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EVALUATION OF TREE LENGTH AND ASSORTMENT LOGGING METHODS WITH RESPECT TO RESIDUAL DAMAGE AND PRODUCTIVITY IN CASPIAN FOREST (NORTH OF IRAN)

In order to find an efficient and careful way of selective logging system, two logging methods, in a ground skidding system, were compared with respect to productivity and damage caused to the residual stand. In this research, for estimating of production and cost of a unit volume of wood in two logging methods the work study technique was used. Stand damages were determined in three stages: 1-stand was investigated in felling gaps before felling operation. 2-Felling damages were determined after felling operation. 3-Winching and skidding damages were determined in primary transportation (from stump to landing). The total productions in tree length and assortment method, without delays were 17.1 and 11.75 cubic meters per hour, respectively. This amount with delays was 13.6 and 10.1 cubic meters per hour, respectively. The production cost without delay times in tree length and assortment method, were 21178 and 30821 rials per cubic meter, respectively. Damages in felling gaps on regeneration and residual trees were calculated 20.7 % and 19.04 %, respectively. Damages in winching strips at assortment method were more than tree length method.

Keywords: Ground skidding system, felling gap, work study, residual stand damage, Iran

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Оцінювання стовбурної та сортиментної лісозаготівлі щодо продуктивності та завданої шкоди в лісах Каспія (північ Ірану)

Для того, щоб знайти ефективний і еколого-прийнятний спосіб вибіркової лісозаготівлі було порівняно дві технології – стовбурна і сортиментна з наземним трелюванням деревини. Акцент робився на продуктивність лісозаготівлі та ступінь завданої шкоди. Для цього проводився хронометраж робочого дня. Оцінка пошкоджень деревостану здійснювалася за трьома етапами: перед початком рубань; після рубань; після трелювання.

Загальна продуктивність під час заготівлі стовбурів і сортиментів без врахування простоювання відповідно становила 17,1 та 11,75 м³/год, а з врахуванням простоювання – 13,6 та 10,1 м³/год. Вартості заготівлі стовбурів і сортиментів – 21178 і 30821 ріалів/м³, відповідно. Пошкодження деревостану після закінчення лісозаготівлі відповідно становили 19,04 % і 20,7 %.

Ключові слова: система наземного трелювання, котловинне рубання, польові дослідження, залишкове пошкодження деревини, Іран.

Introduction

The Caspian forests located in the north of Iran covers the north facing slopes of the Elborz mountain ranges and classified as mountain forest. The majority of these forests is managed as uneven aged forest and about %60 of the forest is used for timber production. For this reason harvesting of the forest is one of the important matters for managers of Caspian forest. In the Caspian forests, most timber is harvested by some form of ground skidding. Wheeled skidders appeared in

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the early 1970's, and are now the most widely used. The major problem with wheeled skidders is their requirement for a dense network of roads. Regarding this matter, there are many different formal and informal reports determined damaging of different logging method.

At present managers of the forest are involved by these matters and try to find suitable approaches to reduce them. In the other hand, forest harvesting costs takes more than half of the total forest costs and in Iran, sometimes reaches to 15 percent. With respect to this matter, it is obvious that how important is to optimize the related harvesting costs in any forest management activities. Industrial development has been introduced as a forwarding motion, from a short wood system to a tree length and then a whole tree system. The main goal was to improve work allocation and to introduce appropriate approaches in order to reduce the expenses (Mc-Donald, p. & clow, M., 1999). The evaluation of two mechanized logging systems (tree length and whole tree systems) at Shafarood forests in Iran, showed that the skidding cost per cubic meter in whole tree system and tree length system were 2858 unit/m³ and 1504 unit/m³ respectively (Feghi, j., 1990). Another study in this area using clark 667 wheeled skidder, showed that the skidding time depends upon the variables such as skidding distance, slope percent in skid trail, number of logs per turn and volume per turn (Sobhani, H., & Ghasemzadeh, 1990).

In east Alberta forest three methods (cut-to-length, tree length and whole tree) were compared in respect to stand damages and the result showed that whole tree has the most damages (Pulkki, 2001). Almost in all of these studies, statistical and simulation models have been used to estimate the skidding time and cost. So far, different methods to evaluate of stand damages have been reported. Their criteria were different and a standard method is not interdicted. Factors like, Area, deep and high of scar and tree diameter were determined as important factors in evaluating of stand damage.

