LOG SKIDDING WITH FARM TRACTORS

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Abstract: *Farm tractors are a multipurpose tool with many applications, particularly in agricultural and forestry sectors activities. In the forestry sector, modified farm tractors can be used to skid logs from stump to landings, to transport logs in tractor-trailer, and to load and unload logging trucks. Log skidding with farm tractors skidding on grand is one of traditional extraction systems in flat and mid slope areas of Turkey, as in many other areas of World. In this study, after determination of skidding effective factors, a continuous empty- weighted time of farm tractor study was investigated. Empty-weighted study time of farm tractor was determined with digital chronometer total 130 times in study area. The empty-weighted time of farm tractors prediction models were found this study. Accordingly the models, slope of area, volume of log, number of log, class of ground, and feature of ground was the most important of effective factors logs skidding with farm tractors.*

1. Introduction

In many regions of the world, farm tractors are a multipurpose tool with many applications, particularly in agricultural and forestry sectors activities. In the forestry sector, modified farm tractors can be used to skid logs from stump to landings, to transport logs in tractor-trailer, and to load and unload logging trucks in Turkey (Ozturk and Akay, 2007).

Farm tractors have been used in forestry where the terrain conditions and the size of the forest operation are not limiting. In developing countries, mechanized harvesting machines are generally not favorable due to high capital investment and energy consumption, which is highly correlated with high fuel prices (Rodriguez, 1986). Farm tractors, on the other hand, have very low initial costs and relatively low operating cost comparing with harvesting machines. In developed countries, farm tractor logging systems have been also used in forest operations in cases where they provide efficient operation and reduce environmental damages. Farm tractors equipped with specialized logging attachments are often used by farmers to perform timber harvest during the winter in Scandinavian countries (Shaffer, 1998).

Log skidding with farm tractors skidding on grand is one of traditional extraction systems in flat and mid slope areas of Turkey, as in many other areas of World. Skidding with farm tractors operations occur on skid trails. In this study, using farm tractors in skidding operations effective factors and time of farm tractor study were discussed.

1.1. Skidding with Farm Tractors

The productivity of the skidding operation with farm tractors is often limited by the type of soil, terrain conditions, and the size of trees and their accessibility. To improve the productivity and efficiency of the

skidding operation, directional felling techniques should be applied. Directional felling may also reduce labor cost, residual stand damage, and soil compaction. According to, the percentages of the damaged trees were from 0.5% to 1.5% during a thinning operation by a farm tractor. Skid trails should be well planned and located in the harvesting unit before directional felling takes place. The average skid trail distance mostly used in farm tractor skidding operations varies from 30 to 70 m (Anonymous). The winch-attached tractors are used for uphill extraction of logs for distance of 30 m to 50 m (Heinrich, 1987).

There are two common methods to perform skidding with farm tractors; winch and grapple. The grapples are used to skid logs only on level grounds since the farm tractor has to drive to each log (Carbaugh, and Hensle, 2005). The farm tractors attached with a winch system can skid logs downhill, up to 25 % ground slope (Heinrich, 1987). The winch-attached farm tractor logging is the least cost farm tractor logging system because it requires least amount of additional investment (Shaffer, 1998).

In order to use farm tractors in a skidding operation, they have to be modified and following equipment should be attached (Cadorette, 1995; Shaffer, 1998; Anonymous).

- Three-point hitch is used to anchor the winch on the ground and to raise the ends up.
- A special logging winch is required to skid logs.
- Chain chokers are to be used to skid multiple logs per turn.
- The pulley has to be installed to pull the timber from stump to the trail in a straight line.
- The farm tractors must be equipped with a protective cab or roll bars for operator's safety.
- To provide stable skidding operation, extra weight should be located on the front end of the tractor.
- To improve traction on soft ground or snow, tire chains should be installed on the rear wheels.

