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Efficiency of Topping Trees in Cable Yarding Operations

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Abstract

The extraction of biomass and nutrients out of the forest is implicit to every harvest operation. In cable yarding, whole-tree harvesting (WTH) has become more prevalent in the last few decades and processing takes place at the roadside. There is a concern that WTH impairs site productivity due to nutrient removal. One option to increase the amount of biomass remaining in the stand is to top the trees before extraction. In order to estimate the influence of topping on system productivity, time studies on a medium-sized tower yarder were carried out in three spruce dominated stands. Heart rate monitoring of the chainsaw operator was performed to examine the physiological workload. The analysis showed that topping only impacts system productivity if it takes place during the inhaul of the load as it leads to interruptions of the extraction progress. These interruptions took on average 13 seconds per turn. In addition, if topping was performed on already lifted trees, a reduction of line-speed during the lateral yarding of the loads was observed. This led to a reduction in productivity between 5 and 11%, assuming that all trees would have been topped during the lateral yarding process. Analyses of the physical workload of the chainsaw operator showed that the workload of topping trees is significantly lower than that of the felling process. Relative heart rate of the subject was lower at the cable corridors where topping was ordered. This confounding result may be a consequence of many additional factors like slope gradient or cycle time. Under both scenarios, the worker never surpassed the limit of a sustainable cardio-vascular workload for an 8 hour working day. Hence, recovery time for the chainsaw operator can be considered as adequate when topping is performed in a three-man crew.

Keywords: topping, cable yarding, productivity, workload

1. Introduction

Efficient harvesting in steep terrain is usually linked to cable based harvesting systems. The use of whole-tree harvesting (WTH) has become more common in Central Europe, mainly due to the technological development of boom-mounted processors. Heinimann et al. (2001) estimated that the use of a processor in cable logging results in cost savings of about 40% compared to motor-manual cut-to-length (CTL) systems.

The change from CTL to WTH leads to a shift of the delimbing process from within the forest to the roadside. This results in a greater removal of biomass and nutrients from the forest stand. The increased removal of the nutrient richest parts of the trees (needles and twigs) has raised concerns about the sustainability of WTH (e.g. Raulund-Rasmussen et al. 2008, Kaarakka et al. 2013, Tveite and Hanssen 2013).

One method to increase the amount of logging residues, remaining in the forest when using WTH, is to top the trees. Nutrient analyses show that young needles contain higher concentrations of most nutrients than older needles, branches or stem wood (Lick 1989). Hence, topping trees is an effective way to increase the amount of nutrients left in the stand as tops contain predominantly young needles and twigs. The advantage of this treatment is dependent on the topping diameter. On the one hand, the quantity of branch and needle residue is largely affected by the topping diameter, but on the other hand the selection of the topping diameter can be influenced by changes in price and demand of wood. The topping diameter may also affect the length of the stem section, which may influence optimal bucking and consequently impair the grade, and thus the value, of the resulting logs.

Motor-manual topping of trees in the forest stand using a chainsaw may increase the workload of the chainsaw operator. It is also likely that topping lowers productivity of the harvesting system, depending on the integration of topping into the working process. However, studies on the economical and ergonomic effects of motor-manual topping in cable logging are lacking.

The purpose of this study was to examine the impact of topping on the productivity of a tower yarder operating in thinning operations of Norway spruce (*Picea abies*). The effect of topping on the workload of the chainsaw operator was also investigated.

2. Materials and methods

2.1 Study site

The thinning experiments were set up in early autumn 2014 in three Norway spruce (*Picea abies*) dominated stands in the eastern part of the Austrian Alps. The three stands differ from each other both by their age and silvicultural pre-treatment (Table 1). At the 34 year old study site »Bairhübl«, no prior thinning had been performed. As a consequence this stand is characterized by a high number of stems (1667 stems/ha) in comparison with the 38 year old study site »Bergtal« (979 stems/ha), which had been thinned once in the thicket-life stage. The third stand »Klommegger« represents a 58 year old stand that had been thinned once. All three stands were considered to be in need of thinning. The slope gradient of the three study sites ranged from 50 to 80%.

