Biological Forum – An International Journal **8**(2): 16-21(2016)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Productivity and Cost of tree Bucking with a Chainsaw in Caspian Forests

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(Received 02 June, 2016, Accepted 02 July, 2016)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Tree cutting is the most important component that affects all stages of harvesting. Tree cutting is included felling, cross-cutting, delimbing and topping. This study was carried out in the northern forests of Iran (Hyrcanian Forests) near the Caspian Sea in the Neka Chob Company, in order to evaluate subsections of tree bucking. The main goals of this study were time study of tree bucking, estimating and measuring productivity and costs of chainsaw as well as identifying regression model of tree bucking time. Multivariate Regression of bucking time was a function of tree diameter and tree length. Hourly production of chainsaw bucking was16.88m^3/h (4 trees per hour). There was found a negative relationship between tree diameter and tree bucking cost per production unit, so that when the tree diameter was increased the cost of tree bucking was being decreasing exponentially.

Key words: time study, regression model, unit cost, forest work study, Iran

INTRODUCTION

Forests encompass various commodities and benefits that could be extracted and presented to the public through planned management actions. These include the production of clean and good quality water, supplies of energy and minerals, soil protection, sustainable supply of wood, wilderness and scenic beauty, clean environments for recreation, and fish and wildlife habitats (Baskent and Keles, 2006). Forest harvesting is the second step of wood production which is called mechanical production. This expensive system is included of felling, bucking, primary transportation, loading, secondary transportation and road construction (Lotfalian, 2012). A harvesting operation consists of several work elements, such as moving from tree to tree, booming, positioning, felling, tree fall, delimbing, crosscutting, and bunching. An analysis of each work element could lead to improvements in harvesting operations (Nakagawa *et al*, 2007). Bucking is the operation resulting in a felled tree being cut into logs. Motor-manual tree bucking in hardwood forest is the effective and important components that will result in the greatest value being recovered from the tree for a specific end use. In past, cutting, branching and timber processing in natural forests or afforestation were done by axes and saws but nowadays, handsaw has been replaced by chainsaw in our natural forest in north of our country, Iran. Adverse weather such as trifle precipitation, high humidity, high and low temperature are some factors that can affect tree cutting operation and this value may not completely cease tree cutting operation but they can decrease efficiency (Lotfalian, 2012). Time study is one of the most common practices of work measurements. It is used worldwide, in many types of production, to determine the input of time in the performance of a piece of work (Björheden, 1991). Time study is the measurement, classification and subsequent systematic and critical analysis of time consumption in work with the purpose of increasing the efficiency of the study object by eliminating useless time consumption (Björheden and Thompson,1995). The time consumption is studied for various reasons. The most typical task is to investigate the main factors affecting work productivity and to establish a base for cost calculations and salaries or payments (Nurminen *et al*, 2006). Majnounian *et al*. (2009) showed that the hourly production of chainsaw limbing with and without delay time were 11.1 m^3/h (4 tree/h) and 14.8 m^3/h (5 tree/h), respectively.

Also productivity of chainsaw tree limbing was increasing with dbh as power. Felling time was found to be highly dependent on diameter at breast height (Ghaffaryan *et al*. 2013). The net production of felling was estimated at 12 trees/h (56.65 m^3/h) and the bucking and delimbing components were less costly than the other logging phases in their study. In other study total bucking time per tree without delays was 100 seconds for rubber (*Hevea brasiliensis*) plantation. The cost of bucking was 22.7 USD/hour and approximately 1 USD/m^3 (Rianthakool and sakai, 2014). Iran government is the owner of almost all forests in Iran. Northern forests of Iran are run by Government Forest Enterprises. Only northern forests of Iran or Hyrcanian forest zone are commercial and industrial (Parsakhoo *et al*, 2010).

The aim of this study is an evaluation of Productivity and cost of tree bucking Crew with a chainsaw in Caspian forests.

MATERIAL AND METHODS

A. Site description

The forest studied belongs to Neka Chob Company located in north forests of Iran. This forest originates from south to southeast of Neka city. This forest ranges from 36°25' to 36°29' N latitude and also originates from 53°17' to 53 °31'E longitudes (Fig. 1). This area covers 13565 hectares that about 1817 ha are farm lands and villages and 11694 ha belong to forest. The maximum and minimum altitude is 1430 and 350 m a. s. l. respectively.

