Journal of Soil Science and Environmental Management Vol. 2(7), pp. 120-124, July 2011
Available online at http://www.academicjournals.org/JSSEM
ISSN 2141-2391 ©2011 Academic Journals

Full Length Research Paper

Time study and skidding capacity of the wheeled skidder Timberjack 450C

Majid Lotfalian[1]*, Mehran Moafi[2], Bahman Sotoudeh Foumani[3] and Ramazan Ali Akbari[2]

[1]Department of Forestry, Faculty of Natural Resources, Sari Agricultural Sciences and Natural Resources University, Sari, Iran.
[2]Department of Forestry, Faculty of Natural Resources, Mazandaran University, Sari, Iran.
[3]Young Researcher's Club- Islamic Azad University- Rasht Branch, Rasht, Iran.

Accepted 21 June, 2011

For evaluating the efficiency of wheeled skidder Timberjack 450C in ground skidding system, a forest in Caspian region was selected. In the research area, trees were logged downhill to the depot by a wheeled skidder Timberjack 450C. The work elements of a skidding cycle from stump area to roadside depots were travel empty, establishment time, release the cable winch, hooking, winching, travel loaded, unhook and piling the logs. 50 skidding cycles were evaluated in this study. Thus, some factors including skidding distance, volume per cycle, slope, the number of logs per cycle and winching distance as well as time of each element in one skidding cycle were measured. After data analysis, the skidding predicting equation was applied. This time model was mainly affected by skidding distance and interaction between skidding distance and slope. The gross and net production rate in the 980 m skidding distance was 20.199 and 16.58 m^3, respectively. The unit cost considering the gross and net production rate was 4.7 and 5.7 Euro m^{-3}, respectively. Delays in times of travel empty and travel loaded were the most frequent. The time of establishment and movements of skidder for winching was the third important part of skidding cycle.

Key words: Wheeled skidder, mathematical model, skidding, time study.

INTRODUCTION

Recent years in Iran, wood extracting systems except traditional methods, are combined with using wheeled skidders and crawler tractors (Sobhani, 1998). Primary wood transportation is one of the most sensitive and most expensive operations in forest utilization (Dvorak, 2005). Nowadays, with the expansion of mechanization, it is necessary to determine machine efficiency in skidding operations. Information on the productivity, costs and applications of the logging system is the key component in the evaluation of management plans for the rehabilitation and utilization of Caspian forests (Naghdi, 2005) and regarding this, there are variety of study fields and two of these fields of study which is considered to be the most sensitive and costly production stages are primary transportation and loading stages which are essential in spatial forestry and time-related planning for optimum use of facilities and labor forces (Majnounian, 1991). With the disappearance of traditional harvesting and the need for suitable forest mechanization systems, it is essential to transform the forest harvesting sector (Heinimann, 1999) for this reason, this study is carried out for evaluating the efficiency of wheeled skidder Timberjack 450C which works in wood logging operations in northern forests of Iran. Previous studies addressed the production and costs of harvesting stands under different machine and harvest prescriptions (Egan, 2003; Minette, 2004).

Naghdi et al. (2005) conducted the production analysis of wheeled skidder Timberjack 450C in northern forests of Iran. The variables including volume per cycle, skidding distance, winching distance and number of logs

*Corresponding author. E-mail: mlotfalian@yahoo.com. Tel: +98 152 4222984. Fax: +98 152 4222982.

in each cycle were entered to the model. The gross and net production rate was 13.38 and 10.56 m^3 h^{-1}, respectively. The unit cost considering the gross and net production rate was 2.3 and 1.9 Euro m^{-3}, respectively. Abeli (1996) compared the production and cost of three wheeled skidders in forests of Sokoine University; results showed that differences between them were affected significantly by size and type of machine, operator dexterity and slope of the area. Adams (1997) stated that the variables stem size; slope, skidding distance and volume of logs per cycle were significantly effective on extracting logs from stump to roadside landing. Klunder (1997) studied the productivities of rubber-tired cable and grapple skidders in southern pine stands and found that grapple skidders were considerably faster and more productive than cable skidders. They also indicated that the productivity of this grapple skidding was sensitive to a skidding distance, stem size, number of stems in a load and harvesting intensity.