2.2 Experimental design

The thinning harvesting operation was performed using a truck-mounted »Wanderfalke« yarder, developed by the company »Mayr-Melnhof«, extracting whole trees uphill to the forest road. The tower yarder was equipped with a Mayr-Melnhof Sherpa U3.0 carriage with a maximum load capacity of 3 tons. At the roadside, processing was done using a Woody H50 processor developed by »Konrad Forsttechnik«. The tower yarder worked in a three-line gravity system, where the third cable (haulback line) is used to pull slack on the mainline.

The crew, consisting of one yarder operator, one choker setter and one chainsaw operator, was constant over the whole experimental period. No job rotation occurred between the workers. At the study site »Bairhübl«, the choker-setter was replaced by another one at the second cable corridor.

During the operation, the chainsaw operator felled a few trees (ca. 5–15) in advance so that the choker-

Table 1 Site and stand characteristics of experiments

Parameter	»Klommegger«		»Bergtal«		»Bairhübl«	
	Corridor 1	Corridor 2	Corridor 1	Corridor 2	Corridor 1	Corridor 2
Coordinates (position of the yarder at corridor 1)	47°19'33.1"N, 15°19'16.6"E 845 m		47°20'13.3"N, 15°20'51.9"E 628 m		47°19'11.1"N, 15°20'31.4"E 822 m	
Operation type	Second thinning		First thinning		First thinning	
Previous operation	First thinning		Cleaning		-	
Number of trees before operation, stems/ha	728		979		1667	
Number of trees after operation, stems/ha	320		454		500	
Average DBH before operation, cm	29.3		18.2		15.5	
Average DBH after operation, cm	35.0		20.5		20.0	
Treatment	Without topping	Topping	Without topping	Topping	Without topping	Topping
Length of cable corridor, m	170	170	240	255	110	140
Average inclination, %	54	51	60	62	68	71
Average piece volume, m^3	0.67	0.61	0.19	0.21	0.16	0.19
Average number of trees per load	1.69	1.69	2.15	2.12	2.63	2.44

setter was not hindered in his job. Another advantage of this working method is that it helps the choker-setter to make an optimum load because he is able to choose between different stems to hook on.

At each study site, two cable corridors were analyzed. At the first corridor, full trees including branches and tops were extracted uphill to the roadside. At the second corridor, all trees were topped by the chainsaw operator at a diameter of approximately 6 cm.

Topping was usually performed during the lateral yarding process before the trees were fully pulled up to the skyline (Fig. 1), which led to an interruption in the extraction progress. During this delay period, the chainsaw operator moved to the head of the trees and topped them. The extraction process continued when the worker was standing in a safe position. This procedure provides the only way to top hung-up trees in the forest stand, but was also applied to facilitate the work of the chainsaw operator. In some cases, at the convenience of the chainsaw operator, trees were topped before the chokers were set.

Fig. 1 Topping of an already lifted tree during lateral yarding process

Table 2 Work task definitions used in three time studies

Cable yarding system	
Outhaul	Carriage movement from the landing to the choker-setter
Hook-on	Starts when the rigging is lowered (carriage positioning is included) and ends when the load reaches the carriage
Inhaul	Carriage movement from the stand to the landing
Grounding the load	Time of lowering the rigging and positioning the load at the landing
Unhooking the load	Starts when the yarder-operator gets off his seat to detach the chain strops and ends when he takes a seat in the cab
Raise rigging at landing	Time to raise the rigging until it reaches the carriage
Waiting	Operational delay time
Choker-setter	
Lower rigging	Time to spool out the mainline until the worker grabs it
Hook-on	Required time to move to the trees, to attach strops to them and to retreat to a safe position afterwards
Break-out	Time to raise the load and pre-extract it to the cable line until it reaches the carriage
Waiting during topping	Time the working progress of the choker-setter is interrupted by topping trees
Waiting	Operational delay time within which the choker setter is both waiting for the carriage and planning the next load
Chainsaw operator	
Felling	Time to fell a tree (including the steps: select and assess trees, clear vegetation around the base, felling the tree, observe tree fall)
Topping	Time to move to the trees and to top them
Other PSH_0	Other activities like crosscutting or fueling the chainsaw
Waiting	Operational delay times within the chainsaw operator is hindered by the choker-setter
General work tasks used in all three studies	
Delays<15 min	Delays shorter than 15 minutes
Delays>15 min	Delays longer than 15 minutes

2.3 Time studies

In order to record process variables that may influence time or system productivity, all trees of each study site were recorded according to tree species and *DBH* (diameter at 130 cm height). The associated heights were measured randomly using a sample of at least 20 heights per tree species and stand. To allocate each felled tree to a specific extraction process, all trees were numbered consecutively using aerosol cans. To estimate the extraction distance of each load in the field, the distance to the landing was measured along the cable corridor and marked on some residual stand trees next to the corridor.