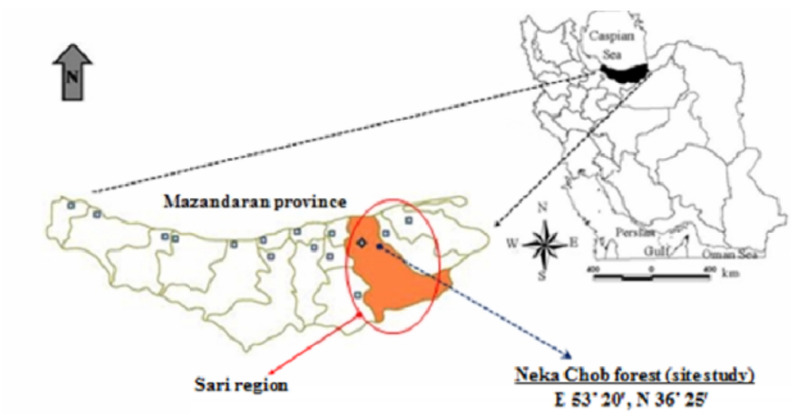

Fig. 1. Location of study area in Mazandaran province and Iran.

B. Study Method

First the parts of work cycle were determined and then time of each part was recorded in order to curry out this research. The time recorder was used for time study base on continuous time method. Work was divided in subsections in order to better accuracy of work and then time of each subsection was recorded. The affective factors on the time of a tree bucking include the tree diameter (cm); tree length (m), the slope (percent), temperature and climate conditions in the environs of the tree were recorded. A time recorder, a tape, a thermometer, a clinometer and inventory forms were applied for doing this research.

The production in bucking system with chainsaw is obtained by formula 1:

$$\text{Production:}\frac{\text{The tree quantity (the stock of bucking trees)}}{\text{total net time}} \qquad (1)$$

C. Determining samples quantity

Basic studies with recording 18 primary samples were done in order to determine the number of samples for time study to create predictable mathematic model of bucking time and also the standard deviation of net times (without delay times) were recorded. Regarding to 95 % of accuracy, 10 percent of a cycle must be considered in bucking phase. The number of samples needed for our research was determined by formula 2:

$$n = \frac{t^2 \times (s_x\%)^2}{(E\%^2)} \qquad \ldots(2)$$

n: The number of samples, *t*: The index that depends the number of samples and validation and extract of T student table, S_x: Standard deviation acquired of fundamental inventory, *E*: Accuracy that is 10 percent of a bucking time.

For doing this research 92 samples were recorded to determine bucking model of tree with chainsaw. Finally 3 samples were measured for validating the model, so that wholly 95 samples were used in this study. When the data were collected the measured cycles of cutting were being measured in the stands. Therefore, mathematic method of bucking-time prediction was prepared by SPSS. After entering collected data, the normality of data distribution were done by Normal Plots and Anderson-Darling. The relationships between measured factors and their binary interactions with bucking time without considering delay time were defined. Stepwise and Multivariate Regression were applied for defining variable and fixed indexes of the predictable model of bucking time.

RESULTS AND DISCUSSION

There are many factors that effect on tree bucking operation. Some of these factors cannot be identified and even many of them cannot be quantified. In this research the variables that have the most effect on tree bucking time were tree diameter and tree length. These values are similar to those obtained by Lortz *et al*., 1997, Rummer and Klepac 2002, Wang *et al*., 2004, Lee *et al*., 2004 and Majnounian *et al*., 2009.

It is remarkable that in the north of Iran is done bucking after felling. Felling is usually done in winter but delimbing and cross-cutting were gathered in summer as in the Gaffaryan *et al*. 2013 report.

A. The predictable model of bucking time with chainsaw

The mathematically predictable model of bucking time is multivariate linear regression that appears as a function of tree diameter and tree length.

$$Y= -13.801 + 0.226x_1+0.608x_2 \qquad (3)$$

Y: Time of the tree bucking (min)

x_1: Tree diameter (cm)

x_2: Tree length(m)

Table 1 Shows summarizes analyze of variance of model (3). The amount of F in table 1 shows significance at 0.01 level and variables of model show differences by 79.6 percent.

Table 1: Analyze of variance of the predictable model of bucking time with chainsaw.

	Sum of squares	df	Mean square	$\frac{MSK}{MSe}$ =F	R^2(%)	r	P
Regression	6748.41	2	3374.20	173.17	79.6	89.1	0.000
Residual	1734.08	89	19.48				
Total	8482.49	91					

B. Qualifying validation of the model

In order to qualify validation of the mathematic model, the information of 3 samples acquired in timing were randomly collected and they were used to valid after applying regression model. Table 2 shows the information of measured amount, estimating by model and the maximum and minimum of predictable range at 95% significance level. The results indicated regression model of tree bucking has the statistical validation.