According to Egan (2003) among effective variables on skidding time, slope and the skidding distance caused a raise in skidding costs and the volume per cycle caused a reduction in skidding costs. Andersson and Eliasson (2004) found that an appropriate prescription is the most effective factor in harvester productivity. Also the variables volume per cycle, skidding distance and stem size were significantly effective on harvester productivity. Sabo and Porsinsky (2005) stated that with skidding distance of 250 m (the average for the researched area), the possible productivity of Timberjack 240C under described work condition is 12 m^3 h^{-1} and the skidding costs of 2.2 Euro m^{-3}. As suggested by Nurminen et al. (2006) harvesting intensity, skidding average distance, volume per cycle and bunching are the most effective factors in skidding system. Ghaffarian et al. (2007) studied the productivity of forwarder in southern forests on Austria and found that the forwarding time rises with increase of skid trail length and forwarding time decreases with raise in slope, number of stems and volume per cycle in skidding cycle time. Behjou et al. (2008) in time study and skidding capacity of the wheeled skidder Timberjack 450C in Caspian forests indicated that the skidding cycle time was mainly affected by skidding distance, winching distance and interaction between skidding distance and slope. The net production rate was 22.93 m^3 h^{-1}.

Therefore, this study was conducted in Hyrcanian forests in Iran with the following objectives: (1) To distinguish the parts of one skidding cycle from stump area to roadside depots, and (2) To examine the efficiency of wheeled skidder Timberjack 450C in Ground Skidding System.

MATERIALS AND METHODS

Study site

Extension of Iran forests with 1.9 m ha is located in southern region of Caspian and 1.3 m ha of this area has merchant value. Three forest districts were selected in Mazandaran Wood and Paper Industry Company. This forest located between 53° 2′, 53° 7′ longitude and between 36° 22′, 36° 26′ latitude. The altitude ranged from 360 to 470 m above sea level and the average slope was 30%. The slope direction is southern. Bedrock is sand stone with silting and argillite and lime stone. Soil type is forest brown with low activity; soil texture is heavy, relatively. The dominant forest type is Fagetum with mixed type of Hornbeam and Alder. Forest management and silviculture methods are uneven aged high forest with selection cutting. The total volume of production was 1839 m^3. The skidding of logs was done from the stump area to downhill roadside depots by a ground based skidding system. The skidder type used in this study was wheeled skidder Timberjack 450C, with the power of 177 HP and the weight was 10.257 kg. This research was performed in the summer of 2008. Table 1 shows the characteristics of the study area.

Data collection

Field study was conducted based on elemental time data with digital chronometer and video camera beginning from logging of timbers to end of operations. The independent variables such as log diameter, length, bark thickness, log form, log position and log volume, affects time spent in performing the work (Ghafarian et al., 2007; Egan, 2003). The functions of the wheeled skidder were travel empty, establishment time, release the cable winch, hook, winching, travel loaded, unhook and piling (Ozturk, 2005). The variables recorded for the wheeled skidder were skidding distance from landing to stump, number of logs per cycle, tree species type, mean of diameter logs, slope and winching distance. To determine the logs volume and loading, Huber's Formula (1) volume and collection logs volume in each time of skidding was used, respectively. Descriptive statistics for each data set were calculated using the SPSS software version 16 (SPSS Inc. Chicago).

$$V = gm \times L \quad (1)$$

where; V is log volume, gm is mean of log basal area and L is log length.

RESULTS

The cycle Time equations calculated for the Timberjack 450C took the following form:

Cycle time = 3.007 + 0.10D + 0.20Ds (min)
$R^2 = 0.81$
D = Skidding distance (m)
Ds = Interaction between skidding distance and slope

This multiple correlation coefficient of 0.96 is interpreted as the 81% of total variability, which is explained by the regression equation. The significance level of the ANOVA (Table 2) shows that the model is significant at $\alpha = 0.01$. The skidding distance in meters and the interaction between skidding distance (Figure 1) and slope are shown in Figure 2, respectively.