Materials & Methods

The research was carried out in three compartments of 2th district, in Neka forest, with the altitude ranging between 1260 and 1570 meters and average annual precipitation of 1100 (mm). The forest was abnormal, uneven-aged and its main type was fagetum with the average growing stock of 310 cubic meters per hectare. Maximum and absolute gradient of the compartment were 65 % and 20 % to 50 %, respectively. Cutting regime and silvicultural method were single or group selective cutting. The total volume of primary transportation which was carried out by skidders in short or long logs and tree length were 3200 m³. The landings were prepared at the border of road in the lower part of the compartment, and therefore the directions of skidding were entirely downward. In this study, we compared production and cost and the damage in Tree length and Assortment logging operations associated with residual stand in Neka region (East of Caspian forest), during June and July 2002. Single selection method was used and felling operation was carried out by chain saws. At the first we studied influence of tree felling on the regeneration and the other trees being in the stand. In the second stage, damaging of tree length & assortment method in winching strips was considered. In order to estima-

te production and cost of a unit volume of wood, the work study techniques was used. Work-study included method-study and elemental time-study techniques. The cycle of skidding turn was broken down into different elements and were defined as follows: 1 – Travel empty; 2 – Releasing: the time needed to release the winching cable; 3 – Choker setting; 4 – Winching; 5 – Travel loaded; 6 – Unhooking (Choker releasing); 7 – Piling.

In addition to these elements, there is a series of delay times in each turn. The delays were divided into three groups: 1 – Operational delay; 2 – Technical delay; 3 – personal delay.

Time study data was collected in June/ July of 2002. In addition to measure the time for each work element; factors like: skidding distances, length and mean diameter of logs, gradient of skidding roads, and number of logs in each turn of skidding and winching distances were also measured. To calculate volume of logs, Huber formula was used. In order to determine the number of required samples, first a preinventory was done to specify the time variance of skidding without consideration of delay time and then thirty cases of skidding were time studied. Finally, 26 and 24 samples were chosen for tree length and assortment methods respectively, with 95 % probability level of 10 % accuracy.

Scientific references and information concerning time studies of forest harvesting operations indicate that, the best way to create mathematical models of task performance time for harvesting machinery is variance analysis and multi-variable regression models. "Minitab for windows software was used and a mathematical model for skidding turn was developed. For estimating of machine rate, the FAO model was used. To investigate the damages affected in residual trees and regeneration in felling gaps and winching strips, complete enumeration forest mensuration method was used in felling gaps. In this matter 74 sample circle plots with areas between 0.18-0.42 hectare were surveyed. Also, the amounts of 97 and 83 winching strips in tree length and assortment methods were surveyed, respectively. The total areas of felling gaps were 22.62 hectare and total of winching strips areas were 1.6 and 1.3 in tree length and assortment methods, respectively.

For determining the total damages in all of felling plots and winching strips with respect to areas variety of plots and strips, the weighted method was used.

$$g = \frac{n}{N} \cdot 100,$$

where: n – number of trees or regeneration damage in plot or strip; N – number of total regeneration or trees.

$$M_w = \frac{\sum_{i=1}^n g_i s_i}{\sum_{i=1}^n S_i}$$

where: M_w = percentage of total damages; g_i – percentage of damages in plot or strip; S_i – areas of plot or strip;

The regeneration was classified into three classes:

- Seedling: trees less than 0.5 m in height.
- Pre-thicket: trees from 0.5 to 2 m in height.
- Thicket: trees from 2 to 6 m in height.

For each plot and strip the following data were recorded:

- The species present.
- The number of undamaged trees in seedling, pre-thicket and thicket classes.
- The number of wounded trees (i.e. trees with any of bark, cambium or wood damage) in seedling thicket and thicket classes.
- Number of broken/uprooted trees in seedling thicket and thicket classes.

Result

Mathematical equation of the skidding time as a function of effective factors in tree length method:

$$Y = -3.45 + 0.0266 \cdot x_1 + 0.97 \cdot x_2 + 0.143 \cdot x_3,$$

where: Y – time needed for one turn (minute); x_1 – skidding distance (m); x_2 – load volume (m^3); x_3 – load winching distance (m).

