BULLETIN 17
May 2011

Bunching stems in steep slopes for efficient yarder extraction

Mauricio Acuna[1,2], Justin Skinnell[3], Rick Mitchell[1,4] and Tony Evanson[5]

[1]CRC for Forestry
[2]University of Tasmania
[3]Oregon State University
[4]WA Plantation Resources (WAPRES)
[5]SCION Research, New Zealand

Introduction

Forest harvesting operations worldwide are becoming increasingly mechanised. Advantages of mechanised felling include increased productivity compared with manual felling, the opportunity to bunch stems for more efficient extraction, and greater protection from physical harm for operators. Recent interest in Australia and New Zealand—and positive experiences elsewhere—in increasing mechanisation in steep terrain prompted this research trial to evaluate the potential of a self-levelling feller-buncher to improve the overall productivity and economics of a swing yarder. The main goal of the study was to determine the effect on productivity of the extraction by cable of bunched wood as opposed to unbunched wood.

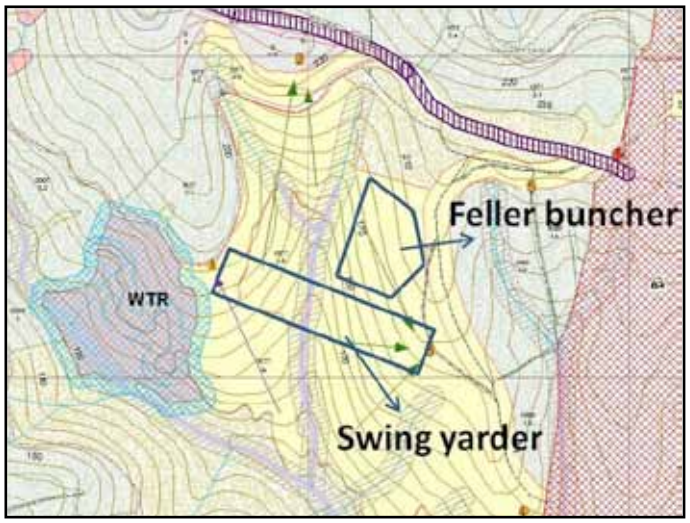

Figure 1. Study layout showing adjacent feller-buncher and swing yarder observation areas

Study description

The study site was located near Yarram, on the South Gippsland coast of Victoria, Australia. The stand was a 33-year-old radiata pine plantation of approximately 1065 trees per hectare with no notable understorey. The dry, sedimentary-based soils enabled good traction in the steep terrain. A feller-buncher with a self-levelling cab felled and bunched all trees except those adjacent to a nearby creek. These remaining trees were manually felled and consequently were not bunched. A 0.58 ha plot was laid out for observing the feller-buncher. In the feller-buncher plot, mean piece size was 0.8 m^3 and mean ground slope was 27°. The swing yarder was observed in an adjacent area of approximately 0.60 ha. This area crossed the creek, and therefore included both bunched and unbunched wood. Mean piece size was 0.81 m^3 in the bunched wood area and 0.87 m^3 in the unbunched area. The average yarding distance was 155 m (range 25–300 m) for the bunched wood and 195 m for the unbunched wood (range 150–240 m). Figure 1 indicates the layout of the study.

Figure 2. Feller-buncher (left); swing yarder (right)

This harvesting trial was conducted during final clearfelling of the site in August 2010. The harvesting system comprised a Valmet 445 EXL tracked self-levelling feller-buncher equipped with a Valmet 233 fixed felling head (chainsaw), a Madill 124 swing yarder and grapple, a Komatsu PC 300 excavator with a Waratah 622 processing head (for cutting stems into logs at the landing), a Hitachi 280LC excavator loader (for loading logs onto trucks), and a tail-hold excavator (to which the end of the yarder cable was attached). In this trial, detailed time and motion observations were limited to the feller-buncher and the swing yarder. (See Figure 2.)

Study results

Feller-buncher productivity

In total, 172 trees were felled and bunched per productive machine hour (PMH) (delay-free time). Figure 3 shows a productivity curve plotted to the observed feller-buncher productivity obtained in this study for a range of piece sizes. For piece size ranging from 0.1 to 1.3 m^3, productivity increased from 19.6 to 206.3 m^3/PMH. For an average piece size of 0.8 m^3, the model predicts feller-buncher productivity of 138 m^3/PMH.

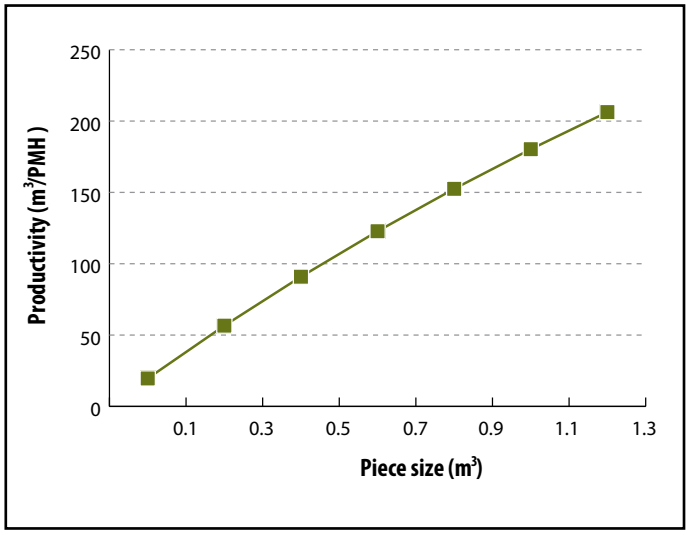

Figure 3. Feller-buncher productivity

This study confirmed that both time required for felling (cut-time) and bunching (swing-to-bunch time) increased with increasing diameter at breast height (DBH). Despite their size, the largest trees—around 50 cm DBH—did not appear to present any problems for the feller-buncher, which felled and bunched them using the same methods as for average-sized trees (31.5 cm DBH). The increased cycle time for larger trees was offset by the greater volume of wood obtained per cycle, and thus resulted in higher productivity.

