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Assessment on Uphill Yarding with the Combination of Log Chute and Portable Winch

H. Hulusi Acar[1*], Saliha Unver-Okan[1], Kemal Ucuncu[2]
[1] Karadeniz Technical University, Faculty of Forestry, Dept. of Forest Engineering 61080, Trabzon, Turkey
[2] Karadeniz Technical University, Faculty of Forestry, Dept. of Forest Ind. Engineering, 61080, Trabzon, Turkey

Abstract

In forestry, it is important that wood production activity, which intervenes most with the ecosystem, should be performed by a minimum quality and quantity losses on wood, along with minimum damage to residual stand. Besides, it is also of a great importance that the operation should be done ergonomically. In this study, the use of an integrated system that consists of a portable winch and chute system was evaluated in the uphill yarding of logs in a mountainous terrain. The average speed of uphill yarding using a portable winch was 14.97 m/min and the productivity was calculated as an average of 5.92 m^3/hour. Statistically, it was determined that the log volume and winching time were the main factors that affect the productivity. Also, it was found that the size of the log and skidding distance are effective on winching time. Moreover, it was confirmed that the speed of uphill yarding did not change significantly considering the different volumes of logs. The portable winch, which has a reasonable price that can be afforded by forestry workers, is productive, environmentally friendly, and multi-purposed equipment. This system combining log chute and portable winch has provided an important alternative by which logging operation can be done easily in an ergonomic way and forest managements can fulfil their duties within the course of planned time without any setbacks.

Keywords: Portable winch, Chute system, Uphill yarding, Productivity, Mountainous terrain

1. Introduction

With the rise of the public awareness towards the environment in recent years, reducing human interference on the ecosystem and minimizing its environmental impact has gained great importance. Due to this trend, instead of considering only economic constraints, current concept requires evaluation of environmental and ergonomic criteria along with economic constraints during forestry activities (Acar and Unver, 2005).

In Turkey, the forestry sector is one of the top industries which has a yearly average working capital of 2 billion 567 million Turkish Liras. About 90% of this working capital is gained by the sales of wood based forest products (e.g. logs, industrial woods, poles, etc.), while production costs constitute almost 37% of the total expenses (GDF, 2015). Thus, it is crucial that the wood products should be brought into the economy without any quality and quantity losses (Unver and Acar, 2009a). In recent years, with the technological improvements and development of the industry, it is possible to make use of wood based products in many sizes and in many possible ways.

The harvesting activities mainly consist of tree cutting, extraction and transportation stages. Especially in mountainous terrain, lack of mechanization can increase operation cost and cause reduction in value of the wood based products during the harvesting activities (Murphy and Twaddle, 1985; Pape, 1999; Spinelli, 1999; Acar and Senturk, 2000). In Turkey, ground-based skidding methods have been used during most of the log extraction activities. In previous studies, it has been emphasized that ground-based skidding methods can lead to a variety of damages to residual stands, forest soil, wildlife, and water resources (Pereira et al., 2002; Gomez et al., 2002; Bozic, 2003; Akay and Erdas, 2007; Yılmaz and Akay, 2008; Unver and Acar, 2009b). Therefore, alternative harvesting techniques that minimize not only the costs but also environmental damages must be implemented.

In Turkey, more than half of the forest lands are located on steep ground where uphill yarding can be the most difficult problem during wood extraction activities. The cable winching systems operated by tractors (i.e. skidders and farm tractors) and small percentage of cable yarding systems are generally performed in mountainous areas (Erdas et al., 2014). Approximately 10% of the timber in Turkey is extracted by using rubber-tired tractors. In addition,

[*]Corresponding author: Tel: +90 4623772817 E-mail: hlsacar@ktu.edu.tr
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modified with a variety of equipment and reinforced farm tractors are used for skidding, pulling, loading and transportation operations (Ozturk and Akay, 2007).

As an alternative extraction method, log chute systems have been introduced to Turkish forestry by Acar et al. (2005) for cost-efficient extraction of firewood. Acar and Unver (2005) reported that using chute systems in downhill yarding of the logs also reduces the damages on forest soil and provides easy and safer work environment. Later, uphill yarding of logs pulled by tractors and other motor system on artificial chute line were also studied in some studies (Acar and Unver, 2012a; Acar and Unver, 2012b).

