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INVESTIGATION ON WORK TIME AND PRODUCTIVITY OF FOREST SKYLINE KOLLER K 300 IN OGRAZHDEN MOUNTAIN

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Abstract

The aim of the present investigation was to establish the duration of work time and productivity of a mobile forest skyline Koller K 300 in Ograzhden Mountain.The length of the studied road-track was 270 m and the transported wood was of Common beech (*Fagus sylvatica* L.). The terrain investigations were carried out with 107 work courses of loaded carriage for a period of four days. Each work course was divided into nine phases. It was established that most time was used for the work phase 'Motion of the loaded carriage to the landing site' similarly to other terrain investigations. The average productivity was 3.22 $m^3 \cdot h^{-1}$. The results indicate that with a proper organization the forest skyline Koller K 300 could yield very good productivity.

Key words: hauling distance, Koller K 300, load, productivity.

Introduction

After the structural changes in forest sector in Bulgaria that took place in 1998-1999 all activities concerning logging were transferred to private companies. This lead to total change of the work organization in the forest sector. Thirty forest skylines Koller K 300 imported in a course of 80 years, together with all available forest machinery went to private companies, too. Most companies do not fully utilize the capacity of the skylines they own because of requirements for the specific abilities for working, peculiarities of the exploitation and because of inadequately developed road infrastructure. The attempts for work with forest skyline Koller K 300 often did not provide satisfying results – frequent failure, low economic profitability, low productivity, as well as cases of staff injuries. Relatively good results were achieved only in regions with long-term traditions and trained workers. At the same time, some published results showed that the extraction of timber using sky-lines is more environmentally-friendly even than that using animal pulling power (Naghdi et al. 2009).

The investigations of sky-lines in Turkey showed that the productivity depends mainly on the length of hauling distance and the number of transported pieces in one stand (Senturk 2007, Çaliskan et al. 2005). It was pointed out that slope of the sky-line and weight of the carriages are also important factors affecting timber extraction process (Erdas and Eroglu 1999).

No such studies were carried out in Bulgaria during the last 20 years. German and Czech standards for planning of the

cost of lumbering were used, after being adapted to Bulgarian conditions (Markoff and Glushkov 2008).

Therefore, the objective of the present study was to investigate the working processes and reliability of the sky-line used in the forests of Bulgaria.

Materials and Methods

The investigation was carried out during the summer of 2009 on the territory of Parvomay Forest Service, Ograzhden Mountains. The cutting area was situated on a steep slope, at altitude 930 m a.s.l. Beech wood was subjected to harvest. The silvicultural system applied was uniform graduate felling, lightenning phase, with 25 % intensity. The volume marked for cutting was 210 m^3. All logs were transported by yarding lifting the timbers suspension positions.

The instruments used were digital chronometer, inclinometer, compass, and meter stand maps at scale 1:10 000. Management plans, silviculture plan and data related to harvesting activities were obtained from the State Forest service in the study area.

The working time was studied using the IUFRO WT 3.04.02 classification. Time was divided into 10 working periods totally, or phases of one work cycle. The time needed for extraction of timber of a definied load from cutting area to the upper station was considered as one full work cycle. One minute (60 seconds) was assumed to be 100 and all other calculations were done accordingly. The working phases for one cycle were as follows:

Y1 – Hauling back of empty carriage;

Y2 – Descending of empty hook;

Y3 – Pulling of hook to log and attaching of loads;

Y4 – Pulling of loaded hook to carriage;

Y5 – Moving of loaded carriage to landing site;

Y6 – Descending of loaded hook to ground;

Y7 – Unhooking the loads;

Y8 – Pulling backwards of empty hook;

Y9 – Nonworking time (covering spare and delay time of workers);

Yst – Total working time for each shift;

X1 m – Distance, of logs at the layout of the line;

X2 m – Distance of dragging loaded carriage with carriage rope;

V m^3 – Transported timber volume.