Table 3 presents the statistics of operational variables of wheeled skidding in the study area. Table 4 shows the average working time and the share of elemental times of working cycle obtained in the study area with the skidder

Table 1. Characteristics of the study area.

Characteristic	Study aspect
Altitude (m a. s. l.)	410
Aspect	Southern
Number of workers	4
Skidding way	Downhill
Average field slope (%)	30
Silvicultural system	Selection cutting
Species	Beech, Alder
Maximum skidding distance (m)	980

Table 2. ANOVA model.

Source	Sum of square	df	Mean of square	F-value	P-value
Regression	636.99	2	318.49	105.121	0.00
Residual	142.40	47	3.03		
Total	779.39	49			

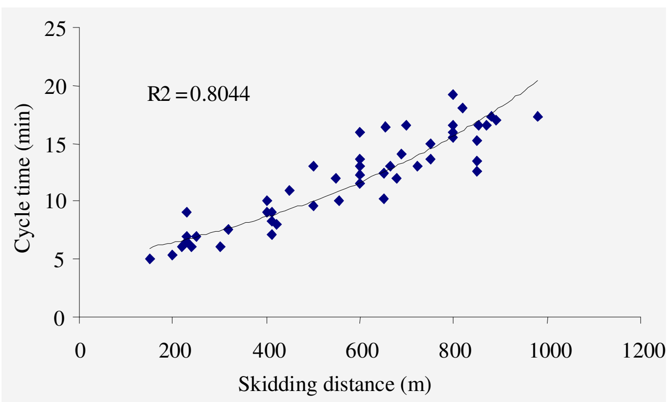

Figure 1. Effect of skidding distance on skidding time per cycle.

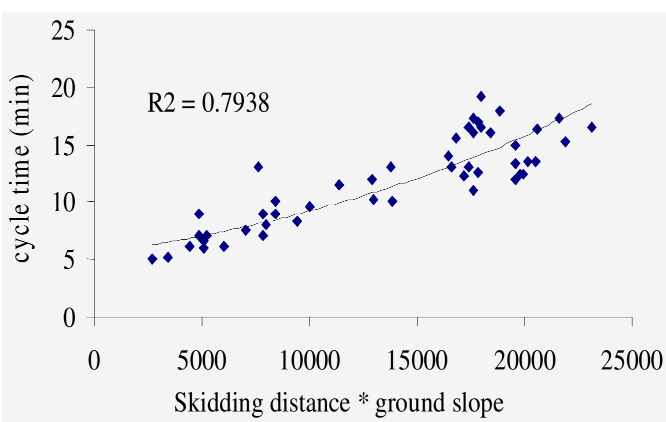

Figure 2. Effect of interaction between skidding distance and ground slope on skidding time per cycle.

Timberjack 450C. Figure 3 shows the percentages of delays. Obviously, operational delays were the most frequent. After the operational delays, mechanical delays were the most frequent. The gross and net production rate in the 980 m skidding distance was 20.199 and 16.58 m^3 h^{-1}, respectively. The unit cost considering the gross and net production rate was 4.7 and 5.7 Euro m^{-3}, respectively.

The total skidding time prediction model

The SPSS 16 statistical program was applied according to its series of phases in Table 4. These series are independent variables. The dependent variable is total time (A). The stepwise regression analysis was applied. The most effective variables with 99% confidence intervals are:

A = 0.945 + 0.937Te + 0.013Ts + 0.017To + 0.004Tc + 0.008Tw + 1.052Tl + 0.030Toc + 0.012Tj

where, Te = travel empty; Ts = establishment time; To = release the winching cable; Tc = hooking; Tw = winching; Tl = travel loaded; Toc = unhook; Tj = piling (min); R^2 = 0.99 F = 1211.15 Durbin-Watson = 2.5;

The Durbin-Watson coefficient value was found as 2.5. If this coefficient is near 2 or above, this means that autocorrelation between residues is negative.

DISCUSSION

The results of this study showed that the skidding time

Table 3. The statistics of operational variables of skidding in the study area.

Variable	Mean	Deviation	Minimum	Maximum
Number of logs per cycle	1.48	0.64	1	3
Skidding distance (m)	590.68	223.40	150	980
Volume per cycle (m^3)	4.07	1.26	1.47	6.92
Winching distance (m)	16.20	4.60	6	26
Ground slope (%)	22.22	3.44	15	30

Table 4. Average time and share of time segments.

