher market returns for stain-free products. Any strategy must also have a financial incentive for all involved, including the contract workforce.

To successfully minimise turnover times there must be:

- innovative thinking
- good communication of ideas between workers, contractors, planners and managers.
- co-operation from all sections of the forest owner/managing company. At planning time, a planner must know the income benefits of reduced sapstain degradation to compare with the costs of each harvest option so that accurate, informed harvest planning decisions can be made
- contractor input to ensure that all parties are working together on the problem
- priority given to downstream trucking and treatment to support contractors efforts
- a high standard of operational planning and supervision by the contractor or foreman.

Finally, turnover times, as discussed in this report, are only a small part of a sapstain control system. Poor practice in just one of the subsequent activities needed to get logs or product to a customer can nullify all preceding effort.

MINIMISING SAPSTAIN - INTRODUCTION

In the process of harvesting, partial bark removal as well as felling and trimming cuts expose the underlying wood to fungal infections which include sapstaining fungi. Sapstain is a serious problem for the forest industry as it reduces the log's potential value by limiting affected timber to lower value end uses rather than higher value appearance grades.

Much work is being done by New Zealand forest owners and the New Zealand Forest Research Institute and other research organisations on understanding the mechanism of sapstain attack and finding effective chemical and biological controls. It is evident however, that the time between felling a tree and its milling or debarking and chemical treatment is an important part of the sapstain equation. LIRO was charged with the task of researching and reporting harvesting systems which minimise the time between felling and anti-sapstain chemical treatment of the log (*Turnover time*). To achieve this, LIRO undertook field work and called an industry group (Sapstain Working Group) together to discuss both tried and untried systems.

The aim of this report is to:

- identify the factors which influence the turnover times in harvesting operations in New Zealand
- list a range of strategies which can be used to reduce turnover time
- suggest auditing systems which will allow contractor and forest owner performance to be assessed.

Many of the harvesting methods which can be used to reduce turnover times will increase logging costs. These methods can only be costed into operations after a careful analysis of the trade-off between extra logging costs and extra market returns for stain-free products.

FACTORS WHICH INFLUENCE TURNOVER TIME

In this report, turnover time is measured in 24 hour days. Timber that is felled one day, loaded out the next day and debarked and sprayed the following day, has a turnover time of two 24 hour days (more precisely, this indicates a time of 48 hours \pm a 9 hour work shift).

Following discussions with members of the Sapstain Working Group and several system studies, the following factors which influence turnover time were identified.

Ability to identify the age of individual logs

If felling dates are not marked on logs, they cannot be extracted or trucked in felling order. If log felling date cannot be identified, turnover time cannot be minimised.

The buffer between felling and extraction

A buffer between felling and extraction is common practice and is desirable as it enhances safety and ensures both phases of an operation can work with minimal interference. The length of that buffer has a major influence on log turnover time. This effect is illustrated in Figures 1 and 2.

Weekends

Intervening weekends automatically extend the cycle by two days as shown in Figures 1 and 2.