Time studies were performed to illustrate the effect of topping on system productivity. Data collections were carried out using three mobile tablet PCs »ALGIZ 7« running in a Windows 7® environment, using a continuous timing method. To analyze the time of each working process, the working cycle of each crew-member was split into several functional elements (Table 2). Parallel to the time consumption measurements, the number of each harvested tree, as well as the extraction distance, was noted during the observation of the choker setter.

2.4 Physiological measurements

The workload of the chainsaw operator was estimated based on heart rate measurements because direct measurement methods, such as the maximum oxygen uptake of a worker ($VO_{2\ max}$), are difficult to obtain under field conditions (Kirk and Sullman 2001). The heart rate of the subject was measured at 1 sec intervals for the entire working time using a Polar RS800 running computer. The computer consists of a heartbeat-capturing transmitting unit and a receiver-storage unit. Before data collection, the transmitter is attached to a strap and secured around the subject's chest just below the chest muscles. The transmitter sends the heart rate signal directly to the running computer, which displays and records the data. The use of sport heart rate monitors has already been proved successfully in several ergonomic studies (Vogelaere et al. 1986, Stampfer et al. 2010, Magagnotti and Spinelli 2012).

At the start of each working day, the heart rate monitor was attached to the chainsaw operator and started simultaneously with the time study software on the hand-held field computer »ALGIZ 7« in order to be able to merge the working heart rate (HR_w) data set with the time study data set. The resting heart rate (HR_r) was obtained for the subject upon arrival at the work site. Therefore, the chainsaw operator was asked to remain seated inside the car without moving, drinking or smoking for a minimum of 10 min. The minimum heart rate within this time period was selected as his resting heart rate. The maximum heart rate (HR_{max}) was estimated by using the standard formula (Rodahl 1989):

$$HR_{max} = 220 - Age \quad (1)$$

Relative heart rate at work (% *HRR*) was determined by applying the following equation (Rodahl 1989, Apud 1989):

$$\% HRR = \frac{HR_w - HR_r}{HR_{max} - HR_r} \times 100 \quad (2)$$

Where:

% *HRR* relative heart rate at work;
HR_w heart rate at work;
HR_r heart rate at rest;
HR_{max} maximum heart rate.

In total, 28 hours of chainsaw operator heart-rate data were collected. The pre-work resting heart rate of the 32 year old subject was 55 bt./min.

2.5 Statistical analysis

Height curves were computed for each stand using the *DBH* as independent variable, with *b* being the coefficient and *a* being the constant:

$$ln(h - 1.3) = a + b \times \frac{1}{DBH} \quad (3)$$

The height of each tree was predicted from the tree height calculated by the height curve, and the volume was calculated using the cubing formulas according to Pollanschütz (1974).

Former productivity studies on tower yarders (e.g. Stampfer 2002, Stampfer et al. 2010, Talbot et al. 2014) showed that the mean piece volumes, extraction distance and harvesting intensity are the main factors influencing system productivity. The following productivity hypothesis is used in this study:

Yarding productivity = f (mean volume per piece (tree vol), Extraction distance (dist), cutting intensity (int), Slope gradient (grad), topping)

As some of these variables only influence parts of the extraction cycle, the productivity of the harvesting system (m^3/PSH_{15}) was determined by calculating individual efficiency models of the main elements of the extraction cycle (cp. Nurminen 2006):

$$Prod_{yarder} = \frac{60}{c \times (eff_{hook\text{-}on} + eff_{carriage} + eff_{landing})} \quad (4)$$

Table 3 *Variables used to describe yarding productivity*

Factors	Topping	(0) Without topping; (1) With topping	2 levels
Covariates	Mean volume per piece	Mean tree volume per load	m^3
	Extraction distance	Distance between tower yarder and stopping position of the carriage	m
	Cutting intensity	Removed fraction of volume in a defined area during harvest operation	%
	Slope gradient	Slope steepness within a defined area	%

Table 3 gives an overview of the variables used to calculate the productivity of the harvesting system.