Farm tractors should be located on level ground and in line with the pulling direction with less than 30 degrees sideways (Anonymous). Pulley can be used to prevent winching sideways, as well as to overcome various difficulties such as limited space on the skid road, obstacles, or inaccessible areas (Cadorette, 1995). Before winching the logs, tractor brakes should be applied and three-point hitch should be lowered down on the ground. Then, logs are attached butt first to the main cable by using chain chokers. Winching should be performed by applying the power gradually and it should be stopped when the logs approach to the tractor within 2-3 m (Anonymous). Then, three-point has to be raised to skid logs to the landing area. The logs can be loaded into the logging trucks by using grapple loader mounted on a modified farm tractor (Akay, 2005).

2. Materials and Methods

2.1. Materials

The study was made in a beech (Fagus orientalis Lipsky) and a pure fir (Abies bornmulleriana Mattf.) forest. The study area is in the 48, 51, 53, 54, 68, 69, 74 and 75 numbered compartments of Duzce Balikli Forest, Turkey. Balikli Forest covering a surface area of 5822 ha is located in the West Black Sea geographical region between latitudes 40º 38' 40" - 40º 42' 40" N and longitudes 30º 57' 35" - 31º 06' 45" E. According to the data given by Duzce meteorology station, average annual precipitation is 884.9 mm, average annual moisture ratio is 76%, average annual temperature is 13.3ºC, high temperature is 42.0ºC and low temperature is -20.5ºC. The climate of Balikli Forest is cool in summer and cold in winter. Average altitude of the study area is 1300 m above sea-level.

The forest was an untended stand, middle old, with an average height of 30 m, average diameter (d.b.h.) of 52 cm and density of 1330 trees/ha. Selecting felling was practiced. Skidding was of logs 1.50 to 9 m long with a minimum middle diameter of 20 cm. Skidding was downhill on an average slope of 22 percent and an average distance of 389 m.

2.2. Methods

Skidding distance (m), power of tractor, number of in each travel, total volume of logs in each travel (m^3), condition of ground, classify of ground, and slope of area are important effective factors of logs skidding with farm tractors skidding on grand operations and time of farm tractor study.

In this study, after determination of skidding effective factors, a continuous empty- weighted time of farm tractor study was investigated (Figure 1). Empty- weighted study time of farm tractor was determined with digital chronometer total 130 times in study area. Methods of time calculate was continues time calculate in this study (Aykut, 1972).

Figure 1. Logs skidding with farm tractor using chain drag on skid trail (Duzce, Turkey)

Logs which were skidded with farm tractor at landing location were volume calculated diameter by diameter gauge and length by meter for their volume determining. Skid trails were sampled at different points at 10 m intervals for soil compaction. Soil compaction was measured at 0-5 cm and 5-10 cm depths by using a hand penetrometer (Figure 2).

Farm tractors in skidding operations and time of farm tractor study were effected factors (independent) which were described xii that were meant different unit. They were grouped or to be real unit. Dependant factors were described yii. Blow, xii and yii were explained.

- x1= power of tractor,
- x2= number of in each travel,
- x3= total volume of logs in each travel,
- x4= condition of ground,
- x5= classify of ground,
- x6= slope of area,
- x7= soil compaction (0-5 cm depths),
- x8= skidding distance,
- y1= weighted time of each travel to extract logs (sec),
- y2= empty coming time of each travel (sec),

Multiple regression analysis was used for determining empty- weighted of time study time of farm tractor. The coefficient of the multiple correlations (R^2), standard errors estimate (Sxy) etc. were calculated. Optimal equation of calculated equations was selected as statistical.

3. Results

Empty- weighted of time study time of skidding logs with farm tractor is real time 100 m distance. Table 1 shows results which are mean value, maximum, minimum, standard deviation of xii and yii.