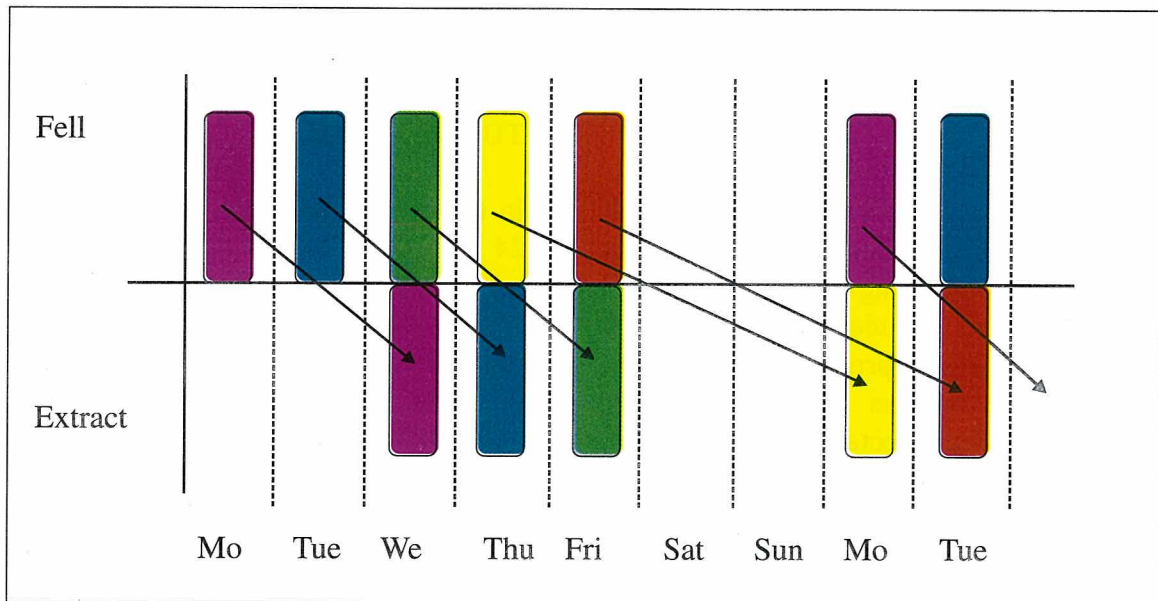


Figure 1 - Felled wood is extracted at a later date, dependant on buffer and weekends

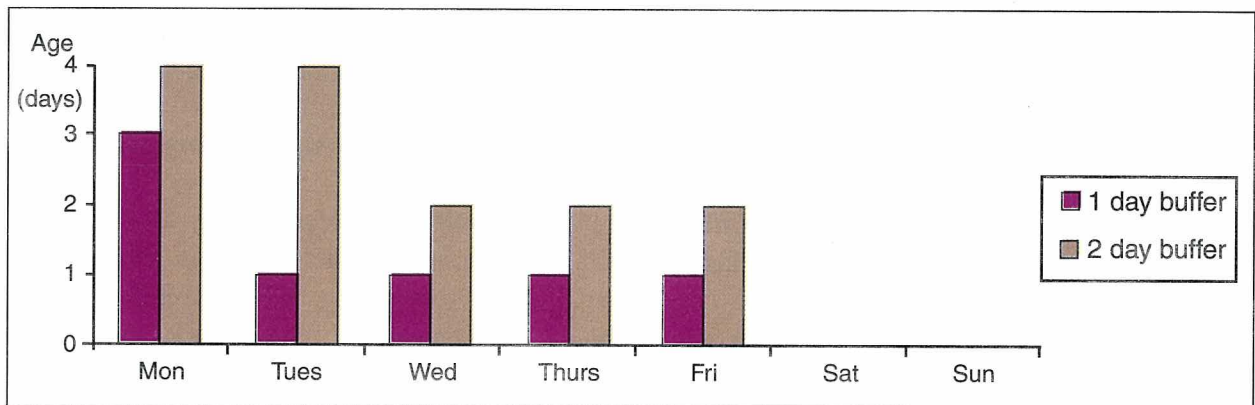


Figure 2 - Age of wood (in days) arriving at landing using 1 or 2 day buffer

Not extracting trees in the order of their felling

When working multiple skids and felling faces in a ground-based setting, the extraction machine rotates from one area to another following the fallers. "Losing" and not extracting all those trees felled in an area means that some trees must wait until the extraction machine returns to that section of the setting again. By this time

the trees will have aged considerably. Figure 1 illustrates this.

In order to further understand the factors which influence turnover time in ground-based operations, LIRO researchers examined a multi-skid operation.

Fifty trees were numbered and tagged at the felling face, and the felling date and time were recorded. These trees were felled by two fallers (25 each) working on

two adjacent felling faces. Tree lengths were extracted to two landings for processing. Tree number, date and time were recorded as the tree reached the landing.

After logmaking, all logs were tagged with a log number, their source tree number and processing date and time. When the tagged logs were loaded out on to trucks, the tags were removed and the load out date and time recorded.

Data collected was then analysed to determine the number of days taken by the tagged product to move from stump to skid, and then from skid stock piles to truck.

Results are shown in Figure 3. The effect of the weekend was apparent, as was the buffer size and the effect of "losing" and not extracting a few of the trees felled on days one and two. These were processed on day seven.

Stack Management

There is a tendency for older logs to accumulate at the back (with front-end loader) or below (with hydraulic loader) fresher logs in the stack. After a partial

load out, these tend to remain, and be covered by more recently processed logs.