In this study, the high stocking level of more than 1000 stems per hectare enabled a high ratio of trees to be felled per move-to-tree element (an average of 2.4 trees). Move-to-tree time was also affected by the bunch size required to match the grapple capacity. To enable maximum efficiency, the grapple should extract a complete bunch in each haul. Optimum bunch size in this study was anticipated to be four trees (varying from two to six trees depending on size), and the feller-buncher produced bunches with an average of 4.3 trees.

Swing yarder productivity

Data from 184 swing yarder haul cycles were collected and analysed. Of these haul cycles, 142 involved bunched trees and 42 involved unbunched trees. For an average of all cycles, the delay-free cycle time was 2.5 min. for an average distance of 155 m and a haul volume of 1.7 m^3. Delays shorter than 15 minutes accounted for 18.1% (84.1 min.) of the total time (465.6 min.). The results of the swing yarder time study (bunched and unbunched wood) for an average yarding distance of 180 m are presented in Table 1 (overleaf).

Table 1. Productivity measurements for bunched and unbunched wood hauled with the swing yarder

Performance measurements	Bunched wood	Unbunched* wood
Observed haul cycles	142	42
Average pieces per cycle	2.3	1.5
Average pieces per PMH	68.1	41.6
Average time per cycle (min.)	2.7	2.3
Cycles per PMH	21.9	26.1
Average volume per cycle** (m^3)	1.9	1.3
Average volume per PMH (m^3)	41.6	33.9

* All unbunched wood was manually felled

** Based on an average piece size of 0.81 m^3 for the bunched wood and 0.87 m^3 for the unbunched wood

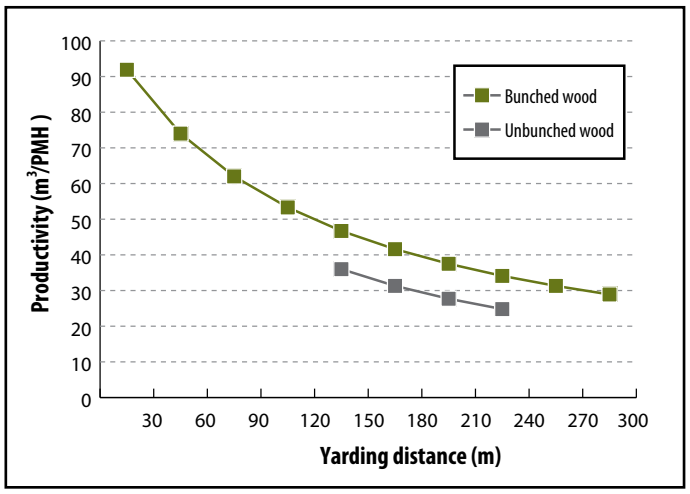

Figure 4. Swing yarder productivity curve (bunched and unbunched wood)

The mean volume per cycle for the swing yarder was 1.9 m^3 for the bunched wood and 1.3 m^3 for the unbunched wood. For a yarding distance range between 150 and 240 metres, this accounted for an average increase in productivity of 24% when bunching wood. Figure 4 shows the swing yarder productivity curve for bunched and unbunched wood. The increased productivity due to bunching was proportionately larger as the yarding distance increased. For example, for a yarding distance of 150 m, productivity increased 20%, while for a distance of 240 m, the increase in productivity was 27%.

The largest time difference per cycle between bunched and unbunched wood was in hooking logs. The bunches were easily visible and provided a larger and easier target for the yarder grapple operator, which reduced hook times for the bunched wood compared with the unbunched wood. Although the feller-buncher produced bunches with an average of 4.3 trees, only an average of 2.3 trees per cycle were hauled to the landing. This is mainly due to the holding capacity of the grapple and the need for the operator to maintain yarder productivity without spending excessive time hooking logs. Despite the discrepancy between the expected optimum bunch size and the actual bunch size able to be hooked, substantially more bunched trees were moved per cycle than the average of 1.5 trees for unbunched wood.

Take-home messages

- The results of this study indicate that in good clearfell conditions in steep terrain a tracked self-levelling feller-buncher can achieve a high rate of productivity (average 138 m^3/PMH).
- Bunching the felled trees substantially increased the productivity of the swing yarder (by an average of 24%), compared with hauling unbunched wood.

Organisations supporting this research

This study was undertaken in collaboration with Future Forest Research (New Zealand), and was supported by Hancock Victorian Plantations (HVP) and contractor ANC Forestry.

More information

CRC for Forestry website: **http://www.crcforestry.com.au/research/programme-three/index.html**

Project scientist: Mauricio Acuna: **Mauricio.Acuna@utas.edu.au**