Elemental times of working cycle (s)	Mean	Deviation	Minimum	Maximum	(%)
Travel empty	303.82	112.97	110	540	40
Establishment time	45.94	16.96	10	87	7.5
Release the winch	30.40	10.30	18	60	4
Hook	25.94	8.07	17	50	3.3
Winching	26.50	6.65	20	45	3.3
Travel loaded	240.12	107.22	60	444	32.2
Unhook	27.32	9.32	15	45	3.7
Piling	31.26	12.42	18	56	6
Skidding cycle time	736.62	246.92	300	11.65	-
Delay	138.52	148.45	0	780	-

Skidding cycle time does not include delays.

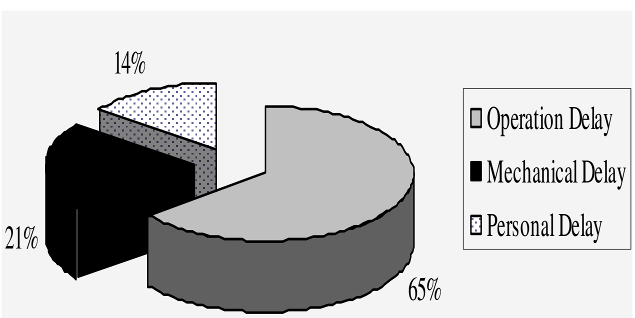

Figure 3. Percentages of delays on total skidding time.

was mainly affected by skidding distance and slope. The skidding cycle time and the travel loaded time as well as cable skidding productivity were primarily affected by skidding distance but the interaction between skidding distances and slope was other major factor that also influenced elemental times and productivity specially in the times of travel empty and travel loaded. According to studies of Naghdi et al. (2005), Adams (1997), Egan (2003) and Ghaffarian et al. (2007), the skidding distance is the most effective variable on skidding time and the forwarding time rises with increase of skidding distance. Also Behjou et al. (2008) in time study and skidding capacity of the wheeled skidder Timberjack 450C in Caspian forests indicated that the skidding cycle time was mainly affected by skidding distance, winching distance and interaction between skidding distance and slope.

In this study, the gross and net production rate in the 980 m skidding distance was 20.199 and 16.58 m^3 h^{-1}, respectively. The unit cost considering the gross and net production rate was 4.7 and 5.7 Euro m^{-3}, respectively. The production equation is a useful tool for helping logging planners. Personal delays are the most important among three kinds of delays. These kinds of delays show incorrect management in skidding operations in the study area. Without any delays, we will have 3.61 m^3 h^{-1}. Abeli (1996) in his study for comparing the production and cost of three wheeled skidders stated that the production of three wheeled skidders were affected significantly by size and type of machine, operator dexterity and slope of the area. The felling sequence should be chosen with consideration for efficiency and chokers should be used. Further yearly working times of the machine should be increased (Väätäinen et al., 2006). Nurminen et al. (2006) indicated that stem size, tree species and bucking affected the cutting, whereas timber density on the strip road, the average driving distance, load capacity, wood assortment and the bunching result of the harvester operator had an effect on the forest haulage performance.

Direction felling can be useful to diminish the skidding cost. In order to prevent a decrease in their efficiency and to reduce delay times and fuel consumption, the maintenance of machinery must be performed according to the technical specification and in a timely manner (Marenče, 2005). An adequate manner of spare parts should be maintained in order to prevent any loss of time in case of urgent maintenance-repair works (Minette, 2004). Because of steep slopes, high elevation and sensitive sites, harvesting and extraction operations in the Caspian forests of Iran needs to be carefully planned and executed. This study is conducted to establish a quantitative base for harvesting management and planning in Iran. Information on the productivity, costs and application of harvesting equipment and system is a key component in the evaluation of management plans for the rehabilitation and utilization of the Caspian forests (Pir Bavaghar et al., 2007).