Hauler operations

Reducing turnover times in hauler operations is a more complex task than in ground-based operations because of limitations imposed by terrain, machine and system characteristics, and additional safety considerations. The distance between fallers and working lines should be two tree lengths for safety reasons, so a faller must fell a complete swath at least two tree lengths wide from the landing to the back of the setting before extraction can start. The next swath must then be felled before the first is fully extracted. Reducing times for both felling and extraction of the swath results in a shorter turnover time. Turnover time then, is influenced by any factor which affects the width or length of the swath, or any factor which influences the speed at which the hauler harvests that swath (production rate). In hauler operations, it may be more practical to land as high a proportion of stems on the landing within a desired time than aim for 100% extraction.

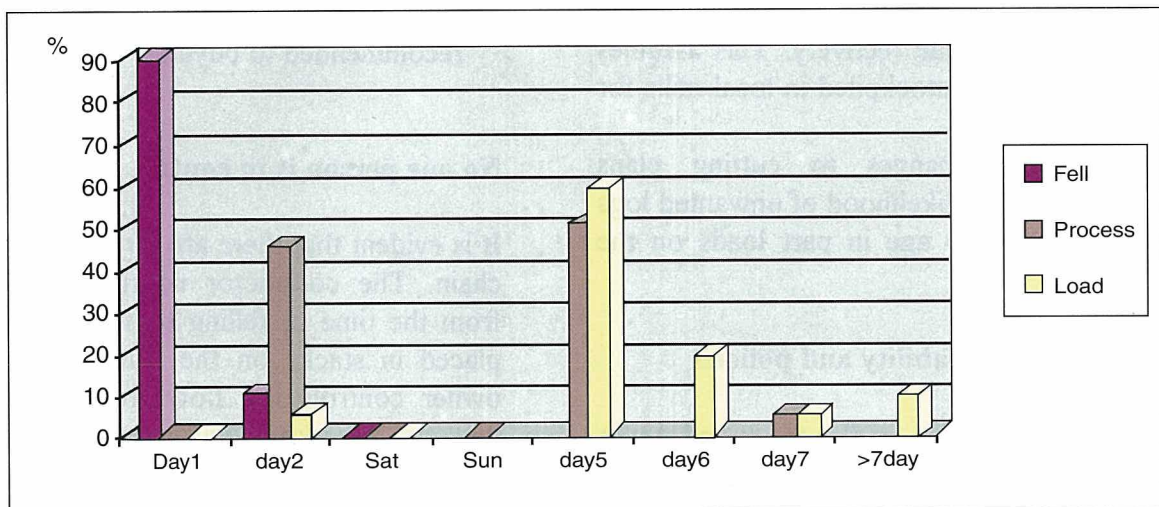


Figure 3 - Time taken to fell, process and load 50 trees

The hours that processing plants or ports are open to accept loads

Many logging and trucking operations are constrained by the opening hours of ports or mills (Robinson, 1996).

Log grade requirements

- The more grades there are, the more time it takes to make a load of each grade.
- It was not always possible to keep within specified turnover times. Blanket turnover time specifications for all grades can lead to false dating and the collapse of system integrity when logs do in fact exceed specified times and logmakers cannot be seen to be making pulp from good logs.
- Having alternative log grades (fall-down grades) to use when logs have exceeded specified turnover times is important. Generally, domestic grades will be used for fall-down grades, not because domestic mills like sapstain, but because domestic logs will be processed within a few days, whereas export logs may not be processed for several months. At worst case sapstain will only penetrate logs at about 1.5cm per week so times of two or three weeks from fell to mill will have lesser effect on value recovery. This assumes logs are not stockpiled in local mills for long periods
- Frequent changes to cutting plans increase the likelihood of unwanted logs being left to age in part loads on the skid

Trucking availability and policies

- Trying to make up full truck and trailer loads from just one contractor and one skid extends turnover time as the production of a full load may take several days for some grades.
- The load out priorities of truck schedulers which dictate that certain log products take precedence over others

may lead to some grades being left over-long on the skid. Using a contractor's skid as a storage facility not only destroys crew motivation to reduce turnover time, but also reduces the safety and efficiency of processing operations by reducing the effective area of the skid.

- Communication of log ages between loader operators and dispatchers assists in prioritising loads.