The hook-on phase involves all activities at the felling site, starting with lowering the rigging and ending with the completed lateral inhaul of the load, and the carriage phase comprises the inhaul and outhaul of the carriage. All working tasks at the landing, including grounding and unhooking the load as well as raising the rigging, are summarized in the landing phase. In order to include delays of up to 15 minutes in the model, a conversion factor (c) of 1.3 was used.

Analysis of variance was used to analyze the influence of co-variables and factors, including analysis of interactions between the variables (Stampfer 2002). Due to the nonlinear relationship between the average tree volume and efficiency, the co-variable »average tree volume per cycle« was transformed using power functions. The suitability of the exponents was evaluated by the coefficient of determination and the distribution of the residuals. In order to estimate the coefficients of the variables used in the models, regression analysis was made.

ANOVA techniques were used to check the statistical differences between the different study sites and treatments. All analyses were carried out using both Microsoft® Excel 2013 and PASW 18.0 for Windows.

3. Results

3.1 Productivity analysis

Interruptions of the working process, which occurred when trees were topped during the lateral inhaul of the load, took on average 12.65±6.68 seconds (Fig. 2) and were significantly higher (Tukey-HSD, p=0.0236) at the first thinning stand »Bairhübl« (14.11±7.49 sec) than at the second thinning stand »Klommegger« (11.05±5.95 sec). The expenditure of time for topping the trees at the study site »Bergtal« was on average 12.05±5.98 seconds and did not differ significantly from the other two stands.

The study also showed that breaking out a load takes more time when topping takes place during the lateral yarding process, even if the interruption times due to topping the trees are not included. This average prolongation of the break-out process, not including any interruption times during this phase, was greatest at »Bergtal« (23.79%), followed by »Klommegger« (15.74%) and »Bairhübl« (11.89%).

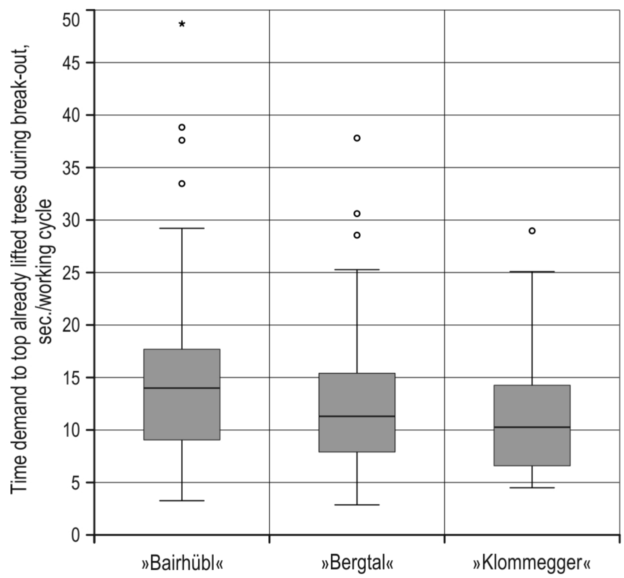

Fig. 2 Delay durations resulting from topping trees during the lateral yarding phase

Topping the trees during the lateral yarding process was mainly performed at the first thinning stands due to a high number of hang ups. Interruptions due to topping trees occurred in 69.17% (»Bairhübl«) and 65.99% (»Bergtal«) of the extraction cycles. In the other cases, the trees were topped before they were attached. In contrast to the first thinning stands, at the study site »Klommegger« only 44.44% of the loads were topped during the break-out task. This result is directly linked to a high number of broken stems during felling, which resulted in fewer trees that had to be topped. At »Klommegger«, 42.20% of the felled trees broke during the felling and extraction operation at an average diameter of 9.77±3.74 cm. At the other two sites, tree breakage occurred less frequently, being more frequent at »Bergtal« (16.60%) than at »Bairhübl« (1.55%). At these two stands, the average size of the broken pieces was 5.02±1.78 cm and 6.50±3.32 cm, respectively, for »Bergtal« and »Bairhübl«.

