

Evaluating machine utilisation rates of a forwarder and harvester in pine plantation operations

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Introduction

Machine utilisation is a key aspect of overall machine performance and productivity (CRC Bulletin 20: Strandgard, 2011) but to get reliable utilisation data requires long term operational tracking. MultiDATs are on-board computers developed by FPInnovations in Canada to monitor and record machine utilisation long term. About 20 MultiDATs have been set up on different machines in Australia as a major ongoing R&D project undertaken by AFORA and supported by FWPA (CRC Bulletin 20: Strandgard, 2011). This project used the recorded machine utilisation of a harvester and a forwarder operating in pine plantations in Southern Tasmania to calculate the average and range of machine utilisation and to verify the impact of site conditions on utilisation rates over a long study period. The site conditions in this project were defined by factors including type of forest operation, stand age, site productivity, ground slope and forwarding distance.

Study area and research method

Data was collected from 22 coupes in Tasmania where MultiDats recorded harvester and forwarder data in *Pinus radiata* plantations for 12 months. The plantations harvested varied from 15-25 years of age and included first and second thinning and salvage clear fell operations. The harvester (a Tigercat H822C, 4 years old) was used to fell the pine trees and process them into short logs to be extracted by a Valmet 890.3 forwarder (a typical Cut-to-Length operation). The harvester's operator had 500 hours of work experience with this machine and over 10 years in timber harvesting. The forwarder was 6 months old and had a payload of 16 GMt. Its driver had 20 years of experience working on forwarding operations.

Prior to the study, a MultiDat was set up in the cabin of each machine (Figure 1). Average machine utilisation for each coupe was determined based on working hours in each coupe from provided utilisation records (expected schedule hours was 10 hours per day). The forwarding distance was calculated using the operation maps of the coupes (including landings, extraction direction and coupe boundaries). Using 10 samples on each map the average forwarding distance was calculated and was then corrected based on the average slope of the coupe to calculate distance on the ground. The stand yield (t/ha) was provided by the Norske Skog as classified data ranging from 1 (very high) to 10 (very low) for each coupe. Type of operation included first thinning, second thinning and clear fell which were allocated the values of 1, 2 and 3 for the analysis. Pearson correlation ratio was calculated

between each variable and machine utilisation and then stepwise regression was applied to test if the mentioned variables had any significant impact on machine utilisation.



Figure 1. MultiDat set up



Figure 2. Valmet 890.3 forwarder

Results

The harvester utilisation rate varied from 48.6% to 100.3% (average 77.3%). Average slope in the study areas was 7.8 degrees while forwarding distance averaged at 111 m. The plantation age varied from 15 to 25 years (with an average of 17.6 years). The minimum, maximum and mean values of variables are presented in Table 1. The forwarder's utilisation rate over this study varied from 47.8% to 96.5% (average 81.1%).

Lower utilisation rates were observed with mechanical breakdowns, especially for the harvester, which was an older machine. However, average utilisation rates of both machines in this trial are high compared to average utilisation rate of 65% for both harvester and forwarder suggested by Brinker et al. 1989 for standard machine cost calculation. Also previous AFORA's studies by MultiDats found average utilisation of 46% for a feller-buncher, 55% for a skidder and 70% for an excavator in Victoria's Central Highlands in a Native Forest operation (CRC Bulletin 20, Strandgard 2011).

In a previous study in Norske-Skog pine plantations using short term time study the average utilisation rates for forwarder and processor were 99% and 97% respectively (CRC Bulletin 23: Ghaffariyan and Acuna, 2012) which are much higher than measured value by on-board computer over long term period in this study. This highlights the advantage of using on-board computer that can determine the actual machine utilisation more accurately over longer period of time which is not possible by short term observation.

Table 1. Descriptive statistics of variables and utilisation rates

Variable	Minimum	Maximum	Mean
Plantation age (year)	15.0	25.0	17.6
Slope (°)	2.0	17.0	7.8
Forwarding distance (m)	34.0	191.0	111.1
Stand yield classification	1	10	5
Harvester utilisation (%)	48.6	100.3	77.3
Forwarder utilisation (%)	47.8	96.5	81.1

The Pearson correlation coefficient was calculated for each variable in relation with harvester utilisation or forwarder utilisation (Table 2). This coefficient is a measure of the linear correlation (dependence) between two variables X and Y, giving a value between +1 and -1 inclusive, where 1 is total positive correlation, 0 is no correlation, and -1 is total negative correlation. The correlation coefficient of each variable versus machine utilisation was not significant based on significance level calculated in Table 2. The correlation ratios were very low varying from -0.17 (operation type vs. forwarder utilisation), 0 (slope vs. forwarder utilisation) to 0.21 (stand yield vs. forwarder utilisation). This fact resulted in non-significant regression models developed to test the impact of each variable on machine utilisation. One

reason might be due to the small sample size, or alternatively, site conditions may not have any impact on machine utilisation in plantation operations.

It is suggested that machine utilisation (% of scheduled hours) should be combined with work productivity (tonnes per hour) to be recorded by using other types of on-board computers that have more capability to capture data and provide a clearer picture of what operational parameters most significantly impact on long term machine performance.

Table 2. Pearson correlation between variables and machine utilisation

		Plantation age	Slope	Forwarding distance	Stand yield	Type of operation
Harvester utilisation	Pearson Correlation	0.06	-0.01	0.15	-0.01	0.04
	Sig. (2-tailed)	0.80	0.96	0.56	0.95	0.86
	N	18	17	18	18	18
Forwarder utilisation	Pearson Correlation	-0.14	0.00	-0.07	0.21	-0.17
	Sig. (2-tailed)	0.57	0.99	0.76	0.40	0.49
	N	19	18	19	19	19

Take-home messages

- On-board computers are effective tools to monitor machine utilisation over a long time period. In this case the average utilisation for a harvester-processor was 77.3% and 81.1% for the forwarder.
- To verify the real impact of operational factors on long term machine performance, more detailed machine utilisation and machine productivity records will be required.

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More information

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