The length of time that logs spend in mill or debarker log yards

- Mill or log yard stocks. There are usually several hours or days volume stored in mill facilities to enable continual production in case of interruptions to supply. The size of this buffer will have a major impact on total turnover time.
- Stock rotation policies. As with the log stacks on the skid, the log yard must manage their stocks so that logs are processed in the order that they reach the yard.
- Export logs. Where ownership extends to the off-shore unloading point, control of shipping and unloading is important. Increasingly, best practices for log handling and minimising times between unloading and processing are being recommended to buyers.

No one person is in control

It is evident that there are three links in the chain. The contractor controls log flow from the time of felling to when logs are placed in stacks on the skid. The forest owner controls log flow from stacks to mill or debarking and treatment plant. Buyers or debarking plant managers are responsible for the time that logs spend in their log yards before processing takes place. Where logs are exported, more links and people are involved. No one person is in total control.

REDUCING TURNOVER TIMES - STRATEGIES FOR GROUND-BASED CONTRACTORS

Within a contractor's control are operational activities such as: felling, extraction, and skid-based activities.

Felling and Extraction Interaction

Felling production rates can be adversely affected by: wind direction, tree form, terrain, tree lean, felling strategy, manpower levels and performance. Under these constantly changing conditions, the extraction machine can extract from the buffer and maintain a constant supply to the skid. A buffer too small for the changing felling conditions can lead to the skid being starved of wood or to faller safety being compromised by them working too near to extraction machinery. Too small a buffer in high production operations may also lead to fallers feeling under pressure to produce at a faster rate than they are capable of doing safely.

Too large a buffer however, can result in felled wood being on the ground for an unacceptable period of time. In practice, buffer size is determined by previous experience, felling conditions, faller safety criteria, and limitations (often due to sapstain risk) imposed by the forestry company. The buffer must be actively managed by the contractor, as faller and extraction machine productivities change constantly.

In mechanised felling operations, the same balancing criteria apply. Generally, mechanised operations expose more points of entry for sapstain fungi and create a log surface more difficult to treat by current methods, so shorter turnover times are needed. This is offset by the potential to reduce turnover time with mechanised operations.

Weekend work and the size of the buffer between felling and extraction has a major influence on turnover time as shown in Tables 1 and 2.

	Options for the Working Week			
Day extracted	Normal week worked	1/2 Saturday worked (whole gang)	Full Saturday worked (whole gang)	Fell Sunday, not Friday
Monday	4	4,3	3	4
Tuesday	4	4,3	3	2
Wednesday	2	2	2	2
Thursday	2	2	2	2
Friday	2	2	2	2
Saturday	-	2	2	-
Sunday	-	-	-	-
Average age of extracted wood	2.8 days	2.5 days	2.3 days	2.4 days

Table 1 - Fell to extract time (days) for an operation with a two day buffer

Day extracted	Options for the Working Week			
	Normal week worked	1/2 Saturday worked (whole gang)	Full Saturday worked (whole gang)	Fell Sunday, not Friday
Monday	3	3,2	2	1
Tuesday	1	3,2	1	1
Wednesday	1	1	1	1
Thursday	1	1	1	1
Friday	1	1	1	1
Saturday	-	1	1	-
Sunday	-	-	-	-
Average age of extracted wood	1.4 days	1.5 days	1.2 days	1 day

Table 2 - Fell to extract time (days) for an operation with a one day buffer

Tables 1 and 2 clearly identify:

- The 'weekend effect', which is aggravated by long weekends
- The benefits of keeping a minimal buffer at all times (but without compromising production or safety)
- The positive impact that Saturday work has on turnover time
- The positive impact that not felling on a Friday has on turnover time

Extraction Phase

In multi-skid operations, there should be complete clearance of an individual faller's production in each time period. If felled trees are left in the cutover following the filling of a skid for log making, then these trees may fall outside time limits if left until the next time round. If there is more than a skid-full on the ground, then trees can be cold-decked by the skid entrance, ensuring that they are processed next. Systems that use excavators for bunching and/or shovel logging can ensure that all of a faller's daily production is kept together with an easily identified felling date.

In single-skid or hot-deck operations, care needs to be taken so that trees are extracted sequentially, that is, the oldest

first. Good communication between fallers and extraction operators is necessary. A whiteboard plan of the block, with updated boundaries of standing trees could aid felling planning as well as identify the location of older wood for extraction.

