Study of production-cost of Mule Logging and products amount of traditional processing method- Case study in Northern forests of Iran, Nowshahr*

Mohammad Reza Ghaffariyan¹, Hooshang Sobhani² and Mohammad Reza Marvi Mohadjer²

¹PhD student, Institute of Forest Engineering, Department of Forest- and Soil Sciences, University of Natural Resources and Applied Life Sciences, Vienna, Austria

²Associated Professors, Dep. of Forestry, Faculty of Natural Resources, Tehran University, Iran

Emails: ghafari901@yahoo.com, sobhani@nrf.ut.ac.ir, mohadjer@nrf.ut.ac.ir

Abstract

Animal logging is one of the traditional logging systems, some researches on production-cost of Animal Logging have been carried out in the USA, Chile, China and India. After determining the work elements, continuous time study method was used to develop wood hauling models for billet, pulpwoods and billet hauling with special equipment. Production in billet hauling was 2.135 m³/h, billets hauling with special equipment 3.275 and pulpwood hauling 1.246 m³/h, costs according to contract were: 1.67 dollar/m³, 1.09 dollar/m³ and 3.58 dollar/m³. According to cutting permits 88.37% of industrial wood production was traditional processing products and 11.63% of industrial wood production was industrial logs.

Keywords: forest harvesting, animal logging, production, cost, wood hauling model, hauling time, hauling distance, load volume

1. INTRODUCTION

Animal Logging is a traditional forest harvesting system. There are 300 million draught animals in the world such as oxens, horses, mules, elephants and Lamas (FAO, 1982).

Information of the cost, productivity and products of any harvesting system will be helpful for logging planners. Such a information helps logging managers to improve the efficiency of the system, decision for changing or applying new machines and prediction of the workers and machines needed to harvest a distinct logging block. One of the usual method to measure production of harvesting machines or systems is time study which can be combined with cost calculation study and finaly the cost of unit work will be measured.

Mule skidding in Alabama was studied in pine and other broad leaves stand with slope 0 to 6% . The work team included 8 workers and 3 mules and production was 18.012 m³/h (McGonagil, 1979).

Wang studied assessment of animal logging and ground skidding machines in Mountain region of Heilongjiang in China. Skidding distance was most important factor influencing skidding costs. The results indicated that the physical soil properties mostly depend on the amount of disturbance. The soil disturbance was higher in machine skidding (Wang, 1997). Toms in Alabama studied animal logging as a small scale harvesting system. Minimum production was 2.45 m³/h and best production was 25 m³ per 8 hours with two teams and a person for cutting. The operators prefered area with slope of 0 to 30% because of low accident.

Mean daily production and payload were 16.095 and 0.212 m$^3$. The cost of harvesting without the loading costs on trucks, was 49.31 $ per 2.36 m$^3$. Mule logging was studied in the east of Alabama in the mixed stands, the results showed that damages to skid trails was low and approximately 2 inches of the soils was disturbed and some of trees were damaged. The most damages to the residual trees included broken branches by tree felling (Toms, 1996). Residual stand damages in selective cutting by two skidding systems was studied in the Missouri Ozark. The area of mule skid trails was 1% of the area of the logging unit, for the skidders was 4.6% (Ficklin et al, 1997).

In Chile wood extraction with oxen and agriculture tractors was studied by E. Rodriguez. The skidding distance was the only factor intered the skidding models developed for two classes of slope; -6 to -15 and -16 to -25 and for to classes of wood types; sawlogs and pulpwoods. Skidding distance differed from 20 to 240 meter (FAO, 1982).

The logging damages was studied by Ahmadi in the forests of Northern Iran (Lavidj, Amol), 27.1% of total damages to the stands was occurred by Mule Logging (Ahmadi, 1996). The Mule Logging damages including damages to seedlings and standing trees was studied in Rouyan forests, 5.14% of seedlings were grazed, 4.2% of saplings were curved, 7.4% of the stems of the saplings were wounded and 4.2% of the seedlings and yearlings were destroyed. 5.1% of the samles had first grade wound, 8.29% second grade and 7.59% third grade (Tashakkori, 1996).

### 2. METHODS

#### 2.1. Sites of study

The first site of study was 114 compartment of Patom district of Research and Training Forest Center of Nowshahr in the North of Iran. Table 1 shows the information of this parcel (Namiranian, 1997).

<table>
<thead>
<tr>
<th>Table 1. Information of 114 parcel</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Area(ha)</th>
<th>Min. height above sea level</th>
<th>Max. height above sea level</th>
<th>General slope(%)</th>
<th>Aspect</th>
<th>Geology</th>
<th>Soil</th>
<th>Forest type</th>
<th>Standing volume (sylve/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>38.4</td>
<td>650</td>
<td>750</td>
<td>35</td>
<td>North</td>
<td>Jurassic lime</td>
<td>brown</td>
<td>Fageto-carpinetum</td>
<td>360</td>
</tr>
</tbody>
</table>

The second site was 111 compartment located in Patom district.
The third site study was 218 compartment of Namkhaneh district.