Based on the chronometry data of 692 cycles and inventory data, efficiency models (min/m^3) for the main elements of the extraction cycle were calculated:

$$eff_{\text{hook-on}} = \beta_1 \times tree\ volume^{-0.9} + \beta_2 \times inc + \beta_3 \times topping$$

$$[R^2_{\text{adj.}} = 0.87;\ F\ (3{,}689) = 1571.55,\ p<0.001] \quad (5)$$

$$eff_{\text{carriage}} = \beta_1 \times tree\ volume^{-0.9} + \beta_2 \times inc + \beta_3 \times dist$$

$$[R^2_{\text{adj.}} = 0.79;\ F\ (3{,}688) = 882.31,\ p<0{,}001] \quad (6)$$

$$eff_{\text{landing}} = \beta_1 \times tree\ volume^{-0.9}$$

$$[R^2_{\text{adj.}} = 0.77;\ F\ (1{,}689) = 2332.61,\ p<0{,}001] \quad (7)$$

Regression results for the efficiency models are reported in Table 4.

The average tree volume per load (tree volume) influenced significantly the efficiency of all three cycle elements. During both the hook-on phase and the carriage phase the slope gradient played a significant role. The equations show that a higher inclination (inc) influences the efficiency (min/m^3) of the hook-on phase in a positive way, and of the carriage phase in a negative way. Topping the trees during the extraction process (topping) only affects the efficiency of the hook-on phase, while the extraction distance (dist) had a significant influence on the efficiency of the carriage phase.

The overall mean values of the variables (Table 3) were used to calculate productivity models (Fig. 3) of the logging systems using treatments with and without topping the trees, as a function of the average tree volume. According to the productivity model, topping leads to a decrease of the average system productivity

Table 4 Regression model parameters for the extraction cycle elements

	Hook-on phase			Carriage phase			Landing phase
	$ß_1$	$ß_2$	$ß_3$	$ß_1$	$ß_2$	$ß_3$	$ß_1$
Coefficients	0.84	0.01	0.50	0.60	-0.01	0.01	0.38
Standard error	0.03	0.00	0.16	0.03	0.00	0.00	0.01
t-stat	27.01	4.48	3.21	21.28	-3.15	8.71	48.30
p-value	<.001	<.001	.001	<.001	.002	<.001	<.001

Table 5 Comparison of relative heart rate, *DBH* of felled trees and number of felled trees per minute within the felling task. Interruptions >15 min. are not included

Results for		Without topping trees	With topping trees	*p* value[a]
»Klommegger«	% *HRR*	26.71	23.43	<.001
	Av. *DBH* of felled trees	24.44	24.53	.895
	Felled trees/min. felling time	1.73	1.36	.001
»Bergtal«	% *HRR*	27.79	27.51	.001
	Av. *DBH* of felled trees	15.96	16.35	.308
	Felled trees/min. felling time	2.04	1.84	.119
»Bairhübl«	% *HRR*	35.26	31.91	<.001
	Av. *DBH* of felled trees	11.98	15.45	<.001
	Felled trees/min. felling time	4.52	2.57	<.001

[a] Statistical significance for the equality of treatment means

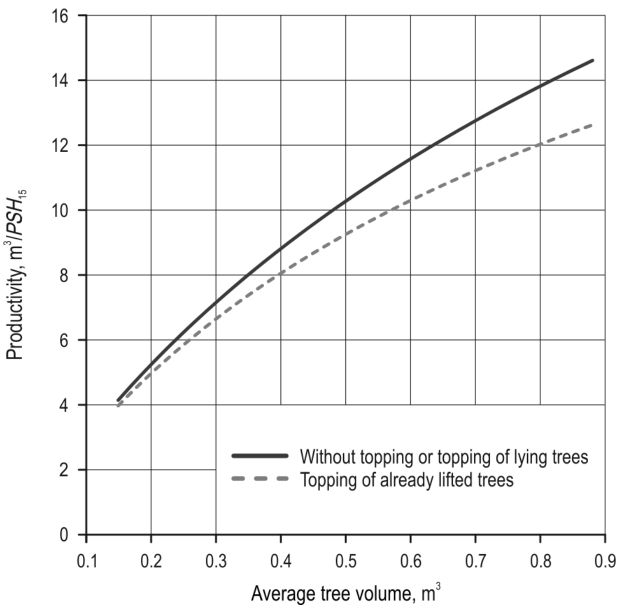

Fig. 3 Productivity of cable yarding system depending on tree volume and integration of topping into the working process