The log chute system combined with cable pulling of forest tractors can be an effective alternative to the cable cranes up to 100 m transportation distance, however this method requires a dense forest road network. Thus, portable engine power is necessary for some areas where transportation distance is longer than 100 m and dense road network is not available. The first study about log extraction by using a portable winch in Turkey was carried out with a semi-mechanized motor system on an artificial chute line by Acar and Unver (2012a). In this study, the motor system was secured on the ground by four feet and connected to at least two anchor trees. It was suggested that the engine could operate with a single button through development of fully mechanized system.

In recent years, some studies were carried out on using a portable hand winch system during logging operations on various slope classes, with or without a skidding cone (Gulci, 2014; Akay et al., 2014a). Besides, a chute system integrated with portable winch were also evaluated in limited number of studies (Akay et al., 2014b; Gulci et al., 2014; Acar and Ucuncu, 2015).

In this study, it was aimed to study uphill yarding of logs on chute system integrated with a portable hand winch and synthetic rope in mountainous terrain with steep slope. Regression models were developed to indicate the main factors that affect the productivity of the system. Besides, environmental effects of the system were examined.

2. Materials and Methods

This study was conducted within the border of Trabzon and Maçka Forest Management Directorates (FMD). Trabzon FMD is located between 41° 00' 07" N and 39° 43' 07" E, and Maçka FMD is located between 40° 49' 00" N and 39° 37' 00" E. In the region, summers are warm and humid, winters are cool and damp (Figure 1). Precipitation is heaviest in autumn and winter with a marked reduction in the summer months (URL-1, 2015). The study areas were selected from stands where timber productions are operated with standing sales method. The measurements were made from July to October in 2014. General properties of the study areas were given in Table 1.

Within the scope of this study; an artificial chute line that consists of polyethylene chute, synthetic rope with a diameter of 10 - 12 mm, and portable winch have been studied. The artificial line used in this study was produced of low density material, which was resistant to external effects such as crushing, tearing and crashing and consisted of half-circle-shaped polyethylene chutes (Table 2).

