F.R.I. PROJECT RECORD

NO. 3277

COMPARISON of ACTUAL OUTTURNS of LOG GRADES with values predicted by PREHARVEST INVENTORY and MODELLING

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REPORT NO. 27 JUNE 1992

Note : Produced jointly with the Stand Management Cooperative as Report No. 31

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EXECUTIVE SUMMARY

Predictions of outturn by log grades are valuable to forest managers, but indications are needed of likely accuracy. This study used existing data from three forests to test predictions of outturn by log grade from both MARVL (pre-harvest inventory) and STANDPAK (modelling system). Inputs to the simulations were selected in line with the level of information which would have been available to a forest manager prior to this study. Potential outturn as assessed by the AVIS system was used as a consistent standard against which to compare predictions, rather than the results actually realised on the skid, which were largely dependent on the skill of the workers involved. Due to lack of measurement and treatment history, STANDPAK errors in the growth modelling module were not tested.

Even in terms of the broadest log grades, magnitude of the errors in predictions of log outturn would have limited the usefulness of results from the pre-harvest inventory and modelling systems studied. STANDPAK showed a strong tendency to overestimate proportions of both pruned and pulp material. MARVL gave a less biased and more accurate prediction of outturn than STANDPAK, though results depended on the observer's subjective estimates of branch size, sweep and other defects, and in common with STANDPAK, on the applicability of tree volume and taper tables.

It is recommended that the proportions of degrade provided as defaults for the log assortment module be re examined, and that for each major crop type, predictions are calibrated against approximately 100 sample trees which have accurate stand histories.

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STANDPAK MARVL AVIS

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June 1992

INTRODUCTION

Information about the quantity and quality of logs available in a stand before felling is of great value to forest managers. Outturn of log grades can be predicted by either pre-harvest inventory or modelling systems.

An earlier report (Eggleston, 1991) concluded that there were significant differences between predictions from a MARVL inventory and the STANDPAK modelling system, especially in terms of log quality, but that it could not be determined which was correct, if either, as both contained elements of prediction and or subjective assessment. Rather than compare predictions from a modelling system against predictions from a pre-havest inventory, this study sought to compare each with what was actually there.

The objective for this investigation was to use existing data to compare actual outturn by log grade with predictions from both MARVL and STANDPAK. The terms of reference had been set in Proposal 14 for the 1991/92 programme of the Stand Management Cooperative, and the project jointly funded by the Stand Growth Modelling Cooperative.

METHODS

The outturn that was potentially available from the stand was considered to be a more consistent standard against which to test results of the prediction systems than the outturn actually achieved in harvesting operations, which depends largely on the skill of the log makers involved and would have confounded the studies with variations in operational performance. The AVIS computerised bucking system, based on detailed stem measurements, provides an objective assessment of the theoretical optimum log allocation from sampled trees (Geerts and Twaddle, 1984).

Data for this project came from three studies in which MARVL and AVIS assessments had been carried out on the same stands. Summaries of the stands from which the studies were taken are given in Table 1:

Table 1: Stands in which the studies were carried out:

Forest	Custodian	Regime	Estb.	Age	Final Stocking* (stems/ha)	Total Rec. Volume* (m^3/ha)
Hochstetter	Timberlands West Coast	Transition Crop	1962	28	213	339
Kinleith	NZFP Kinleith Region	Prod. thinned	1959	32	246	591
Whitord	CHH Northern Region	Prod. thinned	1954	35	-	-

*Determined from MARVL assessments at the time of felling.

Note that it was not possible to calculate stocking or volume per hectare values for the Whitford study, as a measurement of the area felled was not available.

In the Hochstetter and Kinleith studies, log outturns from the pre-harvest inventory, stem assessment and those actually cut could be taken directly from reports or file notes outlining the results of the original comparisons of MARVL, AVIS and outturn actually achieved on the skid. However in order to obtain the stand information needed to carry out the corresponding STANDPAK runs, the inventory data had to be reprocessed. In two cases data, quality code dictionaries and cutting strategies for the MARVL assessment were not supplied in electronic form and had to be keyed in from hard-copy of file listings. Both of these sets were VAX MARVL format files and were converted into *MicroMARVL* format and processed on a PC. In the Whitford study, inventory data and cutting strategy files were obtained in electronic form and analysed using *MicroMARVL*.

