Cost of integrated harvesting of small-diameter tree dominated stand using two apportioning methods

Libin T. Louis[1] & Anil Raj Kizha[2]
School of Forest Resources, University of Maine, Orono, USA
[1]libin.thaikkattil@maine.edu, [2]anil.kizha@maine.edu

Introduction

Small-diameter trees (SDT, diameter at breast height less than 15 cm) is a major concern for any forest managerial activities in northeastern America. Integrated timber harvesting is a common harvest technique to simultaneously generate both sawlog and wood chips (from SDT). The cost of generating wood chips can be estimated using various apportioning methods and could yield different total costs for the same case under different scenarios (Hudson et al., 1990; Puttock, 1995). This is primarily due to the silvicultural prescriptions and contracts prevailing for the specific harvest.

Objectives

1. To examine the cost and factors that influence the productivity of two major timber harvesting methods, i.e., hybrid cut-to-length (Hyb CTL) and whole-tree (WT)
2. To compare the cost of harvesting SDT and sawlog under two cost apportioning methods.

Methodology

The study was conducted on an industrial timberland property in Northern Maine, USA during the summer of 2018 (Fig. 1). SDT and other woody biomass (not meeting sawlog standards) generated from the WT treatment were sorted at the landing and comminuted to pulpwood quality chips. The total area of the harvest units was 60 ha. Detailed time and motion studies was conducted for all in-wood operational phases for both treatments. Machine rates (Miyata, 1980) and other related information were gathered from the logging contractors and timberland managing company.

Regression models were developed for determining the influence of dependent variables over the cycle times for each operational phase. Different apportioning methods such as joint product allocation (JPA), and by-product allocation (BPA) (Hudson et al., 1990), were utilized to calculate the cost of harvesting SDT and sawlog separately.

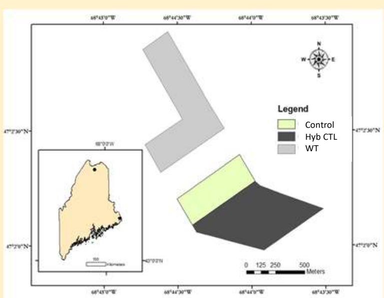

Figure 1. The location of study site in Maine, USA (bottom left) and the treatment units subjected to Whole-tree(WT) and Hybrid Cut-to-length (Hyb CTL) along with control.

Results

Table 1. Regression models developed for the operational phases in whole-tree (WT) and hybrid cut-to-length (Hyb CTL) along with their adjusted R^2 values, and number of observations (N).

Phases	Treatment	N	Adjusted R^2	Standardized models predicting DFC[1]
Felling	WT	390	0.34	DFC = 13.86 + 0.20 (distance between trees)*** + 9.26 (number of trees cut/cycle)***
	Hyb CTL	160	0.18	DFC = 17.70 + 0.34 (distance to bunch)*** + 4.40 (number of trees cut/cycle)**
Processing	WT	100	0.43	DFC = 2.19 + 0.07 (diameter)*** + 0.69 (softwood)***
	Hyb CTL	160	0.29	DFC = 2.94 - 0.18 (softwood)* + 0.23 (number of logs)***
Extraction	WT (skidder)	102	0.75	Log DFC = 4.08 + 0.03 (diameter) + 0.002 (travel loaded distance)*** + 0.04 (number of pieces)* + 0.005 (positioning distance)*
	Hyb CTL (forwarder)	104	Negative value	Model not significant
Chipping	WT	179	0.27	DFC = 3.71 + 1.26 (diameter)*** + 3.79 (number of trees)***
Loading	WT and Hyb CTL	63	0.32	Log DFC = 2.76 + 0.07 (diameter)***

Significance codes: '***' 0.001 '**' 0.01 '*' 0.05 ; [1] Delay-free cycle time

Table 2. Cost of operational phases in whole-tree (WT) and hybrid cut-to-length (Hyb CTL) in US$ m^{-3}.

Phase	WT	Hyb CTL
Felling	4.14	4.71
Processing	3.17	3.46
Extraction*	5.09	5.50
Loading	0.66	0.66
Total	13.06	14.33
Chipping	3.12	N/A

*Extraction for WT and Hyb CTL operations were skidding and forwarding, respectively.

Table 3. Cost of harvesting (stump-to-truck) sawlog and SDT (small-diameter trees, with a diameter at breast height below 15 cm) calculated using JPA (Joint product allocation) and BPA (by-product allocation) for the whole-tree treatment.

Apportioning method	Sawlog (US$ m^{-3})	SDT (US$ m^{-3})
JPA	8.45	7.73
BPA	13.06	3.12

- ❑ Machine movement significantly affected DFC for all operational phases (Table 1).
- ❑ The total cost of Hyb CTL was higher than that of WT (without considering the cost incurred from chipping) (Table 2).
- ❑ t-test on the scaling data showed that the average volume of a piece were similar for the Hyb CTL (0.30 m^3) and WT (0.32 m^3) treatment units (p = 0.32).
- ❑ Cost of harvesting SDT using JPA was (7.73 US$ m^{-3}) twice that of BPA (3.12 US$ m^{-3}) (Table 3).
- ❑ If SDT were further processed (delimbed), the total harvesting cost would have increased to 10.93 US$ m^{-3} (Kizha & Han, 2016).

Discussion

- ❑ Extraction was the most expensive harvesting phase for both WT and Hyb CTL
- ❑ Hyb CTL harvesting cost were higher than WT for all the operational phases.

Figure 2. Pulpwood quality chips produced and the Flail chipper used for the study.

- ❑ Cost of producing wood chips varied based on the apportioning method used.
- ❑ JPA is preferred to calculate the cost of harvesting SDT if there is high demand for woody biomass market.

Conclusion

SDT is an inevitable part of timber harvesting especially in early- and pre- commercial thinning operations where prevailing biomass markets determine the adoption of apportioning method (BPA or JPA). Estimating the cost of harvesting SDT is dependent on the landowners' objectives.

References

Hudson, J., Mitchell, C., Storry, P., 1990. Costing integrated harvesting systems. Proc. IEABA Task 6th Act. Integr. Harvest. Syst. 2, 46–52.
Kizha, A.R., Han, H.-S., 2016. Processing and sorting forest residues: Cost, productivity and managerial impacts. Biomass Bioenergy 93, 97–106. https://doi.org/10.1016/j.biombioe.2016.06.021
Miyata, E.S., 1980. Determining fixed and operation costs of logging equipment.
Puttock, G.D., 1995. Estimating cost for integrated harvesting and related forest management activities. Elsevier Sci. Ltd 8, 73–79.
Thiffault, E., Béchard, A., Paré, D., Allen, D., 2015. Recovery rate of harvest residues for bioenergy in boreal and temperate forests: A review. Wiley Interdiscip. Rev. Energy Environ. 4, 429–451. https://doi.org/10.1002/wene.157

Acknowledgement

We would like to express our gratitude to Harikrishnan Soman, Alex Kunnathu George, Ashish Alex, and Kevaughan Smith for assisting in various aspects of data collection and editing. We would also like to thank Brian Edward Roth, Stephen Dunham and Jenna Zukswert, University of Maine, Orono for support and help in various stages of the study. Our appreciation goes to all the foresters, contractors and machine operators associated with Irving Woodland LLC, Ashland, for their involvement in the operational aspect of the study.

Funding