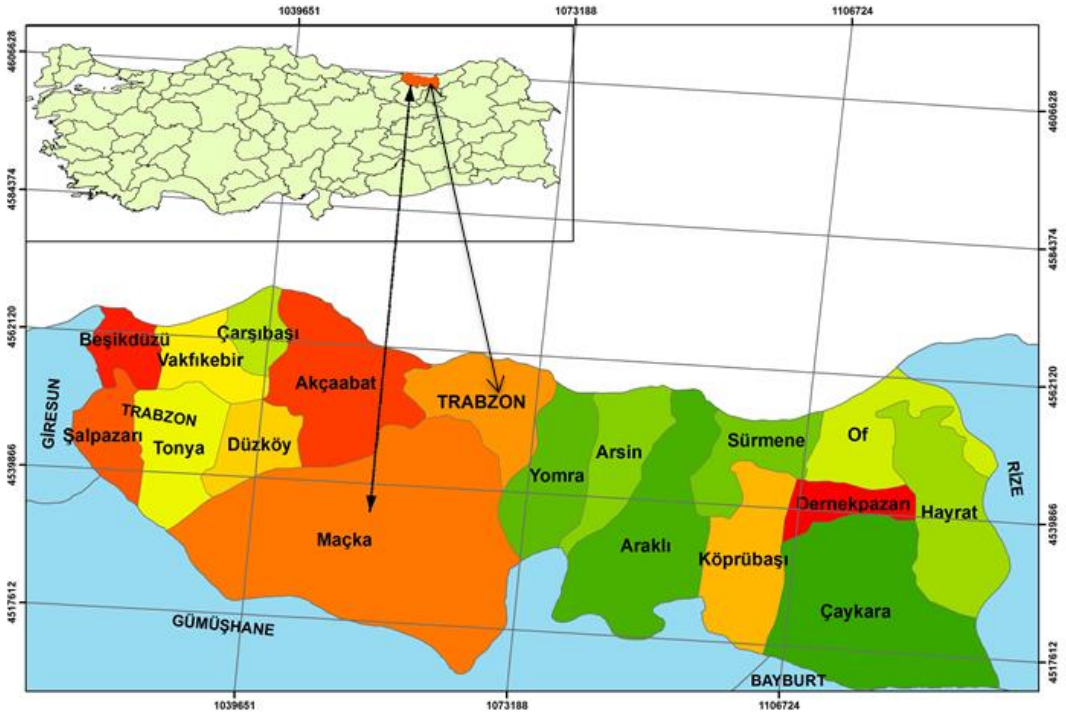

Figure 1. Map of the study area

Table 1. General properties of the study areas

Properties	Study Areas		
FMD	Trabzon	Maçka	
Forest Enterprise	Akçaabat	Maçka-Çatak	Maçka-Çatak
Compartment No	269	106	107
Stand type	Lcd2*	Lcd3**	Lcd3**
Canopy	2	2	2
Slope (%)	90	70	70
Elevation (m)	1607	1600	1600
Aspect	North	West	West
Skidding distance (m)	84	91	35
Number of chutes (unit)	12	13	7
Number of labors (unit)	2	3	2
The transportation direction	Uphill	Uphill	Uphill

*Lcd2, *Picea orientalis* (L.) Link, middle-aged and elderly, from 0.41 to 0.70 canopy
**Lcd3, *Picea orientalis* (L.) Link, middle-aged and elderly, from 0.71 to 1.00 canopy

Table 2. Properties of polyethylene chutes

Properties	
Shape	Semicircular (U)
Material	Corrugated Polyethylene Pipe SN4
Diameter (mm)	500
Thickness (mm)	4
Length (m)	7
Weight (kg)	25

The polyethylene chutes were brought to the testing ground with a truck without any interference such as cutting in the woods or opening a transport route. The chutes were put top-down, vertically against the contour lines. While installing the chute system, the workers slid the chutes down the hillside by pushing them. The disassembly of the system was done bottom to top. The disassembled chutes were tied to the cordage, two or three at the same time, and then pulled up with a hand-operated winch. The head of the lowest chute was installed to be pulled over the head of the chute above when the chutes were transported from bottom towards the top of the hill. In this way, it was aimed to prevent the logs caught in the places where the chutes were linked together (Figure 2).

The chutes were mounted to end portions with fixing screws each other and fixed to the ground with the support bars. Establishment of artificial route system took about whole day, demontage was performed only in a few hours. Transportation and mounting of the chutes was conducted by two workers, and the operation of the system was performed by an operator and these workers. Specifications of portable hand winch used in this study were given in Table 3.

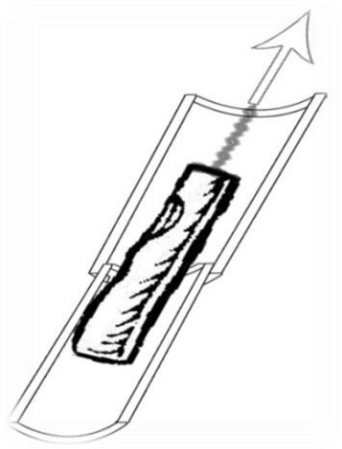

Figure 2. The position of polyethylene chute system

Table 3. Specifications of portable hand winch

Properties		
Type		PCW5000 portable hand winch
Max. drawing power (kg)	Single rope	1000
	Double ropes	2000
Weight (kg)		16
Engine type		Honda GXH-50cc (4 times)
Oil pan		0.25 Liter SAE 10W-30 API SJ oil
Fuel Tank (l)		1.2
Fuel Type		Unleaded gasoline
Fuel Consumption		340g/kwh
Study Time with Max. Power (h)		1.5
Max. drawing Speed (m/h)	85 mm drum	1080
	57 mm drum	720
Dimensions (cm)		33 x 38 x 36
Available Rope Diameter (mm)		10 - 16
Recommended Rope Diameter (mm)		12 - 13

The synthetic rope, chain choker (1.5 m), polyester choker (2 m), three metal locks and two metal hooks were used during the extraction of logs by a portable winch. Portable winch could be installed on trees or stumps with two metal hooks and polyester choker (Figure 3). The portable winch, synthetic ropes and apparatus could be moved easily by a single worker.