Source	SS	df	MS	$F = \frac{MS_{Regression}}{MS_{Residual}}$	R^2
Regression	345.64	3	115.21	10.02	53.6 % $p < 0.001$
Residual	298.89	26	11.5		
Total	644.53	29			

Mathematical equation of the skidding time as a function of effective factors in assortment method:

$$Y = -2.340 + 0.024 \cdot x_1 + 1.170 \cdot x_2 + 0.950 \cdot x_3 + 1.130 \cdot x_4,$$

where: Y – time needed for one turn (minute); x_1 – skidding distance (m); x_2 – load volume (m^3); x_3 – load winching distance (m); x_4 – number of logs in each turn

Source	SS	df	MS	$F = \frac{MS_{Regression}}{MS_{Residual}}$	R^2
Regression	409.65	4	102.41	24.01	79.3 % $p < 0.001$
Residual	106.63	25	4.27		
Total	516.28	29			

Validity of the models:

Previous to analyzing data, two series of time-study information were randomly taken out from the data to be used for determination of the model validity.

Confidence limits of skidding time estimated by the model were calculated and compared with real skidding time. To calculate confidence limits estimated by model (estimated time) following formula was used:

$$\hat{Y} \pm t_{a=\%5} \sqrt{\frac{Mse}{dfe} \left(1 + \frac{1}{n} + \xi' sp^{-1} \xi\right)},$$

where: $\hat{Y}$: Estimated time by model for each turn of skidding without considering delay time; Mse – mean square error; n – number of skidding turns used in the model; ξ – Numeric value obtained from time study of effective variables in the mo-

del to calculate time for each turn of skidding; **Sp** – sum of products; **Sp**⁻¹ – inversion of sp. matrix

Table 1. Validity of model in tree length method

Confidence limit	Measured time	Estimate time
8.83<Measured time<23.25	14.85	16.04
15.17<Measured time<29.59	21.68	23.38

Table 2. Validity of model in assortment method

Confidence limit	Measured time	Estimate time
11.1<Measured time<19.88	13.74	15.49
10.89<Measured time<19.67	15.25	15.28

The results show that the models have required statistical validity.
Calculating the production unit

$$\text{The Production} = \frac{\text{Volume of wood skidded toward landing}}{\text{Time needed for skidding operation}}$$

The production in tree length method

$$\frac{\text{Total volume of wood skidded toward landing (m}^3\text{)}}{\text{Total used time (hour)}} = \frac{162.63}{9.53} = 17.1 \frac{\text{m}^3}{\text{hour}}$$

The production with consideration of delay time =

$$\frac{\text{Total volume of wood skidded toward landing (m}^3\text{)}}{\text{Total used time with considering delay time (hour)}} = \frac{162.63}{11.92} = 1$$

The production in assortment method

The production without considering delay time =

$$\frac{\text{Total volume of wood skidded toward landing (m}^3\text{)}}{\text{Total used time (hour)}} = \frac{120.79}{10.28} = 11.75 \frac{\text{m}^3}{\text{hour}}$$

The production with consideration of delay time =

$$\frac{\text{Total volume of wood skidded toward landing (m}^3\text{)}}{\text{Total used time with considering delay time (hour)}} = \frac{120.79}{11.95} = 10.1 \frac{\text{m}^3}{\text{hour}}$$

Calculating production cost

In order to calculate production cost over the location F.A.O manual was used. So, using this manual the system costs consisting of machine costs simulation and personal costs were calculated and dividing this by the production over the location, production cost for one cubic meter could be calculated. These calculations were in accordance machinery and other instruments price of the year 2003. Scheduled daily work hours were 8 hours and useful work hours were 6 hours per day. The number of work days was considered 150 days per a year. The results showed that skidding cost in tree length and assortment methods are 21178 and 30821 rial/m³, respectively.

Result showed that stand damages affected by felling in felling gaps is 19.4. The amounts of winching damage in tree length and assortment method were 31.07 and 36.5 percent respectively.