2.2 Climate of site study

There is no information of climate data in forestlands, but according to meterology station in Nowshahr, warmest month was July with average temperature about 24.6 °C and coldest month was February with average temperature about 7.5 °C, most rainfall was 237.6 mm in October and lowest rainfall was 475 mm in June.

2.3 Data Collection

Continous time study method was used, work cycle included; loading the processing woods ( billets and pulpwood ) over mules, hauling the loads to landing, unloading and returning. Hauling distance, slope of skid trails and volume per load as important factors influencing hauling time, were measured. There were no technical and personal delays during this time study.

In order to determine the amount of the products of traditional processing method, the cutting permits of Patom and Namkhaneh districts from 1982 to 1996 were used. In the northern forests of Iran, the marking volume is determined from the tariff, after felling the marked trees, the forest service supervisors will measure the felled tree again, separate the industrial and nonindustrial woods of each felled tree, then the contractors allow to process the felled trees to logs, lumbers, pulpwoods and the traditional products. Logs are defined as industrial woods and the lumbers, pulpwood and the other products defined as the traditional products in Iran. After processing the forest service supervisors will measure the products exactly, this stage is named as final measurement and the forest contractors should pay the rent of ownership based on the final measurement.

The percentage of each product for Fagus sp., Carpinus sp., Acer sp., Alnus sp. and the other species was calculated.
2.4 Statistical Analysis

2.4.1 Modeling

Model is a multiple regression to show the effects of variables on production amount (as function). In this study, time of hauling by mule is a function of hauling distance, slope of skid trail and volume of the load. Using stepwise method, if the variable has a significant effect on RMS (residual mean squares) of model, it will be intered to the model, otherwise will not used. Because of saving time and cost, important factors including: hauling distance, skid trail slope and volume per load were measured, although the other factors such as experience of workers, power of mule, ground condition and temperature and… are influencing the time of hauling.

2.4.2. Production

Cost of Hauling System: Cost of system includes cost of purchase of animal, hauling instrument (straps, Pack-saddle, Sandal), maintenance of animals and labour costs. But in this study, cost of system achieved from animal conductor contract.

Number of Samples: By preliminary sampling and holding time accuracy about minimum hauling time, the number of samples was obtained according this formula:

\[ N = \frac{t^2 \times s^2}{E^2} \]

Where, 
N: number of samples 
t: from the student table 
S: standard deviation 
E: Accuracy

2.5 Work Organization

The work team includes a mule, a worker for loading with hand and a teamster. Sometimes, two or three mules may be connected by rope each others. Two lumbers or two large pulpwoods (usually the weight per load is about 120 kg) are attached to the saddle of mule trough a plastic rope but for hauling the small fuelwoods, the workers use V-shap woody instrument.
Picture 1. Unloading the pulpwood at road side

Picture 2. Using V-Shape woody instrument to hauling fuelwoods
3. RESULTS

Hauling models for billets, hauling billets with special v shape woody instrument and pulpwood were developed by Statgeraph software.

a) Mathematical model for billets:
\[ Y = 5.3366 - 0.001032 \times (X_1 \times X_2) + 0.014171 \times X_1 + 0.079074 \times X_2 \]
\[ df : 29 \quad R^2 : 0.850 \]
Y: Time of each hauling cycle (min.)
X1: Hauling distance
X2: Slope of hauling trail (%)

b) Mathematical model for billets with V shape woody instrument:
\[ Y = 0.310203 \times (X_1 \times X_2) \]
Y: Time of each hauling cycle (min.)
X1: Hauling distance (m)
X2: Volume per load (m$^3$)

c) Mathematical model for pulpwoods:
\[ Y = 2.51553 + 0.235887 \times (X_1 \times X_2) \]
\[ df: 11 \quad R^2 : 0.826 \]
Y: Time of each hauling cycle (min.)
X1: Hauling distance (m)
X2: Volume of load (m$^3$)

The validation of the models for billets and pulpwoods was tested, these models were acceptable at significant level of 0.05. Because of the few number cycles in hauling model for billets with V shape woody instrument, the validation test was not carried out.

In order two determine the effect of different variables on hauling time and hauling costs of three type load hauling each variable, was changed and the other variables were held constant. As hauling distance, slope of trails and load volume increase, the time and cost of mule hauling will increase too.

Production in billet hauling was 2.135 m$^3$/h, billets with special equipment 3.275, and pulpwood hauling 1.246 m$^3$/h. The hauling costs, according to contact, for billets was 1.67$/m^3$, billets with special equipment 1.09 $/m^3$, for pulpwood was 3.58 $/m^3$. The use of special woody instrument led to decrease hauling costs by 34.8%.