Table 1. Results of xii and yii logs skidding extract with farm tractor

Variables	Unit	Minimum	Maximum	Mean Value	Standard Deviation
Slope	%	13	31	22	5.7
Power of tractor	HP	50	82	59	8.8
number of in each travel	num	1	7	2	1.2
volume of logs in each travel	m^3	0.196	6.455	1.614	1.02
empty coming time of each travel	sec	18	530	147	130.7
weighted time of each travel	sec	20	687	198	170.6
condition of ground	-	1	2	1.08	0.3
classify of ground	-	2	4	3.26	0.475
empty coming time 100 m distance	sec	11	172	46	29.5
weighted going 100 m distance	sec	13	185	61	36.8

According to results of multiple regression analysis, equations of empty- weighted of time study time of logs skidding with farm tractor were calculated. Table 2 shows result of equations.

Table 2. Results of multiple regression analysis of empty- weighted of time study time

Number	1	2	3	4
y	sqrt y1	sqrt y1	lg10 y2	ln y2
Constant	-28.000	-30.663	1.757	4.045
x1	-1.046	-1.265		
x2	0.711			
sqrt x3	2.113	2.554		
x4	4.138	5.060	0.537	1.236
x5	-1.490	-1.983	-0.221	-0.509
x6	1.604	1.960	-0.110	-0.253
lg10 x7	10.894	12.267		
sqrt x8	0.385	0.383	0.036	0.084
Adjusted R^2	0,749	0.741	0.690	0.690
Sxy	2,939	2,986	0,235	0,541
F	49,052	53,635	72,911	72,911
p-level	0.000	0.000	0.000	0.000

The optimal model could be described for weighted of time study time of logs skidding with farm tractor (Number 1) as shown below.

$$y1 = -28 \oplus (-1.046x1) \oplus (0.711x2) \oplus (2.113 sqrtx3) \oplus (4.138x4)$$
$$\oplus (-1.490x5) \oplus (1.604x6) \oplus (10.894 lg10x7) \oplus (0.385 sqrtx8) \tag{1}$$

where y1, x1, x3, x4, x5, x6, x7, and x8 are weighted time of each travel to extract logs, power of tractor, number of in each travel total volume of logs in each travel, condition of ground, classify of ground,

slope of area, soil compaction (0-5 cm depths), and skidding distance. y1 which was done normal range was applied sqrt transform for its normal range. As a result of regression analyst, numbers 1 and 2 equations were obtained. Number 1 equation is optimal equation. According to the equation, weighted of time logs skidding with farm tractor are affected power of tractor, number of in each travel total volume of logs in each travel, condition of ground, classify of ground, slope of area, soil compaction (0-5 cm depths), and skidding distance. In addition, weighted of time logs skidding with farm tractor is inverse ratio with power of tractor, classify of ground and direct proportion with number of in each travel total volume of logs in each travel, condition of ground, slope of area, soil compaction (0-5 cm depths), and skidding distance.

The optimal model could be described for empty study time of farm tractor (Number 3) as shown below.

$$y2 = 1.757 \oplus (0.537 x4) \oplus (-0.221 x5) \oplus (-0.110 x6) \oplus (0.036 sqrt x8) \tag{2}$$

where y2, x4, x5, x6, and x8 are empty study time of farm tractor, condition of ground, classify of ground, slope of area, and skidding distance. y2 which was done normal range was applied logarithmic transform for its normal range. As a result of regression analyst, 3 and 4 numbers equations were obtained. Number 3equation is optimal equation. According to the equation, empty study time of farm tractor are affected condition of ground, classify of ground, slope of area, and skidding distance. In addition, empty study time of farm tractor is inverse ratio with classify of ground, slope of area and direct proportion with condition of ground, skidding distance. Others independent factors were found that is not important level as statistical.

4. Conclusion

This study presented a discussion on applying logs skidding with farm tractors on skid trails operations. Logs skidding with farm tractors can be limited by some factors including skidding distance, power of tractor, number of in each travel, total volume of logs in each travel, condition of ground, classify of ground, and slope of area. Results of multiple regression analysis, optimal models of empty- weighted of time study time of logs skidding with farm tractor were found. These are base that optimum skidding model be should constitute with optimization algorithms for log skidding with farm tractors skidding on skid trails.

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