Ups and Downs Associated with Implementing Shift Schedules on a Southern Harvesting Operation

Dana Mitchell[1]

Abstract

Extended working hours can increase the number of hours that equipment is available to perform work, but how effective are workers during those additional evening/night hours? A study was conducted in Alabama to compare daytime and nighttime production rates of a feller-buncher. The study was installed in a first thinning of a single-aged loblolly pine (Pinus taeda) plantation. A single operator was observed during both daylight and dark hours. Data indicates that the number of stems cut per accumulation was similar between the shifts. However, bunches created during the night shift were smaller than those created during the day and nighttime production was 8.4% less than daytime felling. Further research is needed on this whole harvesting system to determine machine interactions and system performance when implementing shift schedules.

Introduction

The use of extended working hours in the US is not widespread. Those that implement extended working hours cite a variety of considerations that impact their choice of work schedules. Some operate up to 24 hours per day during the winter months to maximize production while the ground is frozen and operable. Cold winter conditions encourage others to schedule more work hours in a day to avoid unproductive time warming engines and fluids. These are two practical responses for addressing environmental conditions through the use of extended working hours.

Extended working hours are also implemented to reduce equipment costs or to increase production. Increasing the scheduled number of working hours should result in increased daily production. Therefore, the cost per ton produced should decrease when these fixed costs are spread over a larger daily production amount.

The daily production increase may not directly reflect the increased scheduled work hours. In other words, the tons per hour produced during the nighttime hours may not be the same as the production rate observed during daytime hours. Ample evidence exists in literature that indicates that there are psychological, physiological and social impacts associated with working longer shifts, or at night (Mitchell et al, 2008). These impacts can result in decreased night shift production, but also in increased safety risks, higher employee turnover, and even increased health risks.

[1] Research Engineer, USDA Forest Service, Southern Research Station.521 Devall Drive, Auburn, AL, USA 36849. danamitchell@fs.fed.us

Production after dark is typically less than the production obtained during daylight hours. In their recent literature review, Murphy and Vanderberg (2007) found that night shift productivity is approximately 10% less than that of the day shift. Nicholls et al (2004) measured a 22% night shift production reduction for in harvester production in first thinnings. In this Australian study, different operators were assigned to each shift, and each shift included hours of daylight and darkness. In a more recent study, Petersons (2010) measured the productivity of a harvester operating in daylight and darkness in first commercial thinnings in Latvia. He found a 12% reduction in the production between daytime and nighttime hours. The harvester performed functions of felling, processing and sorting. The stands contained a mixture of species and trees were not in rows. The objective of this study was to quantify the productivity difference of a single feller-buncher operator working both daytime and nighttime hours in a planted southern pine plantation.

Study Site

The study site was located in Pike County, Alabama, approximately 18 miles from Troy, AL. The 125-acre bedded and planted loblolly pine (Pinus taeda) stand was owned by a large timber landowner. The stand was 15 years old at the time of harvest, and the prescription was a first thinning. To prepare for a nighttime harvest, the contractor chose to fell every fourth row during daylight hours and thin between these rows during the observation periods (day and night). Productivity was compared between day and night conditions with the operator performing the same thinning task.

Methodology

Data was collected, using 1/10 acre plots, to determine the average dbh and height of the trees in the study area. These data were used to determine the descriptive statistics for the study site. A biometric regression equation developed from similar stand data (Klepac, unpublished data) was used to determine the average stem weight based on stem data collected on the site. The study was installed on September 6, 2012. Sunset occurred at 7:02 pm Central Daylight Time (CDT).

Production data were collected on the felling operation during both daylight and dark hours. Data collected included stems per accumulation, accumulations per bunch, and stems per bunch. A stopwatch was used to gather time per accumulation data.

Results

The average stem was 8-inches dbh with a height of 55-feet. The average stem weight was estimated to be 668.26 lbs/tree.

The operator had over a year of experience on the feller-buncher and 24 years of operator experience. The TigerCat 845D was equipped with a standard lighting package with lights mounted on the front and sides of the cab. The cutting head was a shear. This feller-buncher is part of a harvesting system configured specifically to harvest young pine plantations for biomass (Jernigan et al, 2011).

The feller-buncher was observed for a total of 57 accumulation cycles for each shift type (day and night). A cycle was identified as the time it took for the boom to begin to ascend from setting down an accumulation until the boom began to ascend from the next accumulation. Day shift data collection began at 3:35 pm (CDT), and night shift data collection began at 7:56 pm (CDT). Gross time (including short delays) for the day observations was 2 hours, 10 minutes. Gross time for the night observations was 2 hours, 9 minutes. The average accumulation cycle time during the day shift was 2.29 minutes. The average cycle time per accumulation during the night shift was 2.26 minutes. There was no significant difference in the cycle time per accumulation by shift (α=.05, p-value = 0.9363).
The average stems per accumulation by shift differed by an average of 0.72 (Table 1). This difference was not statistically significant (α=.05, p-value = 0.146). The average accumulations per bunch, however, differed by 0.5 (Table 2). This difference was significant (α=.05, p-value = 0.0032).