C. The production of tee bucking system with chainsaw

The stock of bucking trees was 416.4573m^3 that was applied for the production.

$$\text{Hourly production } (m^3/h) = \frac{416.4573}{24.6577} = 16.88$$

The hourly production of trees with chainsaw in this study was 16.88 cubic meter per hour. It indicated about 4 trees per hour were operated.

Studying the amount of production showed that when the tree diameter was increased the production times was being increased (Fig. 2).

Table 2: Observation sample, parameter acquired by regression model and the maximum and minimum of predictable range at 95% significance level.

Sample	X_1	X_2	Measuring time	Estimating time	Confidence Limits	
					Lower Bound	Upper Bound
(1)	50	26	11.74	13.30	2.32	24.29
(2)	70	26.5	16.32	18.13	5.99	30.26
(3)	95	31	27.41	26.51	12.21	40.81

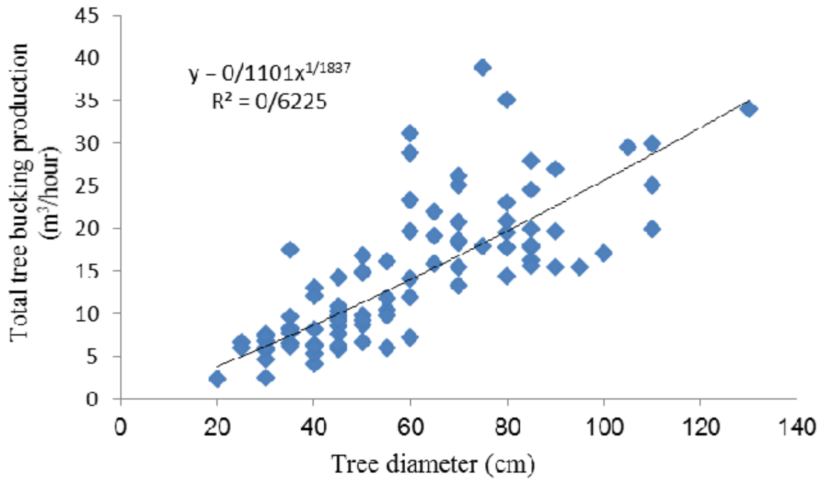

Fig. 2. The variations of total tree bucking production with chainsaw with tree diameter (cm).

D. Analyzing the sections of tree bucking with chainsaw

As there is shown in the figure 3, time study of a bucking cycle in considered parcels indicated that the maximum time applied were for delimbing, cross-cutting and feeding and resting. The average net time of a bucking cycle and the average time of a bucking cycle with delay time were 14.38 and 19.56 min, respectively. Feeding and resting and also personal and operational delay have allocated much time of a cycle and this value can be managed correctly in order to increase efficiency.

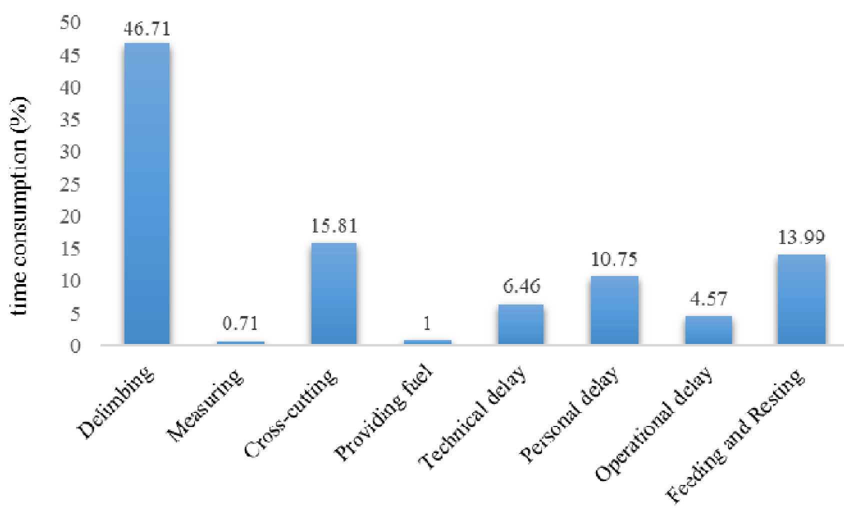

Fig. 3. Statistical characteristics of time study on tree bucking operation.