The tractor used for Koller K300 was Universal-651, produced in Romania. Detailed description is given in Table 1.

Results and Discussion

It was establishes that fan-shaped method was used in the cutting area as only the rope at the lower pillar was removed. The skyline was displaced in a small area above forest lorry road since carriageway road was used as loading platform. The tractor was positioned in parallel to the forest lorry road and road layout was positioned perpendicular to the road. Two pillars were used of the main line, 50 m and 270 m from the upper station, respectively. Standing alive trees were used as pillars. Supporting spars were put on height of 14 m for the upper pillar and of 16 m for down pillar. The average slope of the layout was 37 °.

The installation of the supporting spar from live pillar tree was a typical peculiarity of this skyline. In the most cases this

Table 1. Yarder specifications for forest skyline Koller K 300.

Model	K 300
Height of tower	7 m
Model of tractor	Universal-651
Engine	50 kW
Skyline length	350 m
diameter	16 mm
Mainline length	350 m
diameter	10 mm
Pull	18 kN
Speed	3.2 $m \cdot s^{-1}$

operation was done by worker with the help of special cats put on the shoes allowing climbing to certain height of the tree. In this case a ladder was done from split branches with diameter 0.05–0.07 m hammered with 4–5 nails to the stem of the respective tree at distance 0.7 m from each other. The advantage of such pillars is that the workers have a quick and easy approach to the supporting spar and can easily remove eventual damages springing up in the process of work. The greater charge of the time for doing such ladder can be pointed as fault in comparison with the standard method of work.

The team working with forest skyline Koller K 300 consisted of 4 people: a yarder operator of the skyline and a worker cutting the stem at defined length at the upper station; a worker attaching the stems in the cutting area and a worker who cuts and log at the down station. The worker who cut trees at the down station worked independently and did not participate in extraction of timber, with the exception of loading the lorry with firewood. His main role was cutting, trimming and logging of the timber needed for extraction during the relevant work day. Typical peculiarity was that cutting of trees was carried out only trough work phase **Y5: Moving of loaded carriage to landing site**. Woody wedges were used for directing of trees during of the cutting. In this way the danger of trees falling above the main line was minimized.

Besides forming the load the worker who attached the stems in the cutting area, trimmed the thin branches remaining on the stem, which was the reason for frequent stops during work phase **Y4: Pulling of loaded hook to carriage**. It increased the time of relevant working course and decreased the total productivity.

The worker who cut the stems at defined length at the upper station, unhooked loads from the carriage and logged stems for firewood and construction timber, which. These two timber types were stacked on different loading platforms. The construction timber was moved with forest skyline Koller K 300. Including these additional operations in working phase **Y7: Unhooking the loads** caused frequent stops for drawing out the extracted timber, because the small area of the used loading platforms contained only up to 50 m^3. In this case the lack of extra winch for arranging of the loading platform leads to decreasing of the total productivity of the skyline.

The yarder operator of the forest skyline Koller K 300 was the team leader. He drove the jeep and was responsible for the supply with fuel and lubricating oil. During the work he was dealing only with the skyline operation.

It should be pointed that the cutting area was situated 30 km from the village where the working team was living. In this way the travelling to the work place was taking up to 3 h and 45 min on average every day.

A total of 107 work cycles were measured during the investigation of the skyline work time. The results are given in Table 2.

Distribution of the work phases in the average work time was determined as Y3 > Y5> Y9 > Y7 > Y1 > Y4 > Y2 > Y6> Y8.

