J. For. Res. 2: 199–202 (1997)

A Study on the Productivity and Cost of Cable Logging in Turkey[1]

H. Hulusi Acar* and Tetsuhiko Yoshimura**, [2]

*Faculty of Forestry, Karadeniz Technical University, Trabzon 61080, Turkey.
**Faculty of Agriculture, Kyoto University, Kyoto 606-01, Japan.

Tower yarders have recently been introduced to forestry in Turkey. Clarification of the productivity and cost of logging using the tower yarder is often requested because the cost for machinery is a significant factor in all calculations concerning mechanized operations. Machines are often extremely expensive compared with the low cost of labor in developing regions. In this study, a new logging system using a tower yarder was compared with a conventional system using a stationary yarder in terms of productivity and cost. The research was conducted in the northeast of Turkey, in 1989 and 1992. The productivity of the tower yarder and the stationary yarder was found to be 5.655 m^3/h and 5.002 m^3/h, respectively. Harvesting cost was analyzed based on observed productivity. The harvesting costs of the tower yarder and the stationary yarder were found to be 47,410 TL/m^3 and 17,553 TL/m^3, respectively. With the tower yarder, the machine cost reached 93.1 % of the harvesting cost while the machine cost using the stationary yarder reached 71.1%.

Key words: cost analysis, productivity, stationary yarder, tower yarder, Turkey

Recently, tower yarders have been imported and introduced to forestry in Turkey. Thus far, in Turkey, most harvesting has been carried out by manpower or by a stationary yarder. A tower yarder is mobile and efficient and requires less time and fewer hands for setup and removal compared with a stationary yarder. However, a tower yarder is rather expensive when the Turkish economy is taken into account. Generally, the assessment of cost for machinery is a significant part of all calculations concerning mechanized operations. This is particularly true in developing regions where machines are often extremely expensive and, due to low labor costs, the machine cost component will be very high, sometimes up to 80% of the total direct logging cost (FAO, 1974). Therefore, this study was done to clarify the productivity and cost of a tower yarder operation.

To obtain information on productivity, the research was conducted in 1989 and 1992. The harvesting cost was calculated based on observed productivity, and a comparison between the tower yarder and the stationary yarder operations were made.

Methods

1 Study area

The studied areas for the productivity of a tower yarder and a stationary yarder were in Borçka and Karçkal, respectively. These two areas belong to the Artvin province located in Northeast Turkey as shown in Fig. 1. The total area of Artvin province is 712,882 ha, and 55% of this area is covered with forests. The major species are *Picea orientalis* and *Fagus orientalis*. Annual production is about 400,000 m^3 including bark, and forestry is the major industry. Forest road density is 6.78 m/ha.

In Borçka, the yarding area was 25 ha and the average slope was 60%. Harvested trees were 90-year-old *Fagus orientalis* in a natural forest. In Karçkal, the yarding area was 160 ha and the average slope was 32%. Harvested trees were 80-year-old *Picea orientalis* in a natural forest.

2 Harvesting

For the study in Borçka, 19 trees were harvested, with a total volume of 20.9 m^3. The tower yarder used was URUS MIII, whose specifications are shown in Table 1. The span was 400 m and the yarding distance was 250 m. Figure 2 shows the yarding system using URUS MIII. The cable system was a gravity system, which was used for the uphill yarding. The carriage used was made by Koller and had a self-locking mechanism. The total number of workers operating the system was six; one to operate the tower yarder, three for loading and the remaining two for unloading.

In Karçkal, 39 trees were harvested, with a volume of 67.0 m^3. The yarder used here was Gantner USW 60D, which is stationary. Specifications are shown in Table 1. Both span and yarding distance were 900 m. Figure 3 shows the yarding system using Gantner USW 60D. The cable system used here was a gravity system and yarding was downhill. The carriage used was the same as in URUS MIII. This system required five workers; one was the yarder operator, two did the loading and two the unloading. In Turkey, these two yarding systems are very popular and typical.

3 Productivity and cost

To clarify productivity, we carried out a time study of both systems. Harvesting cost was calculated based on observed productivity. We considered the harvesting cost as the sum of machine, labor and material costs.

Machine cost was calculated referring to the method of FAO (1974) using the following equations:

$$D = A \times (1 - S/100) / Y \qquad (1)$$

$$I = A \times 0.60 \times R_1 / 100 \qquad (2)$$

$$N = A \times R_2 / 100 \qquad (3)$$

$$M = M_1 + M_2 \qquad (4)$$

where D is depreciation (TL/year); A is the acquisition cost of the machine (TL); S is the salvage value allowance of the

[1] A part of this paper was orally presented at the 3rd Annual Meeting of the Japan Forest Engineering Society (1996).
[2] Corresponding author.