Table 1. Stems per accumulation per shift

Shift	**N**	**Mean**	**Standard Deviation**
Day	57	7.1	3.1
Night	57	6.4	2.0

Table 2. Accumulations per bunch by shift

Shift	**N**	**Mean**	**Standard Deviation**
Day	28	2.0	0.7
Night	38	1.5	0.6

The operator created 28 bunches during the day shift and 38 during the night shift. The average number of stems per bunch during the day shift was 14.3, while the average during the night shift was 9.5. This difference in the number of stems per bunch was statistically significant (α=.05, p-value < 0.0001). This equates to the night shift operation placing 33.5% fewer stems per bunch than during the day shift.
Using the calculated average stem weight, the night shift produced 121 tons compared to 134 tons produced during the day shift. This translates to 61.55 tons/hr for the day shift, and 56.37 tons/hr for the night shift. Overall, findings indicate a shift difference of 8.4% fewer tons/hr produced during the night shift.

Discussion

While the entire harvesting system was not observed during this short study, we can make some inferences about the impacts of night logging on system productivity. The smaller bunches created during the night shift would potentially negatively impact the production of the skidder. The skidder may have to grapple more bunches to make a full payload, thus increasing the average intermediate travel time between bunches.

The silvicultural prescription of removing every fourth row was not a common prescription for this operator to implement. Removing every fourth row meant that there were three rows to thin between each removal row. The operator was familiar with odd-numbered row thinnings. With even-numbered thinning, the operator thinned two rows on one side and one on other side. While this awkward movement was the same during the day as after dark, it may result in lower overall production as compared to production in odd-numbered row thinnings. During both shifts, the operator would reach out to two rows on either side of the removal row to remove trees that may have been missed while working down the previous removal row.

The feller-buncher used in this study measures 11.1 feet wide. The counter-weight extends beyond the tracks, making it difficult to turn and maneuver in the row (Figure 1). Operationally, the steps required to turn the machine around with a full accumulation to place bunches behind were complex. The operator would set the full accumulator head between the residual trees, walk the track forward, then retract the head and swing the boom around to place the accumulation in a bunch behind the forward rate of progress. The machine was designed for clearcut harvesting, so the production observed in this study may have been negatively impacted by the silvicultural prescription and planting spacing.

Figure 1. Maneuvering is difficult in narrow rows.

The machine did not have an additional lighting package nor any aftermarket lighting added. The operator suggested that lights pointing upward from the cab would have been useful during night felling to avoid hanging accumulated stems in the canopy of the residual stand. Upward pointing lights would have also aided in tree selection for form, as many of the trees in the stand were forked.

The cutting contract required low stumps. The design of the shear allowed the operator to ‘bump’ the head on the ground before shearing to keep stump heights low. This was made more difficult due to the bedding in the stand. However, the operator stated that he used the same technique to cut low stumps during both shifts.

In discussions with the operator at the end of the night shift, he mentioned that he would not want to work a night shift on a permanent basis. He often arrives to work before sunrise and works in the dark, but that is only on a personal-request situational basis and is not an assigned work schedule. When asked about the isolation of working at night, he responded that he prefers having another equipment operator on site. Even though he doesn’t work closely with the skidder operator, they are aware of each other’s presence and would check on each other for safety if they hadn’t had recent visual contact. In terms of safety, the operator mentioned that he prefers to stay within the safety of the equipment cab at night.

Summary

In this study, the production rate of the feller-buncher during the night shift was 8.4% lower than that of the day shift. However, the production differences were not similar for all feller-buncher functions. The average accumulation cycle time was not different between shifts. In addition, the average number of stems per accumulation did not differ based on shift. The number of accumulations per bunch was found to be significantly different between shifts, which resulted in smaller bunches created during the night shift. These smaller bunches may impact the productivity of the skidding component which was not included in this study.
This short study provides some insight into the impacts of felling trees after dark. Further research is needed on a whole harvesting system to determine machine interactions and system performance when implementing shift schedules.

Acknowledgements

This work was partially funded by the Department of Energy under agreement 10-CO-11330132-088. The authors would also like to thank Corley Land Services for their cooperation with this project.

References

Jernigan, P.; Gallagher,T.; Mitchell, D; Teeter, L. 2011. High Tonnage Forest Biomass Production Systems From Southern Pine Energy Plantations. In: Proceedings of the 34th Council on Forest Engineering annual meeting, Quebec City, Quebec, Canada, June 2011. 6p.

Nicholls, A., L. Bren, and N. Humphreys. 2004. Harvester productivity and operator fatigue: working extended hours. International Journal of Forest Engineering 15(2): 57-65.

Mitchell, D.L., T. V. Gallagher and R. E. Thomas. 2008 The Human Factors of Implementing Shift Work in Logging Operations. JASH 14(4): 391-404.

Murphy, G. and M. Vanderberg. 2007. Modelling the economics of extended shift and 24/7 forest harvesting. NZ Journal of Forestry, August 2007, pp 15-19.

J. Petersons. 2010. Factors affecting harvester productivity in forest thinning in Latvia. In: 16th Annual International Scientific Conference: Research for Rural Development, Jelgava Latvia, May 19-21, 2010: p. 183-187.