In lower production, single skid operations, consider having no buffer. Take trees from fallers as they complete a drag. Production may be lower due to interference in various forms, but where the operation is sensitive to wet weather, this system prevents large amounts of wood being left on the ground if the operation is stopped. All felled trees could be moved out to the skid at the end of each day but this would leave no wood available to extract the next morning. It may be worth leaving one or two drags for the next day.

Skid Phase

Older logs tend to accumulate under (with excavator loaders), or at the back of the stack (with rubber-tyred front-end loaders). Stack management to reduce this effect could include:

- Moving older logs to the front of a stack following large load out

- If there is space for multiple stacks of the same log type, small stacks with old logs could be added to another stack or loaded out first so that fresh stacks can be started
- load out from stacks with the oldest wood first, which may mean loading from several skids
- Small quantities of a log type left after a load out could be taken to stacks on an adjacent skid.

Having the loader operator call in the oldest dates on each stack allows for uplift priorities to be set by trucking managers.

REDUCING TURNOVER TIMES - STRATEGIES FOR HAULER OPERATIONS

Reducing turnover times in hauler operations is a more complex task than in ground-based operations because of limitations imposed by terrain, cable systems and safety considerations. Most of the following strategies will involve extra planning, management, extraction effort and cost, so will probably only be used during periods of high sapstain risk and in high value stands. For this reason, harvest planning and operational staff must be informed as to the cost of sapstain degradation in the market place. Marketing staff are the key in providing sapstain degradation costs in the market place. This provides clear guidelines as to how much extra can be spent on logging. In many cases, the main aim may not be to get all logs to the landing within a specified turnover time, but to get as high a proportion of the logs to the landing within that time. This policy must be combined with fall-down grades for those trees which fall outside the time requirements.

Approaches which can be taken to reduce turnover time in cable operations include:

- to shorten the haul distance
- to reduce the width of the felling swath
- to increase hauler productivity.

Shorten Haul Distance

The distance between fallers and working lines should be two tree lengths, so a faller must fell a complete swath two tree lengths wide from the landing to the back of the setting before extraction can start. The next swath must then be felled before the first is fully extracted. By shortening the maximum haul distance, the area of each swath is reduced. This reduces times for both felling and extraction of the swath which results in a shorter turnover time. (Note: a shorter turnover time alone is no

use unless it is below the target time required). Some options to achieve this are as follows:

- Planners could save the close pulling or small settings for times of high sapstain risk
- Long settings could be extracted in two portions using a two stage system with a hauler on a mid-distance road or small skid. Secondary extraction machines could then take extracted wood along to a larger processing site. Such two stage systems help reduce earthworks and other costs associated with this method. There are now several successful two stage systems in use (Bennett, 1995).
- Another possibility with the same outcome is to consider splitting long settings as above, not with a road, but by extracting the front half of the setting first and then the back half to the same landing. This effectively halves the length of each felling swath. Although twice the line shifts are needed to complete the setting, the time trees lie on the ground before extraction is substantially reduced. Another option is to log the front easy part of a setting with a different, lower cost system (shovel log or skidder) before a hauler takes over.

Reduce Width of Felling Swath

Reducing the width of each felling swath is another way to decrease the total area of each swath which must be felled at one time and so reduce turnover time. The width of a swath could be reduced from two tree lengths to one. Safety considerations mean other changes in the system must be made. Two possible changes are:

(i) De-phase the felling and extraction parts of the operation, so felling takes place at different times of the day to extraction. This could be achieved by felling before hauling commences each day, or after hauling finishes each afternoon, and falling only enough to last one or two days' extraction. This need only be necessary during periods of high sapstain risk (summer time) when day length is longer. Contractors may need one or two extra fallers during these periods. Some considerations are:

- an extra vehicle may be required for fallers
- felling on Sunday rather than Friday is a useful way to minimise weekend effects

With this option, feller-bunchers, feller-directors or single grip harvesters could be used to fell narrow swaths. Those machines with level-swing capability can operate on slopes up to 30° depending on soil type and soil moisture content. They can be faster than conventional motor-manual felling and are perhaps better suited to dealing with such variables as unfavourable tree-lean when felling only one tree length wide strips at a time. To fully utilise a feller-buncher, it will need to fell for other gangs. A better option could be to replace an existing machine with one with a feller director or harvester head. This machine could then be fully employed for processing tasks on the skid whether the setting suited mechanical felling or not. Where possible, mechanical felling could be done out-of-shift.