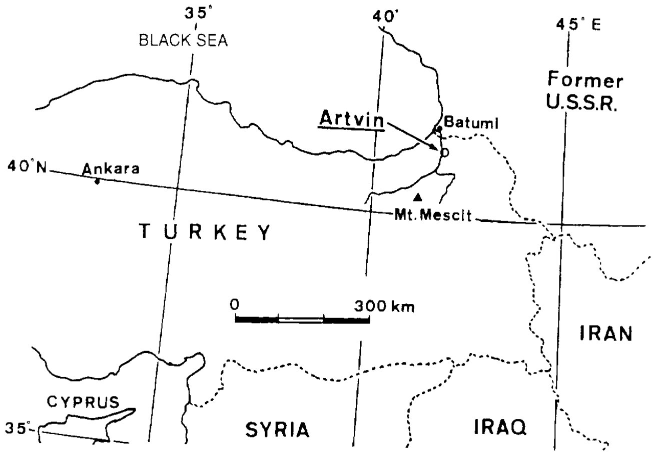

Fig. 1 Study area (Artivin province, Turkey).

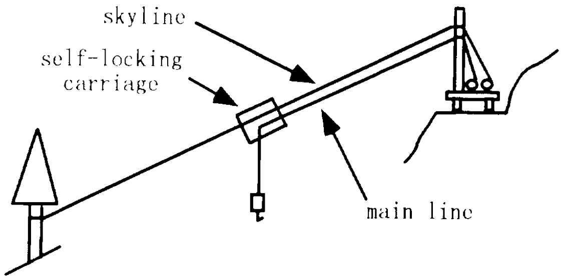

Fig. 2 Harvesting system using tower yarder (URUS MIII).

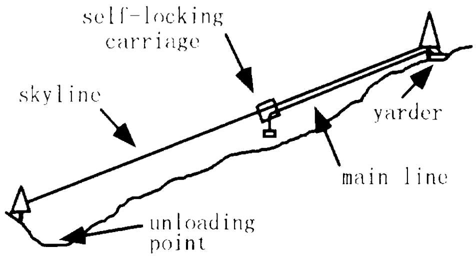

Fig. 3 Harvesting system using stationary yarder (Gantner USW 60D).

machine (%); Y is the life span of the machine (year); I is the interest cost (TL/year); N is the insurance cost (TL/year); R_1 is the interest rate (%); R_2 is the insurance rate (%). TL is the unit of Turkish currency and 2,600 TL is equivalent to 1 US$ in 1990. In Eq.(2), the annual interest cost is calculated by considering 60% of the acquisition cost to be the average capital tied up. In Eq.(4), M is the repair and maintenance cost (TL/year). In this equation, M_1 and M_2 are expressed by the following equations:

$$M_1 = D \times 0.40 \quad (5)$$

$$M_2 = 0.03 \times D \times W / 100 \quad (6)$$

where is M_1 is the fixed part of the repair and maintenance costs (TL/year); M_2 is the utilization-dependent part of such cost (TL/year); and W is the hours of operation (h/year). A certain portion of this cost is more or less unaffected by the degree of utilization, and this portion is estimated at 40% of the annual depreciation. The remaining portion depends on the degree of utilization and is assumed to be 3% of the

Table 1 Specifications of yarders.

URUS MIII	
Base machine	Mercedes 1500T
Weight (kgf)	8500
Rate output (PS)	75−116
Height of tower (m)	8.7
Maximum number of drums equipped	3
Maximum cable speed (m/s)	6
Skyline (ø mm × m)	22 × 650
Main line (ø mm × m)	12 × 650
Haulback line (ø mm × m)	12 × 1300
guyline (ø mm × m)	16 × 50
Gantner USW 60D	
Overall length (mm)	2500
Overall width (mm)	1900
Overall height (mm)	1200
Weight (kg)	1630
Rate output (PS)	60
Number of drums	1
Maximum cable speed (m/s)	8.5
Drum capacity (ø mm × m)	12 × 2000

annual depreciation per 100 working hours. Consequently, the machine cost per year X (TL/year) is obtained as follows:

$$X = D + I + N + M \quad (7)$$

Finally, machine cost per volume C (TL/m^3) is obtained as follows:

$$C = X / W / P \quad (8)$$

where P is the observed productivity (m^3/h).