Table 3: Statistics of operational variables of the chainsaw bucking in the study area.

Variable	Diameter (cm)	Tree length (m)	Temperature (°c)	Slope (%)	cross-cutting (min)	Measuring (min)	Delimbing (min)	providing fuel (min)	technical delay (min)	personal delay (min)	operational delay (min)	feeding and resting (min)
minimum	20	11	14	2	0.67	0	1.55	0	0	0	0	50.65
maximum	130	41	30	45	13.83	2.5	33.12	2.81	34.76	31	43	62
mean	59.07	24.4	22.5	15.53	3.59	0.16	10.62	0.22	1.46	2.44	1.03	58.53

Results showed that there was found a positive relationship between tree diameter and the production without delay of tree bucking so that when the tree diameter was increased the production was being amplified exponentially. This result is similar to those obtained by Lortz *et al*. 1997, Wang *et al*. 2004, Lee *et al*. 2004 and Ghaffaryan *et al*. 2013.

E. The cost of tree bucking system

The instruction of forests and rangelands office was used for costing the system (Sobhani and Rafatnia, 1997). According to this instruction, system cost belongs to the chainsaw and personnel costs. The cost of production unit can be accounted with system cost divided by total production. Accounting costs of machines and other tools were based on costs of 2013. Regarding to local climate and also working labors on other works, the number of working days was considered 155 days. Economic life 5 year and Purchase price 3125 US$, also the Machine utilization 70 % were considered. Productive Machine Hour (PMH) and Scheduled Machine Hour (SMH) for the chain saw are considered to be 775 hours and 1085 hours, respectively (Table 4).

Table 4: Summary of detailed chainsaw cost calculation parameters.

Cost factors	bucking (chain saw)
Purchase price (US$)	1400
Salvage value (US$)	140
Economic life (year)	5
SMH (hour)	1085
PMH (hour)	775
Utilization (%)	70
Total fixed cost (US$/m^3)	0.61
Total variable cost (US$/m^3)	1.45
Total machine cost (US$/m^3)	2.07
Total labor cost (US$/m^3)	3.53
Total cost (US$/m^3)	5.6

F. The cost of tree bucking with chainsaw

The unit cost of tree bucking was acquired by the system cost divided by the production.

The unit cost of chainsaw acquired was 0.33 USD/m3(1.5USD per tree). Results showed that there was a positive relationship between tree diameter and the cost of tree bucking so that when the tree diameter was increased the cost of tree bucking was being amplified exponentially (Fig. 4).There was a negative relationship between tree diameter and the tree bucking cost of production unit, so that when the tree diameter was increased the cost of tree bucking was being decreasing exponentially (Fig. 5).

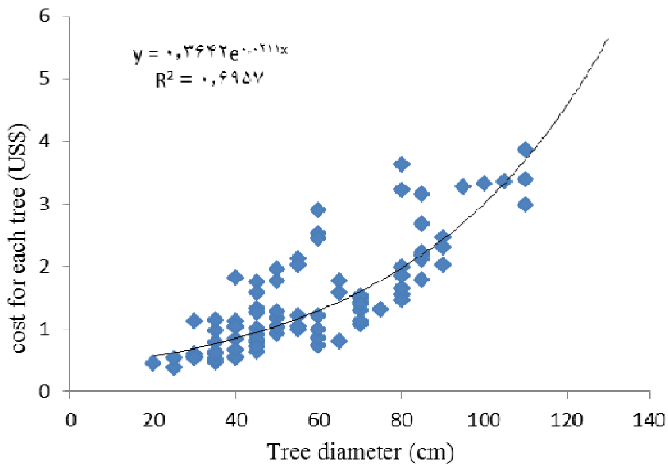

Fig. 4. The effects of tree diameter variations on the cost of tree bucking.