Treatment histories of the stands were sketchy (see Appendix 1). Had accurate measurements been available the hypothesis (Eggleston, 1991) that growth model errors compound those of the log grade prediction modules would have been tested. But as the main concern in this project was with the performance of the log assortment and log grading capabilities of the STANDPAK modelling system, sources of error from the growth prediction and diameter distribution modules were minimised by adjusting stand parameters used by the model to those measured at the time of felling. Basal area, stocking and MTH were taken from *MicroMARVL* summaries, while the pruned height of the various stand elements was calculated from the raw data (see Appendix 2).

The volume and taper tables used in the STANDPAK simulations were those which had been considered most appropriate by the inventory officer who originally processed the MARVL data.

Table 2: Summary of inputs used in STANDPAK simulations:

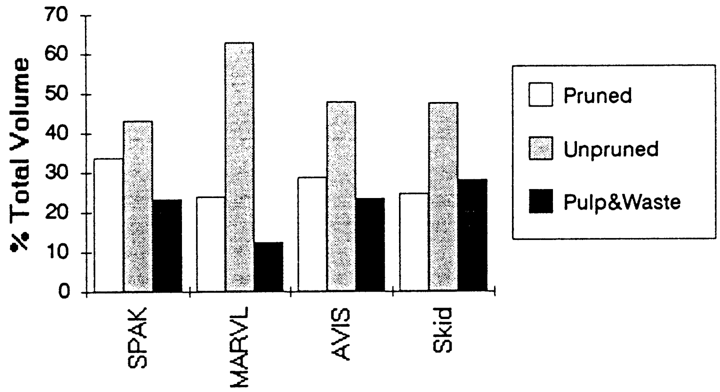
Forest	Site Index	Volume table	Taper table	Break table	Sweep
Hochstetter	22	Westland	Kroa YC	GDNS	Med
Kinleith	32	Kroa YC	Kroa YC	Kroa	Med
Whitford	22	Glnb/Whng	Tairua	Tairua	Low

Selections of internode distances, wood density and several other inputs did not affect the results of this study, as the simulations were not being continued to the processing stage. Other selections for the STANDPAK simulation were intended to represent the best knowledge available to stand managers before the study was carried out, which in many cases meant that default values were accepted.

RESULTS

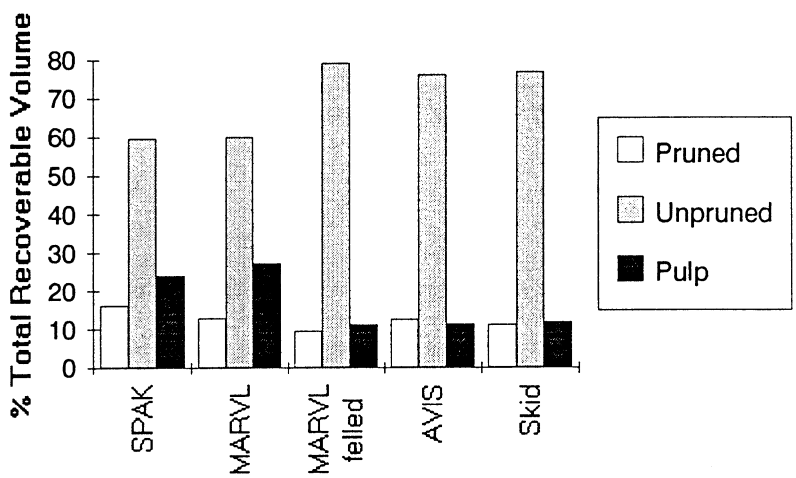
Comparing the proportions of log outturn for each of the systems gave the results shown in figures 1 to 3.