The work phase **Y3: Pulling of hook to log and attaching of loads** was the most time consuming. It was due to many factors but mainly to significant hauling distance, which was 33 m in average. Furthermore, the worker forming the load at the down station trimmed with axe the stems of already hooked stem sections. The steep terrain as well as the messy brushwood caused additional difficulties to the work of load formation. The operation **Y5: Moving of loaded carriage to landing sit** was taking significant amount of time, too. This phase depend mostly on the drawing out distance, in this case being between 150 m and 265 m. Different kinds of stops were included in the skyline in work phase **Y9: Nonworking time** (covering spare and delay time of workers) and they cannot be classified separately. The most frequent reason for this was catching of extracted loads to trunks and staying trees. The data about the productivity of the Koller K 300 Mobile Skyline are as follow: 0.60 $m^3 \cdot shift^{-1}$, 3.22 $m^3 \cdot shift^{-1}$ and 25.76 $m^3 \cdot shift^{-1}$.

The productivity of Koller K 300 Mobile Skyline can be defined as moderate. Our results are comparable with those published in Turkey – 4.9 $m^3 \cdot h^{-1}$ with 250 m drawing out distance (Senturk 2007).

Table 2. Work phases and their percentages in average shift time consumption.

Sledge Winch Skyline		Work Phases									
		Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Yst
Time consumption	s	64	14	187	54	138	5	84	5	107	659
	%	9.7	2.1	28.3	8.3	21.0	0.8	12.7	0.7	16.3	100

The correlation analysis aiming at determining the degree of relationships between different work phases, drawing out and hauling distance, and timber volume extracted through each course. The results are presented in Table 3.

Statistically significant correlation coefficients were established during the working phases: **Y1** correlated with **X2** (0.543)**, Y3** – with **X1** (0.461)**, Y4** – with **X1** (0.804) **and Y5** correlated with **X2** (0.473).

There were few significant correlations:

1. **Y1: Hauling back of empty carriage** moderately (0.543) correlated with **X2: Dragging distance** (expected value was close to 1). This result shows that the

Table 3. Correlation coefficients.

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9
X1	0.485	0.076	0.461	0.804	0.665	-0.133	0.158	-0.005	0.030
X2	0.543	0.181	0.405	0.428	0.473	-0.077	0.146	-0.145	0.053
V, m^3	0.104	0.129	-0.030	0.122	0.051	-0.094	-0.091	-0.050	0.020

operator could not control a carriage precisely all the time.

2. **Y3: Pulling of hook to log and attaching of loads** moderately (0.461) correlated with **X1: Load distance** (expected value was close to 1). This could happen because the load was not standardized, but there are a lot of other factors, so hypothesis should be defined more accurately. In order to minimize time period it is necessary to standardize timber heap. That includes: allocated worker(s) only for load preparation, cutting of boughs from logs, optimizing of log structures.

3. **Y4: Pulling of loaded hook to carriage** significantly (0.804) correlated with **X1: Load distance**. This result was expected and the practical aspect is establishment of timber heap near the skyline-bed. Using of special motor saw for trimming could be recommended for avoiding the periods of stay during the work phase**,** since a lot of time is lost for trimming. The worker forming the load should not deal with other kind of activity.

4. **Y5: Moving of loaded carriage to landing site** is average (0.473) correlated with **X2: Dragging distance** (expected was nearby 1). That shows that the operator could not control a carriage precisely all the time (same as point 1). In order to minimize time period **Y5** it is necessary to ensure fast and effective feedback information for skyline operator, which will provide him with opportunity for more precise carriage manipulation. That could be done with camera on the carriage and monitor on operator station.

5. Weak correlations between period times and timber capacity show their independence of current timber load. These results indicate that the time of one full work cycle was not influenced by the load volume.

6. In order to minimize time period **Y9: Nonworking time** (covering spare and delay time of workers) it is necessary to improve planning of activities and internal organization of people. That will increase the effective working time with the skyline.

Conclusions

1. Average productivity of skyline Koller K 300 in Ograzhden Mountain was 3.22 $m^3 \cdot h^{-1}$ for 33 m load distance and 230 m transportation distance.

2. To increase the productivity, time periods Y3 (28 %), Y5 (21 %), Y9 (16 %) and Y7 (13 %) should be minimized.

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