(ii) Fell and extract a setting in segments. A given setting could be split and worked in segments to physically separate fallers and hauler operation. This requires extra time to be spent pre-rigging, and again may require an extra worker and possibly extra strawline and tail blocks. This method will mean more guyline shifts and/or hauler shifts depending on the

hauler's allowable lead angles Riddle (1996).

Increase Hauler Productivity

Increasing a hauler's production rate reduces the time it takes to extract a swath, so reducing turnover time. Options to consider are:

- Most hauler operations are constrained by landing operations to the extent that many contractors restrict the number of breaker-outs used. Eliminating this bottleneck would allow increased hauler productivity. A number of options to achieve this goal are in use and include mechanisation of skid activities and separating extraction and processing with a two staging system.
- Planners should save settings with good deflection for high risk periods. Good deflection allows greater average drag size which increases productivity. There may sometimes be a compromise however, between increasing deflection and reducing average yarding distance (AYD)
- The largest haulers that are available should be used, where landings and anchors allow, if doing so will achieve higher productivity and the target turnover time. For example, a setting may be of a size that a hauler with a 22mm skyline might take three days to extract a two tree length swath but one with a 32 mm skyline may only take two days. If sapstain is of concern and a larger machine is available, using it will reduce turnover time.
- Increasing hauler working hours (for example, two shifts) over the summer period would reduce turnover time as each swath would be extracted over a shorter number

of elapsed days (for example, the 21 machine hours it might take to extract a swath could be achieved in two days instead of three).

- Using an excavator, feller-buncher or harvester head (as previously discussed) to bunch as much of the setting as possible would reduce turnover time by increasing hauler productivity through shorter hook-up and break out times.
- Increase the size of the minimum merchantable piece to be extracted. Extracting small broken pieces slows production. Relaxing these requirements has a cost in lost (pulp) volume but will improve productivity, thus reducing turnover times. Site preparation costs may need to be considered in the equation.
- Reducing breakage will increase productivity as there will be fewer small pieces to pull. Good felling techniques reduce breakage. The ratio of average number of butt logs extracted per drag to the number of strops used is a good monitor of breakage levels. Using a feller-buncher on as much of the setting as possible could also reduce felling breakage substantially and reduce the breakage caused by the hauler itself when breaking out. Felling machines can align trees or bunches so logs do not have to be turned at break out.
- On suitable parts of a hauler setting, a ground-based machine may be able to skid or shovel log felled trees to a point where a hauler can pull them to a processing area. Fallers could fell drag for drag with a skidder or work alternative faces with an excavator and so at least a percentage of a high value stand could be extracted on the day it is felled, without much of the tracking network and site impacts normally associated with ground-based systems on hill country.
- If using a mechanical or motorised dropline carriage, pre-stropping will reduce cycle times and increase production.
- Electronic choker bells will also reduce cycle times and increase production.

REDUCING TURNOVER TIMES - STRATEGIES FOR FOREST OWNERS/MANAGERS

Beyond the contractor's control are specific company requirements such as trucking policies, the number of log grades each crew is given, how often cutting instructions or load out priorities are changed and how many grades have short turnover requirements. Strategies for forest managers to consider include:

Management and Marketing

- Maximum effort should go into carefully selected, high value product. The drive to reduce turnover times should only occur if it is financially worthwhile. Blanket restrictions on all grades are likely to be impractical and may lead to false dating, and the system collapsing, so concentrate on a few key grades.
- Set achievable objectives for contractors and then
- Supervise/audit to demonstrate commitment to achieving those objectives.
- Incentive system - If there are financial benefits for the forest owner in reducing turnover time, then an incentive system encouraging production of fresh logs would assist and encourage the logging work force. Such a system would need to be transparent, and consistently applied in an approved manner. Conversely, crew and contractor motivation is destroyed if timely load out of their production does not take place
- Fall down grades -Weekends and unforeseen delays mean that there need to be alternative grades available for those trees that have exceeded their target dates
- Fewer grades per crew - Crews in a forest could get different log making instructions. Trying to obtain maximum volumes from a minimum number of crews reduces the time taken to make up full truck loads of a special order on each

skid. Research is being undertaken into tools which will suggest crew cutting instructions given orders, stocks, distances from each crew to each destination and pre harvest inventory details.