Labor cost is calculated as the total wages of a yarder operator and logging workers who are also engaged in the setup and removal of the cable system. Labor cost L (TL/m^3) is expressed as follows:

$$L = L_1 + L_2 + L_3 \quad (9)$$

where L_1 indicates wages of logging workers (TL/m^3); L_2 indicates wages of workers for the setup (TL/m^3); L_3 indicates wages of workers for the removal (TL/m^3). At first, L_1 is calculated as follows:

$$L_1 = T_1 / E / P \quad (10)$$

where T_1 is the total wages of logging workers per day (TL/day); E is work hours for logging per day (h/day). Next, L_2 is calculated as follows:

$$L_2 = T_2 / F \quad (11)$$

where T_2 is the total wages of setup workers per day (TL/day); F is the total production per setup (m^3/setup). It is known that one sixth of the labor cost for the setup is needed for removal in Turkey (Acar, 1990). Thus, L_3 is calculated as follows:

$$L_3 = L_2 / 6 \quad (12)$$

Material cost is calculated as the total cost of fuel, oil and cables. Material cost G (TL/m^3) is expressed as follows:

$$G = G_1 + G_2 + G_3 \quad (13)$$

where G_1 indicates fuel cost (TL/m^3); G_2 indicates oil cost (TL/m^3); G_3 indicates cable cost (TL/m^3). At first, G_1 is calculated as follows:

$$G_1 = H / P \quad (14)$$

where H is fuel cost per hour (TL/h). It is also known that 23% of fuel cost corresponds to oil costs in Turkey (Acar, 1990). Thus, G_2 is calculated as follows:

$$G_2 = G_1 \times 0.23 \quad (15)$$

Next, G_3 is calculated as follows:

$$G_3 = Q_1 / J_1 + Q_2 / J_2 + Q_3 / J_3 \quad (16)$$

where Q_1, Q_2 and Q_3 are the prices of skyline, main line and guyline, respectively (TL); J_1, J_2 and J_3 are life spans of skyline, main line and guyline, respectively (m^3).

Finally, the harvesting cost K (TL/m^3) is obtained as follows:

$$K = C + L + G \quad (17)$$

The method employed is a simplified method, which is, however, accurate enough to compare the harvesting cost and its structure between a tower yarder and a stationary yarder.

Results

1 Productivity

The result of the time study is shown in Fig. 4. According to this figure, unloading and running the carriage downward in the URUS MIII takes much less time than with the Gantner USW 60D. This result illustrates the advantage of a tower yarder operation which employs a gravity system, that is, a very simple cable system. Actually, the downward cable speeds of URUS MIII and Gantner USW 60D are 5.0 m/s and 2.6 m/s, respectively. However, running the carriage upward with URUS MIII takes comparatively more time. That is because the average volume per load was 1.102 m^3, which is rather large. There is actually a relationship between volume and time as shown in Fig. 5. It takes 222 min to harvest logs of 21 m^3 in Borcka while it takes 804 min to harvest logs of 67 m^3 in Karckal. Finally, it was found that productivity using the

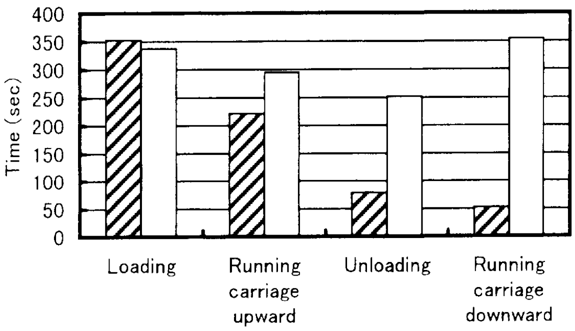

Fig. 4 Comparison of time element between URUS MIII and Gantner USW60D. ▨, URUS MIII; □, Gantner USW 60D.

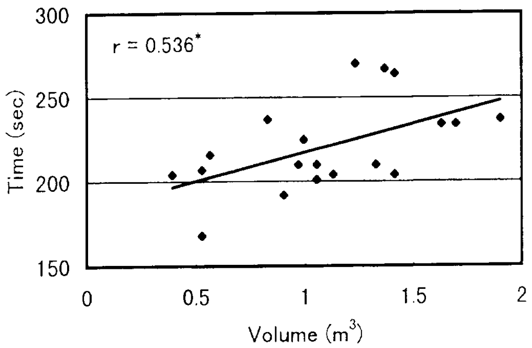

Fig. 5 Relationship between volume and time in uphill yarding using URUS MIII.* Significant at the 5% level.

tower yarder and the stationary yarder was 5.655 m^3/h and 5.002 m^3/h, respectively, with the former being just a little greater than that with the conventional method. However, these productivity values do not include either setup or removal and the conditions of the harvested sites and the cable distances are not considered for simplification. Actually, one day is sufficient to set up a tower yarder, although the setup time for a stationary yarder is about 20 days.

