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An Analysis of Utilizing Helicopter Logging in Turkish Forestry

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Abstract: Harvesting operations in Turkey are performed using traditional methods employing mostly animals and manpower for skidding and tractors mainly for winching. To apply these methods efficiently, the trees have to be bucked into short lengths logs (3-4 m), which reduces log values and overall profits. To produce longer logs, aerial harvesting methods such as cable logging and helicopter logging could be implemented, especially in productive forests located in steep mountainous regions of Turkey. Almost all of the forests in Turkey are state forests and managed by the General Directorate of Forestry (GDF). The GDF uses helicopters in firefighting activities; however, helicopters have not been used in harvesting operations. Using helicopters in both firefighting and harvesting may increase the utilization rate of helicopters and reduce the average helicopter unit cost. The purpose of this study is to identify the factors affecting the cost and productivity of helicopter logging and to analyze the utilization of helicopter logging in Turkish forestry.

Key words: Forest transportation, helicopter logging, harvesting cost, Turkey

INTRODUCTION

In Turkey, the application of mechanized harvesting is currently limited since harvesting machines are very expensive and highly correlated with the fuel prices (Akay *et al*., 2004). They are also undesirable due to negative effects of mechanization on the workforce. In Turkey, most of the harvesting operations are performed using animals and manpower while mechanized equipment (i.e., tractors) are employed in some areas for mainly winching logs. The percentages of using manpower, animals, mechanized equipment and skylines in the harvesting operations are 75, 15, 7 and 3%, respectively (Akay and Sessions, 2004).

In Turkish forestry, the trees have to be bucked into short lengths logs (3-4 m) since longer logs can not be handled easily by traditional harvesting methods. Also, the standards of the forest roads are low, which will not allow using large logging trucks to haul longer logs. Thus, producing short logs reduces the log values, which leads to significant reduction in the potential profits. To produce and transport longer logs, aerial harvesting methods such as cable logging and helicopter logging could be implemented, especially in productive forests located in steep mountainous regions of Turkey. Cable systems are not used very often by the logging contractors due to lack of experienced and skilled cable yarding operators. The General Directorate of Forestry (GDF) utilizes helicopters in firefighting activities; however, helicopters have not been used in harvesting operations. In Turkey, helicopter logging can be used in harvesting high quality logs and in extraction of mature trees in environmentally sensitive areas where road construction and logging operations are restricted. This study aims to identify the variable factors influencing the productivity and cost of helicopter logging and to present an overview of utilizing helicopter logging in Turkish forestry.

Helicopter harvesting is an aerial harvesting system whereby logs are removed vertically from the forest and flown to a roadside landing or drop zone (Chua, 2001). Commercial helicopter logging, also called as helilogging, dates back to early 1970's in the Pacific Northwest of the USA and in Western Canada. Table 1 shows various helicopter models and their load capacities. Helicopter logging plays an important role in timber production by providing logging managers with advantages of applying environmentally friendly harvesting practices and ecologically based silvicultural treatments and harvesting from timber salvage sites and by enabling access to unreachable areas due to extreme terrain conditions or remoteness from the road network (Christian and Brackley, 2007).

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Compared with ground-based logging methods, helilogging operation increases the woody biomass regrowth and minimizes the soil disturbance and sediment yield (Aust and Lea, 1992). Table 2 compares various harvesting systems. In order to develop a productive and cost effective helilogging system, the stages of the logging operation should be carefully planned and implemented considered various working conditions and different helicopter models.

The felling operations should be planned ahead of time and proper felling techniques should be implemented during the operation. Felling should be done prior to move in of the helicopter since the felling production may be much lower than the helilogging production due to hard working conditions (Stampfer *et al*., 2002). Directional felling should be performed. The trees should be bucked into suitable log sizes according to optimum payload capacity of the helicopter and logs selected for each trip should be marked clearly (Hartsough *et al*., 1986). The logs should be pre-bunched for lifting and any obstacles should be moved away from the area (Chua, 2001).

After felling and bucking, the logs are extracted by the helicopter. In helilogging, the logs are carried by a grapple or load-hook, which is positioned at the end of a lifting cable below the helicopter. In more recent helilogging operations, double load-hooks are utilized so that pilots can release some of the logs when the load exceeds the payload capacity (Krag, 1995). The grapple can be controlled electrically, hydraulically, or mechanically. The following factors should be considered during the lifting operation:

- The length of the lifting cable might range from 75 to 100 m (Chua, 2001).
- During each trip, the grapple or load-hook should target precisely the point where logs are prepared for lifting (i.e., well-experienced and trained pilots are required for helilogging) (Sloan *et al*., 1994)
- If there is a logging crew on the ground, they should stay clear when helicopter is picking up the logs
- After picking up the logs, the helicopter lifts the logs clear of the forest and then flies to the landing area (Stampfer *et al*., 2002)
- Heavy logs should be extracted near the end of fuel cycle (i.e., weight of the helicopter is low) (Chua, 2001) and when the air temperature is coolest (air is dense).
- In helilogging, the helicopter is usually flown by two pilots; one for flying the helicopter and monitoring the operation and other for controlling the instruments in the helicopter (Chua, 2001).