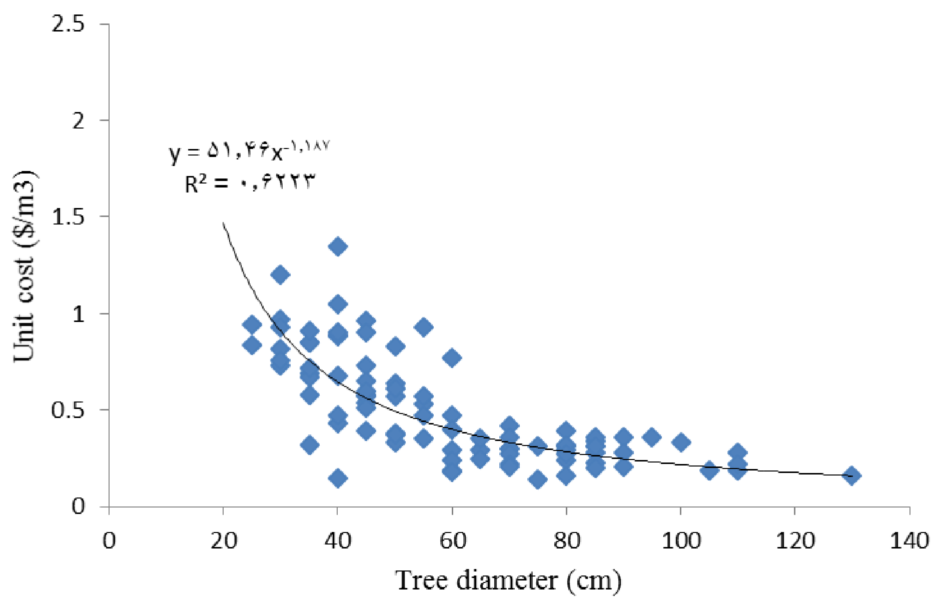

Fig. 5. The effects of tree diameter variations on the production unit cost.

The results of this study can be used to compare the production and cost of other harvesting machines or systems used in the region and will be helpful for the loggers in selecting an appropriate system under certain stand and harvest circumstances.

REFERENCES

Baskent, E.Z. & Keles, S. (2006). Developing Alternative Wood Harvesting Strategies with Linear Programming in Preparing Forest Management Plans. *Turk J Agric For.*, **30**: 67-79.

Bjorheden, R. (1991). Basic time concepts for international comparisons of time study reports. J. For. Eng2: 33-39.

Bjorheden, R. & Thompson, M.A. (1995). An international nomenclature for forest work study. In: Field DB, editor. Proceedings of IUFRO 1995 S3.04 subject area: 20th world congress, 6-12 August 1995; Tampere, Finland. Orono, Maine, USA: University of Maine, pp. 190-215.

Ghaffariyan, M.R., Naghdi, R., Ghajar, I. & Nikooy, M. (2013). Time Prediction Models and Cost Evaluation of Cut-To-Length (CTL) Harvesting Method in a Mountainous Forest. *Small-scale Forestry*, **12**(2): 181-192.

Lortz, D., Kluender, R., McCoy, W., Stokes, B. & Klepac, J. (1997). Manual felling time and productivity in southern forests. *Forest Product Journal*, **47**: 59-63.

Lotfalian, M. (2012). Looging.1st ed. Tehran, Iran: Aiizh Press, 488p.

Majnounian, B., Jourgholami, M., Zobeiri, M., Feghhi, J. & Fathi, J. (2009). Production and Costs of Tree Limbing Operation Using Chainsaw. *Journal of Wood and Forest Science and Technology* **16**(4): 43-57.

Nakagawa, M., Hamatsu, J., Saitou, T. & Ishida, H. (2007). Effect of Tree Size on Productivity and Time Required for Work Elements in Selective Thinning by a Harvester. *International Journal of Forest Engineering*, **18**: 24-28.

Nurminen, T., Korpunen, H. & Uusitalo, J. (2006). Time consumption analysis of the mechanized cut-to-length harvesting system. *Silva Fennica* **40**: 335-363.

Parsakhoo, A., Lotfalian, M. & Hosseini, S.A. (2010). Forest roads planning and construction in Iranian forestry. *Journal of Civil Engineering and Construction Technology*, **1**: 14-18.

Rianthakool, L. & Sakai, H. (2014). Short wood harvesting and pickup transportation during regeneration of rubber plantation. *Bull. Univ. of Tokyo For.* **130**, 45-58.

Rummer, R. & Klepac, J. (2002). Mechanized or hand operations: which is less expensive for small timber?. In: Baumgartner DM, Johnson LR, De Puit EJ, editors. Proceedings of Small Diameter Timber: Resource Management, Manufacturing, and Markets. 25-27 February 2002, Spokane, Washington. USA: Washington State University Cooperative Extension, pp. 183-189.

Wang, J., Long, C., McNeel, J. & Baumgras, J. (2004). Productivity and cost of manual felling and cable skidding in central Appalachian hardwood forests. *Forest Product Journal*, **54**: 45-51.