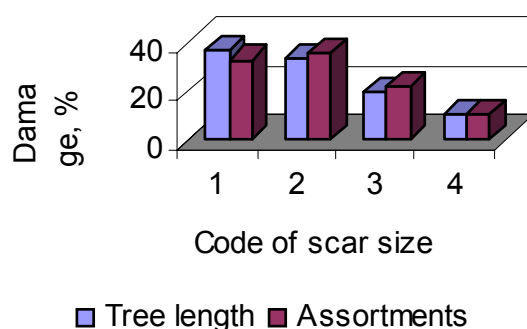


Figure 1. The relationship between scar size and logging method. Scar size in tree length is more than assortment method

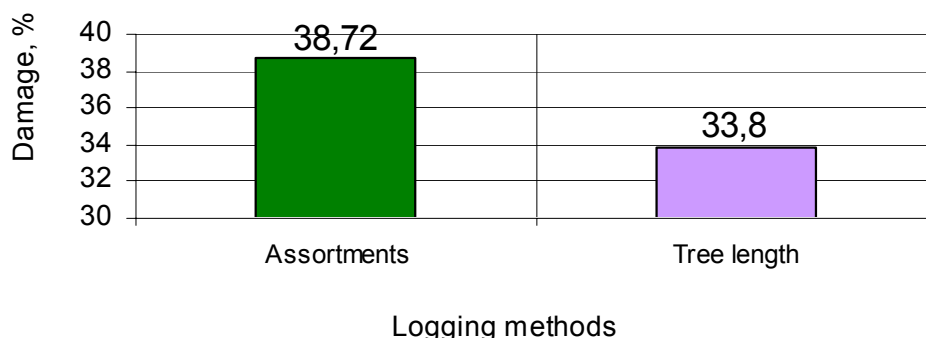


Figure 2. Damages of regeneration in two logging methods in winching strips

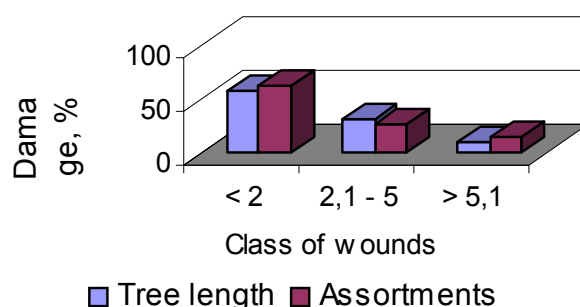


Figure 3. Percentage of regeneration in two logging methods in winching strips

Conclusions and discussion:

The result of the study shows that the best model for skidding turns time is a function of independent variables: volume in each turn, skidding distance, winching distance and number of logs. Based on % 99 confidences, the model proved to be valid. Slope variable was not entered in the model, because gradient variability was too few. Skidding cost in assortment method was more than tree length method (30821 rial/m³ versus 21178 rial/m³). In this research felling damage was more than expected damage, because the felling operation was done in unsuitable season (early of spring).

Designing skid trails before felling operation can reduce the winching damages. The results of this research showed that in case of using of the "Assortment method" a forest stand can be damaged more than when the "Tree length logging method" is used.

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FELLING AND WINCHING DAMAGE ON REGENERATION FOLLOWING SELECTION LOGGING IN SEYAHKAL FOREST (NORTH OF IRAN)

Seyahkal forest area in east of Guilan province, Iran, consist of hardwood, s species such as Beech (*Fagus orientalis*) and Hornbeam (*Carpinus betulus*), that is managed by selection logging. The forest was logged by a private company under a government concession. A total density of 2.4 tree/ha and 12.77 m³/ha of wood (113 trees in 31 felling gaps) were harvested. The felling and winching damage on regeneration (dbh<10cm) was assessed in total felling gaps and winching strips with handered percent inventory. Damages in winching strips were greater than felling gaps. In felling gaps the percentage of damage on regeneration in height-limit of 0-0.5m, 0.5-2.5 and 2.5-8m were estimated %9.57, %14 and %17.4 respectively. From this amount %28 were bent and %31 wounded and %41 crown breakage were seen.

Also in the winching strips the percentage of damage on regeneration in height-limit of 0-0.5m, 0.5-2.5m and 2.5-8m were estimated %11, %15.3 and %21 respectively. From this amount %17 were bent and %25 wounded, %43 had crown breakage and %15 were uprooted.

Keywords: Hardwood forest; Selection logging; Regeneration damage; Felling gaps; Winching strip

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