from 5.25 m^3/PSH_{15} to 4.97 m^3/PSH_{15} (-5.36%) and from 4.78 m^3/PSH_{15} to 4.54 m^3/PSH_{15} (-4.90%), respectively, for »Bergtal« and »Bairhübl«, assuming that all trees would have been topped during the lateral yarding phase. At »Klommegger«, topping all trees after attaching them to the mainline would reduce the productivity from 11.92 m^3/PSH_{15} to 10.56 m^3/PSH_{15} (-11.39%). However, productivity loss due to topping was much smaller because of tree breakage and numerous trees that had been topped before they got hooked on. Considering these factors, topping trees decreased system productivity in fact to 4.62 m^3/PSH_{15} (-3.39%), 5.06 m^3/PSH_{15} (-3.54%) and 11.32 m^3/PSH_{15} (-5.06%), respectively, at »Bairhübl«, »Bergtal« and »Klommegger«.

It is very likely that topping trees not only affects system productivity, which results in higher harvesting costs, but also increases the workload of the chainsaw operator. Hence, the time of each work phase was determined for the chainsaw operator (Fig. 4). The diagram illustrates that felling trees was the longest work task within the working cycle consuming 30 to 45% of the entire working time. At the cable corridors where topping was required, it took the chainsaw operator between 4.76% (»Klommegger«) and 8.59%

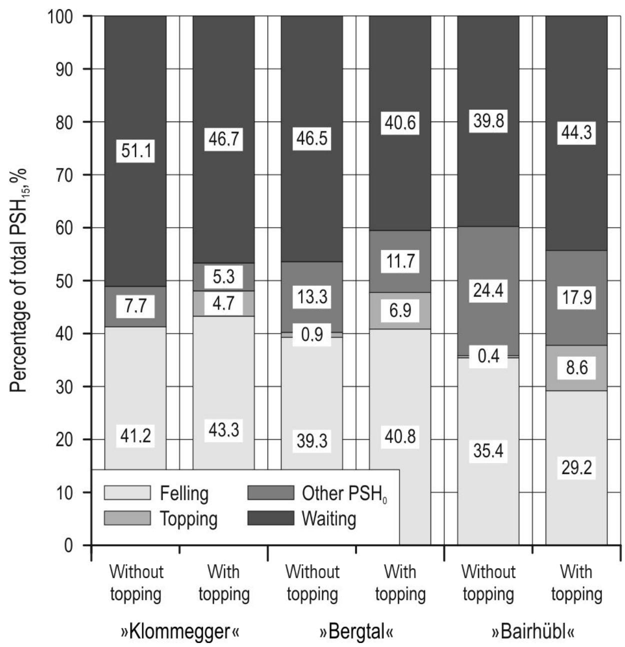

Fig. 4 Time consumption of different working tasks of the chainsaw operator

Table 6 Relative heart rate (*%HRR*) by working tasks at different study sites and treatments. Pairwise comparisons were performed, and different statistically significant means ($p<0.05$) were marked with different letters

Study site	Treatment	Felling	Topping	Other PSH_0	Operational delays	Delays >15 min	*F* value	*p* value[a]
»Klommegger«	With topping	23.55a	21.9b	22.47b	22.69b	22.57b	17.90	<.001
	Without topping	28.25a	-	27.99a	28.09a	18.94b	792.05	<.001
»Bergtal«	With topping	28.73a	27.24b	27.39b	27.54b	24.15c	166.52	<.001
	Without topping	29.83a	-	30.33a	27.33b	18.32c	929.44	<.001
»Bairhübl«	With topping	34.30a	31.11b	33.64c	31.57b	26.34d	423.38	<.001
	Without topping	37.32a	-	37.00ab	36.96b	31.04c	1802.07	<.001

[a] Statistical significance for the equality of treatment means

(»Bairhübl«) of his working time (PSH_{15}) to top trees. The working task »other PSH_0« was mainly scrub-cleaning and was most time consuming at the first thinning stands, especially at »Bairhübl«, where no previous silvicultural treatment had been performed.