Figure 1: HOCHSTETTER; Predicted, Potential and Actual Outturn



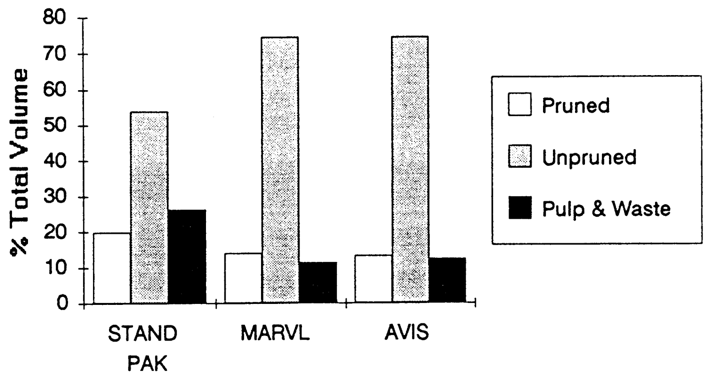
Relative to the assessment of potential outturn (AVIS), the modelling system (STANDPAK) overestimated the proportion of pruned material, as it underestimated the percentage that would be degraded due to defects. On the other hand in the pre-harvest inventory (MARVL) the assessment of degrade in the pruned section of stems was somewhat conservative, leading to an underestimate of the volume of pruned logs, while the quality of material further up the stem was overestimated.

Figure 2: KINLEITH; Predicted, Potential and Actual Outturn



STANDPAK overestimated the proportions of pruned logs and of pulp. MARVL overestimated the volumes being degraded to pulp, due to an overly harsh assessment of sweep and malformation. In the Kinleith study, in addition to information from the pre-harvest inventory, another assessment was made after felling ("MARVL felled" in Figure 2). Results matched potential and actual outturn quite closely, though coding of the pruned section tended to be on the conservative side. In terms of the broad aggregations of log grades shown in Figure 2, the outturn produced on the skid was similar to the potential, however, when examined in terms of value there was still theoretically room for improvement in log making.

Figure 3: WHITFORD; Predicted and Potential Outturn



In the Whitford study, STANDPAK overestimated the proportion of pruned volume and of pulp and waste. The error in predicting lower grade material was caused by an overestimate of branch size, while like both other cases, there was an underestimate of degrade within the pruned section.

The performance of the prediction systems and log makers were compared with the potential from the AVIS assessments for the three situations. Figures are percentage difference in volume relative to the AVIS results. Positive numbers indicate the method overestimated outturn, negative an underestimate.

Table 1: Summary of differences between results from prediction systems relative to volumes determined by AVIS.

		STANDPAK	MARVL	MARVL Felled	Skid
Pruned	Hochstetter	18%	16%		-14%
	Kinleith	29%	-16%	-24%	-11%
	Whitford	49%	7%		
Unpruned	Hochstetter	-10%	31%		-1%
	Kinleith	22%	-21%	4%	1%
	Whitford	-28%	0%		
Pulp	Hochstetter	-1%	-47%		20%
	Kinleith	113%	142%	-1%	5%
	Whitford	113%	-8%		

STANDPAK tended to overestimate volumes of both pruned and pulp grades. Results from MARVL showed no clear trend, while the outturn achieved on the skid tended to be of lower grades than the potential indicated by AVIS.

DISCUSSION

Modelling System

Predictions made by the STANDPAK modelling system varied widely with the particular situation being modelled. There are a vast number of combinations of sites, regimes and possible user inputs, but these three cases showed a tendency for the proportion of pruned volume and pulp to be substantially overestimated. The user has the opportunity to override the default percentages of degrade in the system, but to do this users have to have access to results from studies like this one, so that experience factors can be developed.