Figure 3. Installation of portable winch on a standing tree

In field studies, an inclinometer was used to determine the average slope of the study area and the UTM coordinates and altitude data were recorded by Garmin Oregon 650 GPS. Medium diameter and length of each log were measured by using MANTAX Precision caliper and Weiss (50 m) with a tape measure, respectively. A stopwatch was used to measure the skidding time. The volume of each timber was calculated by the Huber formula (Equation 1):

$$V=\pi/4*d^2*L \quad (1)$$

where V is volume (m^3), d is medium diameter of the log (m), and L is length of the log (m). The pulling speed of the timber (m/h) was calculated in Equation 2:

$$Speed=l/WT \quad (2)$$

where *l* is skidding distance (m) and WT sis kidding time (h). Finally, the productivity of the system (P) (m^3/h) was calculated in Equation 3:

$$P=V/WT \quad (3)$$

The time study was conducted by monitoring an average worker completing a task at a normal pace (Sable, 2014). During data collection, when the log was set onto the chute and was ready to be transported, the chronometer was started, and finally, when the log was off the chute system at the end, the chronometer was stopped and the time of transportation was calculated after which the stopwatch was reset again. To evaluate the main factors that affect the productivity of the chute system, statistical analysis (Regression analysis, F-test, ANOVA) was performed by using SPSS 13.0 software.

3. Results and Discussion

In this study, the use of an integrated system that consists of a portable winch and chute system in the uphill yarding of log in a mountainous terrain was evaluated. Logs were pulled up on the chute system having average slope of 35% and average distance of 55.8 m. The logs were moved upward with this system by average speed of 14.97 m/min. The average productivity was calculated as 5.92 m^3/hour. These results were consistent with Gulci et al. (2014) where productivity was 5.24 m^3/hour for a distance of 60 m chute system at 50% ground slope.

The average diameters and the average lengths of the logs were determined as 29.3 cm and 5 m, respectively. Average log volume transported per cycle was 0.428 m^3/cycle, and totally log volume of 19.88 m^3 was extracted in 3 hours. The average set up time of hand winch and average placement time of logs into the chute system were determined as 28 seconds and 37 seconds, respectively. The effects of skidding distance and volume per cycle on total cycle time were shown in Figure 4 and Figure 5, respectively. The results indicated that total cycle time increases as skidding distance and volume per cycle increase during logging operation.

The stepwise regression analysis was applied to determine fixed coefficient and F-test was performed for determining the compatibility of the coefficient. The first regression model was indicated in Equation 4:

$$WT=0.008 + 0.001*SD - 0.001*L \quad (4)$$

R^2= 0.965, F= 623.651 and p<0.01

where; the independent variables were log length (L) and skidding distance (SD), while the dependent variable was winching time in each cycle time (WT).

The coefficient of determination (R^2) was 0,965, and the significance level of ANOVA shows that the model was significant at $\alpha = 0.01$. The results of statistical analysis showed that the winching time was mainly affected by skidding distance and log length. Previously indicated that log size and skidding distance are the main factors that affect the cycle time (Wang et al., 2004). Several studies emphasized that the skidding distance was the most effective variable on skidding time which rises with increase of skidding distance (Naghdi et al., 2005; Ghaffarian et al., 2007).

In the second regression model, independent variables were winching time (WT) and log volume (V), while the dependent variable was productivity (P). The regression model was shown in Equation 5. The results from the regression analysis indicated that productivity was closely affected by log volume and winching time.