At the final stage of the helilogging, the logs are flown to the landing area and placed on the drop zone (Chua, 2001) (Fig. 1):

- The landing areas should have a well organized drop zone with enough space to ensure an efficient and safe helilogging operation.
- To perform economically, the location of the landing area should be determined by considering the optimum flying distance (e.g., flying distance should be within 2 km).
- The pilots should gently place the logs on the ground to minimize log damage.
- The landing area should be large enough to pile logs since helicopter logging has a very short cycle time.

Table 1: Scheduled payload capacities for some logging helicopters reported by various helilogging companies (Logging and Sawmilling Journal- Dec 2000/Jan 2001)

Company	Make/model	Maximum payload (kg)
Advantage HeliLog	Bell 204/205	1800
Black Tusk Helicopters Inc.	Bell 214B	3600
Cariboo Chilcotin		
Helicopters Ltd.	KMax	2700
Helifor Industries Ltd.	Boeing Vertol	4800
Pacific International Helilog	Sikorsky S-61	12700
Tundra Helicopters	Sikorsky S58ET	4500
Vancouver Island		
Helicopters Ltd. Kamov	KA 32	2300
Wildcat Helicopters Inc.	Bell 21	1800

Table 2: Comparisons of various harvesting systems (Far Eastern Aerostatic Center, Russia)

Parameters	Helicopter Mi-8 MTV	Balloon logging Q = 3t	Skidding CAT TT-4	Cable system ML-43	Timberjack Harvester1270 Forwarder 1110
Scheduled payload, (m^3)	2-3	2-3	8-14	2-4	8-10
Shift output (m^{-3})	100-150	100-120	60-80	30-50	200-250
Operating personnel	6	8	7	8	3
Purchase price ($)	3,500,000	200,000	25,000	45,000	700,000
Forest roads check	-	-	v	v	v
Undergrowth damage (%)	0	0	80	75	60
Soil deterioration (%)	0	0	100	80	100
Noise affect (%)	100	0	100	50	100
Safety of work (%)	0	80	50	80	50
Flying distance (km)	3-5	1.5-2	0.3-0.5	0.3-0.5	0.3-0.5

Fig. 1: Lifting (left) and landing (right) operations in helilogging (Ericson Air-Crane Inc., USA)

- The number of logging crew members at the landing should be kept low to avoid accidents.

Timber volume per unit area, stem volume and optimum payload capacity are critical parameters that affect the productivity of helilogging (Krag, 1995). An experienced ground crew and pilot increase the productivity in helilogging (Hartsough *et al*., 1986; Sloan *et al*., 1994). Jackson and Morris (1986), in South Carolina, reported that the unit cost of helilogging (using Boeing Vertol07 II with the average cycle time of 2.57 min) under excellent weather and timber conditions was about \$23 m^{-3} with production rate of 78.5 m^3 h^{-1} and hourly cost of \$1,781.

Sloan *et al*. (1994) studied helilogging in Virginia where they reported that the unit cost of helilogging (using KMAX with the average cycle time of 2.2-3.0 min) was about \$82 m^{-3} with production rate of 21.0 m^3 h^{-1} and hourly cost of \$1,713. They reported that the productivity and cost of helilogging is mainly affected by the loading operation, flying distance and pilot experiences. In another study, Sloan and Sherar (1997) reported that the unit cost of helilogging (using KMAX) was about \$60 m^{-3} with production rate of 37.2 m^3 h^{-1} and hourly cost of \$2,232. In their study, estimation of suitable payload sizes was the main factor affecting the productivity of the helilogging.

A study conducted by Stampfer *et al*. (2002) reported that the productivity of the helilogging (using KMAX) highly depended on average stem volume and flying distance. They also reported that predetermined felling directions and bunching the logs prior to lifting operation increased productivity. According to Stampfer *et al*. (2002), a well-experienced helicopter pilot resulted in a 63% increase in productivity of helilogging operation. Optimum payload is one of the major factors, which may be affected by silvicultural treatment (Wang *et al*., 2005). Various retention levels reflects the load per turn based on the site conditions (Lyons and McNeel, 2004).

Wang *et al*. (2004a, b) reported that helilogging (using Boeing Vertol-107 with the average cycle time of 3.29 min) was 6 and 11 times more expensive than grapple and cable skidders, respectively; but the production rate of helilogging operation was 1.5 to 2.8 times more than these ground-based methods. They found that the unit cost of helilogging was about \$64 m^{-3} with production rate of 23.04 m^3 h^{-1} and hourly cost of \$1,479.