Another cause of bias in STANDPAK predictions of pruned volume, relates to the simplified model of reality that the system operates on. The LOGASORT module assigns a single pruned height to each stem in a crop element, with the result that each stem yields a uniform pruned length. In reality, pruned height of a stand element approximates a normal distribution around the mean, so that the pruned section of some stems may not meet a pruned log specification while others will exceed it. The simplification made in STANDPAK, results in the system overestimating the volume of pruned logs that will be cut from a stand, a situation which is accentuated when a fixed length pruned log specification is being used and the mean pruned height is close to the sum of log length plus stump height (see also Eggleston, April 1991).

In the Hochstetter case, had there not been errors in the prediction of diameter distribution within STANDPAK, errors in pruned volume would have been even greater, as the modelling system had overestimated the proportion of stems that would have been too small to produce logs that met the minimum SED specification for pruned logs (see Appendix 3).

Production from two of the stands in this study were being cut to log specifications in which sections of unpruned stem were allowed to be mixed with pruned material, a situation which could not be directly simulated in STANDPAK.

Predictions from the modelling system are influenced by user inputs of the level of sweep, the tree volume and taper tables chosen and the predictions of the branch size model, with the importance of each varying with the situation. Though errors in estimates of these factors affect the performance of STANDPAK, in the three situations modelled there was little guidance as to the most appropriate selections of sweep level, volume/taper tables and adjustment to branch size predictions.

Pre-harvest Inventory

MARVL predictions showed no clear trends through the three examples studied. Accuracy of the MARVL system is limited by the subjective nature of the observer's estimates of branch size and sweep and also depends on how appropriate the tree volume and taper tables are for the stand. Skilled observers, receiving frequent feedback from actual measurements or outturn (or where results are adjusted by the inventory manager in light of past experience) can give acceptable estimates in terms of broad product classes where the tree volume and taper tables provide good descriptions of the stems sampled, especially where the majority of stems are clearly within the specifications for branch size and sweep. However even then, estimates of sweep are very difficult to make by eye and though overall predictions of the volume of unpruned material may be reasonably good, other studies have shown that the proportion of longs to shorts can be "well wide of the mark" (Jonathan Gadd, pers. com.). The major causes of error in the pre-harvest inventories in this study were thought to be observer fallibility and error between the actual shape of stems and the tree volume and taper tables.

MARVL assessment of stems after felling showed how predictions could be improved with a closer inspection of the stem.

As would be expected when comparing a theoretical optimum (AVIS), with actual achievement (skid outturns) there was a degree of slippage due to sub optimal log allocation, which was most evident within the unpruned category. In the two studies where figures for actual outturn on the skid were available, under achievement in log outturn was even noticeable as a difference between the three broad aggregations examined in this study (Pruned, Unpruned, Pulp).

Limitations of the study

STANDPAK simulations were based on measurements of basal area, stocking and mean top height from the MARVL inventory at the time of felling. In the Hochstetter and Kinleith studies stand parameters required for modelling were not available in time for use in this exercise, so STANDPAK predictions had to be based on stand average values rather than for the sample of trees that were assessed by AVIS, resulting in an element of sampling error. According to MARVL summaries for each stand as a whole, the total volume was estimated to around 10% in all cases. Sampling error was not thought to have been a major component of the error in the STANDPAK predictions produced for this study.

As the main concern in this project was with the performance of the log assortment and log grading capabilities of the FRI modelling system, rather than with the growth prediction and diameter distribution modules, and the fact that stand histories and initial values were unknown, these sources of error were minimised by adjusting stand parameters used by the LOGASORT and LOGRADES modules to those actually measured at the time of felling. The errors of the modelling system in real life situations would be greater than shown in this study.

The original studies from which the pre-harvest inventory and stems assessment data were taken for this project, had been concerned with the relative accuracy of pre-harvest inventory, actual outturn and potential outturn, so that records could not be found of the precise area felled in all cases. Not knowing the area meant that volumes could not be compared in *absolute* terms, so this study had to be limited to analysing the *proportions* of products between the different systems and stands. In the two cases where volume per hectare could be calculated and from previous studies (Eggleston, 1990) the prediction of total volume from MARVL and STANDPAK and actual outturn are generally accurate to within a few percent of each other, so having to use relative proportions rather than absolute volumes in these comparisons was not thought to be a limitation in this exercise.