$$P=7.369+13.579*V-108.556*WT \quad (5)$$

R^2=0.895, F= 191.852 and p<0.01

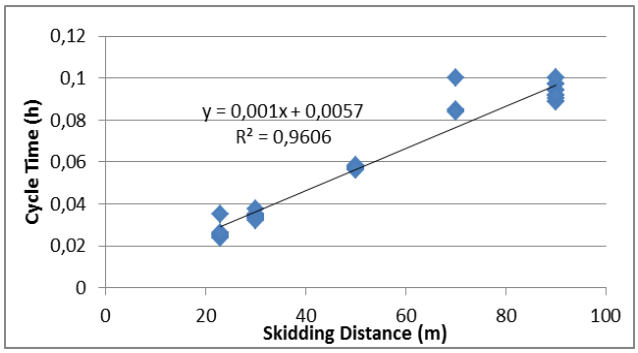

Figure 4. Effect of skidding distance on cycle time

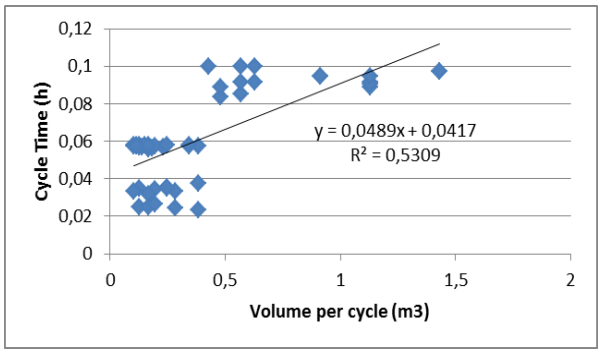

Figure 5. Effect of volume per cycle on cycle time

When the system is evaluated considering economic point of view; it can be said that the portable winch system is more cost effective than traditional mechanized logging systems. The portable winch can be used for large harvesting units since it is easy to install and uninstall the system in the stands. When considering environmental effects; it should be noted that there is no need for the opening corridors in the stand of an artificial chute system in the woods due to the fact that the natural spaces in nature are sufficient. The system causes a minimal stand damage since logs transported within the chute do not damage residual stand or forest soil. However, it was observed that partial and small injuries occurred on some residual tress near the beginning and the ending part of chute system due to uncontrolled logs hitting the trees during.

The system does not require specialized staff for operating the system. Besides, the fact that the portable winch and other necessary equipment can be easily carried by a single worker in the woods. The system set up can be done in a short amount of time and provides ergonomic operation environment by reducing the workload of the workers.

4. Conclusion

Extraction of the logs uphill by using chute s 38 integrated with portable hand winch is especially suitable and effective alternative in the forest areas without sufficient road networks. Statistically, it was determined that the size, volume, and winching time of logs have important effects on the productivity of the system. Also, it was determined that the size of the log and distance of ground skidding are effective factors in the ground skidding time. Moreover, it was confirmed that the speed of uphill yarding do not change considering the different volumes of logs.

The polyethylene chute system can be established through the space between the trees without any intervention in the forest. The logs could be skidded in chute system without contacting with the ground and damaging the residual stands.

In the operation, the workers took place during the process of tying the cords to the logs, putting the logs onto the chute system, taking the logs off of the chute system, and finally untiying the cords from the logs. The tying up and untying of the cords was done in a very short time without having any difficulties, it was observed that the worker could experienced some difficulties in the other actions.

The portable winch is a system that can be afforded by forest workers for an reasonable price. Besides, it is productive, environment-friendly and multi-purposed alternative. The workers can run the system easily, in a short time and ergonomically. Moreover, the forest managers can fulfil their job without running into any unexpected setbacks during operation. The following points should be considered for implementing chute system integrated with portable winch:

- The shorter chutes should be implemented in order to easily transport the system during installation or uninstallation stages.
- A flat polyethylene pieces should be placed on the end of chute system to ensure ease unloading of logs from the system.
- Stem protectors must be located on the trees especially at the beginning and end of the chute system in order to minimize the damages to the residual trees.
- Sufficient number of workers should be organized depending on the length of the chuting distance.
- The portable winch integrated with the chute system can double the pulling capacity if the synthetic cords are double wrapped around the winch drum.

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References

Acar H.H. and Ucuncu, K., 2015. Implementation of a Portable Winch System in Extracting of Timber Uphill Using Log Chute System and Log Cap in Mountainous Terrain. Karadeniz Technical University Project Code No: 10360, Trabzon, Turkey.

Acar, H.H. and Unver, S., 2012a. Implementation of the TOKK-M System for Timber Extraction Activities. *Faculty of Forestry Journal Süleyman Demirel University*. 13 (2): 103-106.

Acar, H.H. and Unver, S., 2012b. Working Efficiency during the Controlled Sliding of Logs in the Polyethylene Chute by Tractor Power (TOKK-T). *Faculty of Forestry Journal Süleyman Demirel University* 13(2): 97-102.

Acar, H.H. and Unver, S., 2005. Work Production of Extracting of Small Size Woods by Polyethylene Chute System: Its Application in The Giresun Region. *Journal of Forestry Faculty Gazi University* 5(2): 154-162.

Acar, H.H., Eroglu, H., Ozkaya, M.S., 2005. A Research on Possibilities of Extracting small-diameter woods by plastic chute system on mountainous terrain. OGM Project No: 2003A050090. Ankara, Turkey. 171p.

Acar, H.H. and Senturk, N., 2000. Mechanization in Wood Production Operations in Mountainous Forest Area. *Journal of Faculty of Forestry Istanbul University. Sery: B*, 46: 77-94.