Conclusions

Managers of logging operation are faced with profit reduction due to rapid increases in equipment costs, rapid depreciation of equipment and changing logging systems from harvesting the large trees to the smallerones. The simplest way to confront this problem is improving the efficiency of the logging operation. Using work study methods, the required information for this purpose can be obtained. We found that time model of Timberjack 450C skidding was mainly affected by skidding distance and interaction between skidding distance and slope. These findings indicate that the gross and net production rate in the 980 m skidding distance was 20.199 and 16.58 m^3, respectively. Moreover, present study results reveal that the model of skidding turn time as a dependent variable is a function of the independent variables of skidding distance, volume per turn, winching distance, and the number of logs per turn. The unit cost considering the gross and net production rate was 4.7 and 5.7 Euro m^{-3}, respectively. Delays in times of travel empty and travel loaded were the most frequent. In conclusion, the time of establishment and movements of skidder for winching was the third important part of skidding cycle.

ACKNOWLEDGEMENTS

The authors wish to thank the helpful comments from anonymous reviewers, whose remarks and indications significantly improved the original manuscript.

REFERENCES

Abeli WS (1996). Comparing productivity and costs of three sub grading machines. Int. J. For. Eng., 51: 33-39.

Adams PW (1997). Soil and water conservation: an introduction for woodland owners. Oregon state university extension service Ec, 1143: 4.

Andersson J, Eliasson L (2004). Effect of three harvesting work method on Forwarder productivity in final felling. Silva Fenn, 38: 195-202.

Behjou FK, Majnounian B, Namiranian M, Dvorak J (2008). Time study and skidding capacity of the wheeled skidder Timberjack 450c in Caspian forests. J. For. Sci., 54: 183-188.

Dvorak J (2005). Analysis of forest stands damages cased by the usage of harvester technologies in mountain areas. Electro. J. Polish Agri. Univ., 8: 1-9.

Egan AF (2003). Ground skidding and harvested stand attributes in Appalachians hardwood stands in West Virginia. Forest. Product. J., 53: 59-63.

Ghafarian MR, Stampfer K, Sessions J (2007). Forwarding productivity in Southern Austria. Croatian J. For. Eng., 28: 169-175.

Heinimann R (1999). Ground based harvesting technologies for steep slopes. Corvalis. OR. Department of Forest Engineering. Oregon. Uni, p. 7.

Klunder RA (1997). Productivity of Rubber-tired skidders in southern pine forests. Forest. Product. J., 47: 53-58.

Marenče J (2005). Logging operations in small private forests in Slovenia. Croatian J. For. Eng., 26: 27-30.

Minette LJ (2004). Technical and economic analysis of a forwarder under three eucalyptus forest harvest subsystems. Revista Árvora. 28: 91-97.

Majnounian B (1991). Investigation of utilization place and position in forest production system. Iranian J. Nat. Res., 43: 101-107.

Naghdi R, Rafatnia N, Jalali Gh, Hosseini SM (2005). A survey of the efficiency of Timberjack 450C wheeled skidder in Shafaroud forests in Guilan province. Iranian J. Nat. Res., 57: 675-687.

Nurminen TK, Heikki K, Usitalo J (2006). Time consumption analysis of mechanized cut-to-length harvesting system. Silva Fenn., 40: 335-363.

Ozturk T (2005). Research on transportation forest products with varied forest skylines in mountainous forest zone of Turkey. I. U. Review of the Faculty of Forestry, 54: 87–165.

Pir-Bavaghar M, Sobhani H, Feghhi J, Darvishsefat AA, Marvi- Mohajer MR (2007). Investigation on production rate and cost of Timberjack-450C in two skidding direction in combined harvesting system. Iranian J. For. Poplar. Res., 15: 374-385.

Sabo A, Porsinsky T (2005). Skidding of fir round wood by Timberjack 240c from selective forests of gorski kotar. Croatian J. For. Eng., 14: 13-27.

Sobhani H (1998). Evaluation of needing cable system. Iranian J. Nat. Res., 51: 87-97.

Väätäinen K, Asikainen A, Sikanen L, Ala-Fossi A (2006). The cost effect of forest machine relocations on logging costs in Finland. Forestry Studies|Metsanduslikud Uurimused, 45: 135-141.