In the Kinleith study the sample size was only 15 trees which was considered to be rather limited, while in each of the other cases there were 100, which appeared to be sufficient for these comparisons.

This study was restricted to examining external features of log quality, as the MARVL and AVIS systems do not attempt to assess internal characteristics. STANDPAK predictions of wood quality were not tested.

Being restricted to existing data was thought to have contributed to the magnitude of the errors between MARVL and AVIS, as part of the reason for the original studies was concern about the accuracy of pre-harvest inventories. Performance of MARVL in other situations may be better than indicated by the results of these comparisons.

Variation in the performance of individual log makers within a study served to reinforce the decision to use the results of AVIS assessments of potential outturn as the standard against which to compare prediction systems, rather than what was actually achieved.

CONCLUSIONS

Even in terms of the broadest log grades, there were errors in predictions of log outturn which would limit the usefulness of results from the pre-harvest inventory and modelling systems studied.

The performance of STANDPAK depended on: the suitability of the tree volume and taper tables, the sweep level chosen, and predictions of the branch size model.
In the three situations studied, STANDPAK showed a strong tendency to overestimate the proportion of pruned material and pulp.

MARVL gave a less biased and more accurate prediction of outturn than STANDPAK, though results depended on the observer's subjective estimates of branch size, sweep and other defects, and on the applicability of tree volume and taper tables.

There were some limitations in the suitability of data used in these comparisons, as this study had been restricted to the use of existing data, which had not been collected specifically for the purpose of testing predictions from the modelling system.

RECOMMENDATIONS

Re-examine the proportions of degrade provided as defaults for the log assortment module.

Testing of STANDPAK predictions should first involve the validation of each component individually.

Then for each major crop type, predictions from the system as a whole should be calibrated against potential outturn from detailed assessments of approximately 100 trees for which stand history can be accurately determined. These studies should be carried out on suitable permanent sample plots as they reach rotation age, or by destructive sampling.

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Comparing the range of regional tree volume and taper tables
Stand Management Cooperative report No. 26

Geerts JMP and Twaddle AA, 1984
A method to assess log value loss aused by cross-cutting practice on the skid site
NZ Journal of Forestry, 29(2): 173-84

APPENDICES

1. Stand Histories

Hochstetter

Planted	1962			
Thinned	1973	to	731 stems/ha	
Pruned	1973		500 stems/ha	to 2m
Thinned	1980	to	287 stems/ha	
Pruned	1980		287 stems/ha	to 6m
Felled	1990			

Kinleith

Not cleared for disclosure at time of printing

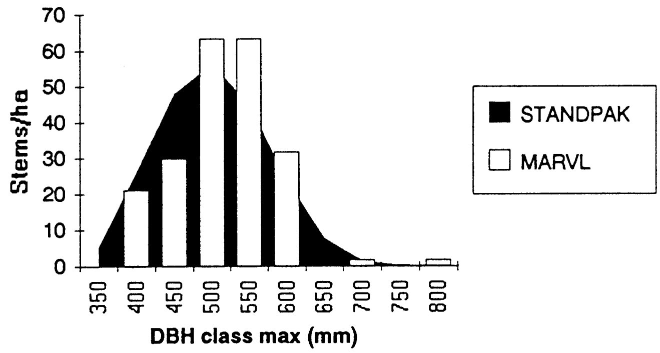
Whitford

Planted	1954		3000 stems/ha	
Pruned	1959-60		1/2 height	
Pruned	1961-62		6m	
Thinned	1964	to	450 stems/ha	(post & pulp)
Fertilised (P)	1964			
Thinned	1977	to	190 stems/ha	
Fertilised (P)	1977			
Felled	1989			

2. Determining Parameters of Crop Elements

Not cleared for disclosure at time of printing

3. Predicted and Actual Diameter Distributions - Hochstetter



4. Detailed Outturn - Hochstetter