3.2 Heart rate analysis

Table 5 shows the relative heart rate of the chainsaw operator in conjunction with the average *DBH* of the felled trees and the average number of felled trees per minute within the felling task. The results are presented separately for the three study sites. Overall, the relative heart rate of the chainsaw operator was significantly lower at all three sites at the cable corridors where topping was performed. At the study site »Bairhübl«, the average *DBH* of the felled trees differed significantly between the two treatments. During the felling task, a significantly higher number of trees were felled by the chainsaw operator at study sites »Bairhübl« and »Klommegger«. However, the average resting heart rate never surpassed the 40% cardiovascular load mark, which is defined as the limit of a sustainable workload for an 8 hour working day (Stampfer 1996).

Table 6 shows the differences in relative heart rate between different work tasks of the chainsaw operator. The highest physiological workloads were measured during the felling task. At 50% of the cable corridors, relative heart rate of the felling task was significantly higher than at any other working task. No significant differences were observed between the working tasks topping and operational delays. Both work steps were characterized by significantly lower relative heart rates compared to the felling task.

4. Discussion

Topping seems to decrease system productivity only when it is performed during the break-out phase because the lateral yarding process has to be delayed. These interruptions took on average 12.65 seconds, and were longer at the first thinning stands than at the second thinning stand »Klommegger«. It seems to be very likely that these differences in time demand are directly associated with the number of trees per load. While at the study sites »Bairhübl« and »Bergtal«, an average load consisted of 2.52±0.78 and 2.14±0.86 stems, respectively, at »Klommegger« only 1.69±0.70 stems formed a load. If a load consists of more trees, it will take more time to top all the trees. Conversely, the average time to top a single tree will probably decrease if the load is formed by a higher number of stems.

The results show that the break-out phase is not only prolonged because of interruption times due to topping the trees. Also the time to spool in the mainline in order to pull the load to the carriage, not including any interruptions, required more time at all sites when trees were topped during the lateral yarding phase. It is very likely that factors like positioning the load next to the chainsaw operator or reducing the line speed to minimize hazards for the chainsaw operator may decrease the extraction speed.

At »Klommegger«, tree breakage was an important factor influencing the quantity of trees that had to be topped. In comparison to the other two study sites, the size of the broken pieces was much larger at Klommegger. This observation concurs well with Fitec (2000), reporting that trees usually break at 2/3 of their total height.

Topping trees during the break-out phase not only affects productivity and logging costs; it also poses hazards for the chainsaw operator. Partially suspended trees can have tension and compression forces within them that make the job of topping more difficult and dangerous. Unexpected release of stems or unplanned load movement during topping may also be a significant safety hazard for the worker.

Additionally, topping trees also influences the time consumption of the chainsaw operator, mainly by the need to walk longer distances. A large amount of broken or topped trees remaining at the forest site also affects the ease with which the workers can safely move at the cutover area. However, Fig. 3 shows that the operational delay times of the chainsaw operator was at least 40%. During this period he was mainly waiting until most of the felled trees were extracted by the choker-setter. Consequently, a large part of this period can be considered as recovery time.

Table 5 showed that an introduction of topping trees into the working process of the chainsaw operator resulted in a statistically significant reduction of relative heart rate, although topping was included as an additional work task into his working process. It is very likely that the reduced workload relates to the chainsaw operator working at a lower pace when topping was ordered, but also other factors like slope gradient or walking distances may have influenced the physical workload and covered other effects.

5. Conclusions

Topping can be a useful treatment to increase the amount of logging residues remaining at the forest site. When working with a three-man crew, this study showed a decrease in system productivity by only 3.4 to 5.1%. Consequently, the harvesting costs increase by approximately 1.00–2.50 €/m^3. Topping does affect the work time of the chainsaw operator. Especially in steep terrain, walking to the head of the trees to top them can be a time-consuming task. However, in this study, physiological workload measurements of the chainsaw operator showed that the average heart rate reserve never surpassed the endurance limit of performance at any working task. Therefore, recovery time for the chainsaw operator can be considered as adequate when working in a three-man crew.

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