Trucking

- Minimise stocks on skids - To reduce sapstain, truck scheduling must be improved to minimise stocks on the skids. High priority must be given to those grades which are important. A suitable goal in many cases is to have no special order logs left on skids overnight. This is termed a "clean-skid" policy.
- Communication - Loader drivers must regularly communicate the age of the oldest logs in the stacks to truck dispatchers
- Do not use contractor's skids as a storage facility for special order logs surplus to current requirements. Take these away and treat them
- Get high value logs away from skids as soon as they are ready. Options include:
 - Split loads on trucks (different log types on truck and trailer)
 - Pruned butts on top of loads of another log grade
 - Completion of loads from more than one of a contractors skids
 - Using sweep trucks to complete loads from more than one contractor. Either use on-board scales or count logs for accounting purposes or for export logs use the scalers to report on contractor volumes.
 - Another possible strategy is a central sorting yard. At the end of each day, trucks take all logs left on skids to a central sort yard where loaders sort into saleable loads. Trucks start in the morning by emptying the sort yard before going back to working from skids.

LOG TURNOVER AUDITING

For day-to-day management of log turnover, a workable auditing method is required. Ideally, such a system should be integrated with the forest owner's woodflow control system. A suggested method for auditing of log turnover follows.

Contractor

Fallers mark the butts of all or a sample of felled trees with the felling date. (If on slopes, mark a date on the scarf face before the final felling cut is made) Random checks of the cutover should ensure that marking is kept up-to-date and that no future dates are being applied. All slovens are left on until processing to reduce the risk of infection of the ends of logs.

As trees come on to the skid, the logmaker checks the felling dates to ensure that grades with tight turnover time requirements can be cut from each tree. Logs from these trees can be marked in two ways:

- The skid worker who cuts a sloven can transfer the felling date to the end of the butt log. The person branding at the stacks can then regularly transfer the dates appearing on the butt log stack to the other stacks of grades that need dating.
- If daily production by each faller is kept together (by skidder or excavator) with a known felling date (good records or marked felling dates), the logmaker will know the felling date of each batch of trees that comes on to the skid. When that batch of trees is processed and fleeted, the felling date can be marked on to all the undated logs in the stacks before a new batch arrives.

A regular sample of the trees that arrive on the skid throughout the day should have

felling dates recorded and compared to the current date, to derive the time between felling and arrival on the skid. Stacks should also be checked to ensure that no old logs are left at the base or the back of log stacks.

Forest Owner

The effectiveness of the truck scheduling/log priority system can be easily measured if the contractor's system is running smoothly and the forest owner is auditing it. The forest owner is audited by taking the dates on the logs in the stacks for comparison with the current date.

Where logs in the stacks are three days from felling, and logs coming on to the landing are only one day from felling, you can assume that logs are spending two days in stacks and truck scheduling needs improving.

An alternative system is to ask truck drivers, weighbridge or log scaling staff to regularly record the dates on the logs they carry or weigh, for comparison with the current date. This would be a monitoring system which only looked at a sample of contractors rather than an auditing system.

Log Yard

The third link in the felling to sapstain treatment chain which has not yet been considered, is what happens to logs after they have been loaded on to trucks at the skid. Careful logging and trucking management is wasted if logs are delayed in a mill or debarker log yard. To measure the time logs are delayed at these yards, compare the dates on the logs going into the mill proper or into the debarker with the current date, and with the efficiency of logging and trucking already derived.

A stand-alone audit could be carried out by dating logs as they enter a yard and recording dates as they enter the processing facility.

REFERENCES

Bennett, D. (1995) : Using Two Stage Logging to Improve Logging System Performance. In proceedings 1995 LIRO Conference on Harvest Planning.

Riddle, A. (1996) : Minimising Sapstain in Hauler Operations - A Case Study. LIRO Report, Vol. 21 No. 8.

Robinson, T. (1996) : Log Truck despatching in Auckland Region. LIRO Report, Vol. 21, No. 12.