2 Cost

The prerequisite conditions for the machine cost calculation are shown in Table 2. In this table, the acquisition cost of URUS MIII is four times as high as that of Gantner USW 60D. Productivity shown in this table is the value obtained for this study. The other conditions are the same between URUS MIII and Gantner USW 60D. Machine costs were calculated for URUS MIII and Gantner USW 60D based on these conditions. Tables 3 and 4 show the prerequisite conditions for

Table 2 Prerequisite conditions for machine cost calculation.

	URUS MIII	Gantner USW 60D
Acquisition cost (TL)	400,000,000	100,000,000
Life span (year)	5	5
Productivity (m^3/h)	5.665	5.002
Production (m^3/setup)	1000	400
Days of operation (day/year)	100	100
Hours of operation (h/day)	6	6
Hours of operation (h/year)	600	600
Interest (%)	10	10
Insurance (%)	3	3
Salvage value allowance (%)	10	10
Repair and maintenance rate (%)		
1. Fixed	0.40	0.40
2. Utilization-dependent	0.03	0.03

Table 3 Prerequisite conditions for labor cost calculation.

	URUS MIII	Gantner USW 60D
Wages of an operator (TL/day)	8320	8320
Wages of other workers (TL/day/worker)	7500	7500
Number of workers in addition to operator	5	4
Number of days needed for setup	1	20
Number of workers needed for setup and removal	4	6

Table 4 Prerequisite conditions for material cost calculation.

	URUS MIII	Gantner USW 60D
Skyline (m)	650	1500
Life span of skyline (m^3)	16000	16000
Cost of skyline (TL/m)	6000	6000
Main line (m)	650	1500
Life span of main line (m^3)	4500	4500
Cost of main line (TL/m)	3000	–
Guyline (m)	50	–
Life span of guyline (m^3)	4500	–
Number of guyline	4	–
Cost of guyline (TL/m)	4000	–
Cost of fuel (TL/l)	900	900
Fuel consumption (l/h)	5	3

Table 5 Summary of cost analysis.

	URUS MIII	Gantner USW 60D
Machine cost (TL/m^3)	44138 (93.1%)	12475 (71.1%)
Labor cost (TL/m^3)	1438 (3.0%)	2852 (16.2%)
Material cost (TL/m^3)	1834 (3.9%)	2226 (12.7%)
Total harvesting cost (TL/m^3)	47410 (100%)	17553 (100%)

labor cost and material cost, respectively. In the case of URUS MIII, a haulback line was not included in the cost analysis because this line is unnecessary for uphill yarding. Life spans of cables in Table 4 were determined according to Umeda (1984).

As a result, the harvesting cost of URUS MIII and Gantner USW 60D was 47,410 TL/m^3 and 17,553 TL/m^3, respectively, as shown in Table 5. According to this table, the machine cost using URUS MIII reached 93.1% of the harvesting cost while the machine cost using Gantner USW 60D reached 71.1% of that.

Conclusions

In this study, the conditions of the studied site differed between those of the tower yarder and the stationary yarder. In addition, the cable distances and the cost of constructing forest roads were not considered in this study. Therefore, the estimates of the output are subject to considerable uncertainty. However, the results will fall within the range of an acceptable error, in which we can compare the harvesting cost and its structure between a tower yarder and a stationary yarder.

The productivity of both a tower yarder and a stationary yarder was obtained based on the results of a time study. As a result, the productivity of URUS MIII was found to be a little higher than that of Gantner USW 60D. The results of cost analysis showed the harvesting cost with a tower yarder and a stationary yarder was 47,410 TL/m^3 and 17,553 TL/m^3, respectively. It was also noted that the machine cost using URUS MIII reached 93.1% of the total harvesting cost while the cost using Gantner USW 60D reached 71.1% of the total harvesting cost. The harvesting cost of URUS MIII is higher than that of Gantner USW 60D because the acquisition cost of URUS MIII is four times that of Gantner USW 60D. However, setup and removal of a stationary yarder is very hard work, lasting for many days. In order to introduce more tower yarders to Turkey, it is necessary to improve the productivity of the tower yarder and to reduce the harvesting cost to the same level as that of a stationary yarder. At the same time, more forest roads are needed for tower yarders to access as many productive forest areas as possible.

The authors thank Dr. K. Numata and Dr. Y. Suzuki for their valuable advice.

Literature cited

Acar, H. H. (1990) Comparison between long distance winch skyline and short distance mobile skyline for forest harvesting in Artvin Region. 106pp. A master thesis. Karadeniz Technical Univ., Trabzon. (in Turkish with English summary)
FAO (1974) Logging and log transport in tropical high forest. 90pp. FAO, Rome.
Umeda, M. (1984) Logging cost. *In* Introduction to forest engineering. Kamiisaka, M. (ed.), 260pp, Chikyusha, Tokyo. 149–159. (in Japanese)*
* The title is tentative translation from the original title by the author of this paper.

(Accepted September 9, 1997)