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Slope(%)</th>
<th>Load volume (m$^3$)</th>
<th>Loading time (min.)</th>
<th>Hauling time (min.)</th>
<th>Unloading time (min.)</th>
<th>Returning time (min.)</th>
<th>Total time (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>64.34</td>
<td>20.1</td>
<td>0.202</td>
<td>1.55</td>
<td>1.629</td>
<td>0.765</td>
<td>1.712</td>
<td>5.685</td>
</tr>
</tbody>
</table>
Table 2- Mean of the variables and working elements in Billet hauling with woody instrument

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Slope (%)</th>
<th>Load Volume (m³)</th>
<th>Loading time (min.)</th>
<th>Hauling time (min.)</th>
<th>Unloading time (min.)</th>
<th>Returning time (min.)</th>
<th>Total time (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>58.5</td>
<td>16.37</td>
<td>0.379</td>
<td>2.277</td>
<td>1.25</td>
<td>1.832</td>
<td>1.592</td>
<td>6.952</td>
</tr>
</tbody>
</table>

Table 3- Mean of the variables and working elements in pulpwood hauling

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Slope (%)</th>
<th>Load Volume (m³)</th>
<th>Loading time (min.)</th>
<th>Hauling time (min.)</th>
<th>Unloading time (min.)</th>
<th>Returning time (min.)</th>
<th>Total time (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>144.08</td>
<td>17.67</td>
<td>0.194</td>
<td>1.01</td>
<td>2.705</td>
<td>0.647</td>
<td>4.997</td>
<td>9.363</td>
</tr>
</tbody>
</table>

The calculations based on the cutting permits and final measurement of Patom district (area of 908 ha) and Namkhaneh district (area of 1084 ha) are summarized in the next tables.

Table 4- Percent of the products for Fagus sp. relative to final measurement

<table>
<thead>
<tr>
<th>Product</th>
<th>Pulpwood</th>
<th>Lumber</th>
<th>Traditional and small lumbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage relative to final measurement</td>
<td>12.86</td>
<td>45.34</td>
<td>22.7</td>
</tr>
</tbody>
</table>

Table 5- Percent of the products for Carpinus sp. relative to final measurement

<table>
<thead>
<tr>
<th>Product</th>
<th>Pulpwood</th>
<th>Lumber</th>
<th>Traditional and small lumbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage relative to final measurement</td>
<td>31.46</td>
<td>2.88</td>
<td>64.32</td>
</tr>
</tbody>
</table>

Table 6- Percent of the products for Acer sp. relative to final measurement

<table>
<thead>
<tr>
<th>Product</th>
<th>Pulpwood</th>
<th>Lumber</th>
<th>Traditional and small lumbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage relative to final measurement</td>
<td>7.11</td>
<td>68.01</td>
<td>8.55</td>
</tr>
</tbody>
</table>

Table 7- Percent of the products for Alnus sp. relative to final measurement

<table>
<thead>
<tr>
<th>Product</th>
<th>Pulpwood</th>
<th>Lumber</th>
<th>Traditional and small lumbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage relative to final measurement</td>
<td>8.79</td>
<td>64.36</td>
<td>0.39</td>
</tr>
</tbody>
</table>
Table 8- Percent of the products for the other species relative to final measurement

<table>
<thead>
<tr>
<th>product</th>
<th>pulpwood</th>
<th>lumber</th>
<th>Traditional and small lumber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage relative to final measurement</td>
<td>26.07</td>
<td>47.34</td>
<td>21.78</td>
</tr>
</tbody>
</table>

In average for all the species, according to the results, 88.37% of the wood products are lumbers and traditional and small lumbers, only 11.63% are sawlogs.

4. CONCLUSION

Production-cost study of mule logging indicated that hauling time depends on hauling distance, slope of trail and load volume, amount of production is different in pulpwood and billets, cost of hauling will increase if hauling distance, slope of trail and volume of load increase. Because of a simple development by using V shape instrument to billet hauling cost, we propose that some skidding instruments should be used and studied.

The damages to soil and seedlings was studied in this area (Ghaffarian, 2003) too, the authors offered to plan skid trails carefully before logging to decrease site damages by mule logging, so it is necessary to note that hauling cost will increase if hauling distance increase and logging planners should pay much attention to both site damages and hauling costs. In order to achieve costs of this system, another research plan should be carried out on prossecing cost of woods so that they have suitable weight and dimensions.

It is needed to carry out the research plans on the comparison of mechanized logging systems and animal logging systems based on economical and environmental issues.

Because of the huge amount of traditional wood products and low amount of sawlogs, we offered to extract the sawlogs as much as possible inorder to achieve more added value, prevent the wood wastage at the stump and decrease the satnd damages caused by mule logging.

5. SUMMARY

This study was carried out to measure cost production of mule logging and products of this traditional processing method. Using time study method, production of the mule logging was obtained, also the predicting hauling models for pulpwoods, billets and billets hauled by especial instrument were developed, skidding distance was a significant variable in the models and this is similar to the results of the other researchers as Wang (1997) and Rodriguez (1987), but the production rate is lower than the production of mule skidding in Alabama and the other places, it may be related to the different extracting method, because in Northern forests of Iran, the pulpwoods or lumbers are hauled on the mules, so they are not skidded as animal skidding in the USA, China and the other countries. In slope area, heavy loads can not be hauled by mules and productivity is not so high. Therefore animal skidding equipment such as sledges, small sulkies or suitable saddles with chains adopted to the mules and forest condition of Iran should be made and tested on the operation.
6. LITERATURE CITED

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