Akay, A.E., Sert, M., Gulci, N., 2014a. Evaluating Productivity of Mobile Winch System Used in Logging Operation on Gentle Ground Slope. II. National Mediterranean Forests and Environment Symposium. 22-24 October, Isparta, Turkey.

Akay, A.E., Gulci, N., Gulci, S., 2014b. A Chute System Integrated with Mobile Winch and Synthetic Rope to Extract Logs in Mountainous Regions. 5th Forest Engineering Conference with 47th International Symposium on Forestry Mechanisation. 23-26 September. Gerardmer, France.

Akay, A.E. and Erdas, O., 2007. Estimating Rut Depth during Skidding with A Rubbertired Skidder. SDU *Faculty of Forestry Journal Süleyman Demirel University* 1:49-57.

Bozic, T., 2003. Impact of Forest Harvesting, Alberta Government, Agriculture, Food and Rural Development, November 28.

Erdas, O., Acar, H.H., Eker, M., 2014. Transport Techniques for Forest Products. KTU Faculty of Forestry. Publish No: 233/39, Trabzon, Turkey. 504 p.

General Directorate of Forestry (GDF), 2015. 2015 Revolving Fund Budget. Ministry of Forest and Water Affairs, General Directorate of Forestry. Ankara, Turkey. 154 p.

Ghafarian, M.R., Stampfer, K., Sessions, J., 2007. Forwarding productivity in Southern Austria. *Croatian J. For. Eng.,* 28:169-175.

Gomez, A., Powers, R.F., Singer, M.J., Horwath, W.R., 2002. Soil Compaction Effects on Growth of Young Ponderosa Pine Following Litter Removal in California's Sierra Nevada. *Soil Sci. Soc. Am. J.* 66: 1334-1343.

Gulci, N., 2014. Researches on precision forestry in forest planning. Phd thesis, Kahramanmaraş Sütçü İmam University, Faculty of Forestry, Kahramanmaraş, Turkey. 264 p.

Gulci, N., Erdas, O., Acar, H.H., Akay, A.E., 2014. Economic and Ecological Evaluation of Chute System in Extracting Large Size Logs in Mountainous Regions. TUBITAK 113R001 Research Project Report, Ankara, Turkey. 93 p.

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

Ozturk, T. and Akay, A.E., 2007. Modifying Farm Tractors for Forest Harvesting Operations. The 150th Anniversary of Forestry Education in Turkey International Symposium: Bottlenecks, Solutions and Priorities in the Context of Functions of Forest Resources. 17-19 October 2007, Istanbul, Turkey. pp. 1111-1120.

Pape, R., 1999. Effects of Thinning Regime on the Wood Properties and Stem Quality of Picea abies. *Scandinavian Journal of Forest Research*. 14:38-50.

Pereira, R.J., Zweede, J.C., Asner, G.P., 2002. Forest Canopy Damage and Recovery in Reduced Impact and Conventional Logging in Eastern Para, Brazil. *Forest Ecology and Management*. 168:77–89.

Sable, S.R., 2014. A Study of Labor Productivity through Application of Stop Watch Time Study Method and Most in Skoda Auto India Private Limited. PhD Thesis. SNDT Women's University. Nasık, India. 331 p.

Spinelli, R., 1999. The Environmental Impact of Thinning: More Good Than Bad? IUFRO 3.09.00 Harvesting and Economic of Thinning. pp. 136-143.

URL-1. 2015. http://en.wikipedia.org/wiki/Trabzon #Climate (Accessed date: 20.05.2015).

Unver, S. and Acar, H.H., 2009a. A Damage Prediction Model for Quantity Loss on Skidded Spruce Logs during Ground Base Skidding in North Eastern Turkey, *Croatian Journal of Forest Engineering*. 30(1):59-65.

Unver, S. and Acar, H.H., 2009b. Evaluation of Residual Tree Damage in Sloping Areas Due to Harvesting Operations by Manually. *Austrian Journal of Forest Science*. 126(3):119-132.

Wang, J., Long, C., Mcneel, J., Baumgras, J.E., 2004. Productivity and Cost of Manual Felling and Cable Skidding in Central Appalachian Hardwood Forests, *Forest Product Journal*, 54: 45–51.

Yılmaz, M. and Akay, A.E., 2008. Stand Damage of a Selection Cutting System in an Uneven Aged Mixed Forest of Çimendagi in Kahramanmaras-Turkey. *International Journal of Natural and Engineering Sciences*. 2 (1): 77-82.