MATERIALS AND METHODS

In Turkey, the GDF uses helicopters in various forestry activities such as fire fighting, forest protection, wildlife management, shipping and other activities. The GDF owns USA-designed Eurocopter AS-355 F-2 Ecureuil II/Twin Star and Aerospatiale AS-365 Dauphin II" model helicopters mainly for monitoring, reconand picture taking (Fig. 2). The GDF utilizes Russian- designed Mil Mi-8M series helicopters for fire fighting activities (Fig. 3). The

Fig. 2: AS-355 F-2 Ecureuil II (left) and AS-365 Dauphin II (right) model helicopters

Fig. 3: Mil Mi-17 Hip-H (left) and Mil Mi-8MTV-1 (right) model helicopters

Mil Mi-17 Hip-H model helicopters, owned by the Military Police (Gendarme), are used during the fire season, based on a protocol between the GDF and the Gendarme. The GDF also rents a number of Mil Mi-8MTV-1 model helicopters for fire fighting activities.

Since Mil Mi-8MTV-1 series helicopters are not owned by the GDF and are utilized for only for fire fighting activities, they are not available for helilogging. The AS-355 F-2 Ecureuil II can not be employed in helilogging due to limited payload capabilities. Thus, AS-365 Dauphin II is the only helicopter model owned by the GDF which can be available for helilogging operations in Turkey. The hourly cost of renting the Mil Mi-8MTV-1 is about $3000. The option of renting additional helicopters specifically for helilogging was not considered for this study. Therefore, the analysis of utilizing helilogging was performed for the AS-365 Dauphin II model helicopter.

AS-365 dauphin II: The AS-365 Dauphin II (Fig. 4) is categorized as a medium twin engine helicopter with following specifications (Eurocopter, 2007):

- With standard seat configurations, the AS-365 can carry 1 or 2 pilots and 8 passengers
- The empty weight (including engine oil and fuel) and maximum take-off weight are approximately 2400 and 4300 kg, respectively
- The maximum external cargo sling payload capacity is about 1600 kg
- With maximum take-off weight, the recommended cruise speed and hourly fuel consumption at this speed is 269 km h^{-1} and 314 kg h^{-1}, respectively
- The maximum continuous power is about 600 kW (800 HP)
- The helilogging operation with the AS-365 Dauphin II has some operating limitations such as maximum flight altitude of 4575 m, maximum temperature of 50°C and minimum temperature of -40°C.

Machine rate estimation: The unit cost of helilogging can be estimated by dividing the hourly equipment cost of the helicopter (machine rate) by the production rate. The machine rate is divided into three components; labor costs, ownership costs and operating costs. The hourly cost of labor is estimated as $150 h^{-1}.

The ownership cost components include depreciation cost, interest cost and insurance, tax and storage costs of the equipment. The yearly depreciation cost is function of initial purchase price, salvage rate and economic life. The initial purchase price, salvage rate and economic life were estimated as $3.5 million, 25% and 16 years (i.e. considering 20000 h service life and 1250 flight h per year

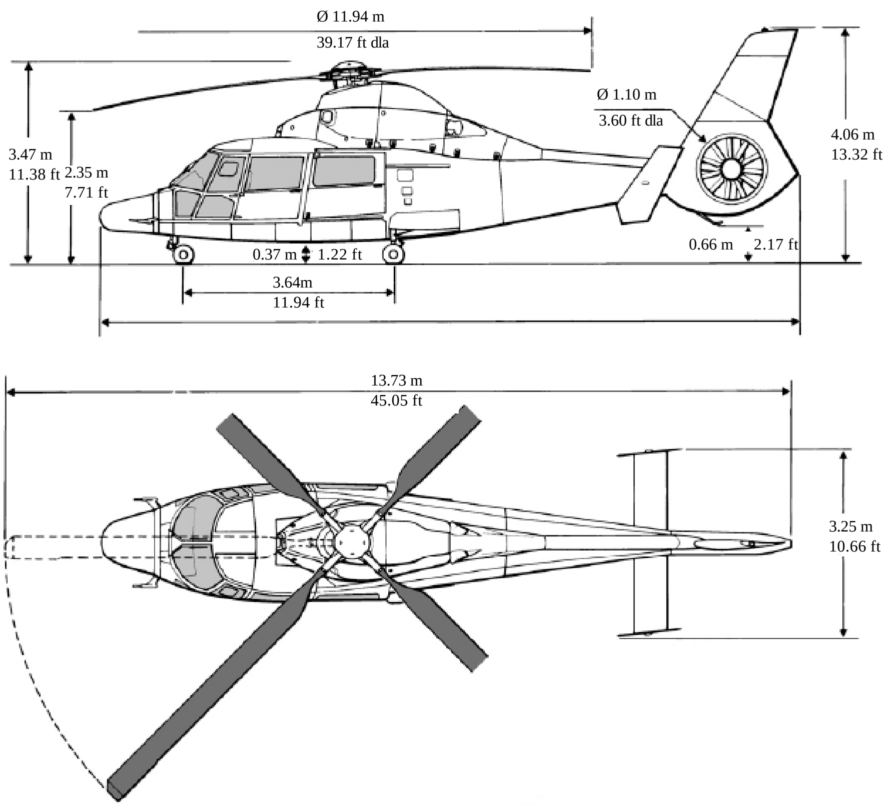

Fig. 4: Dimensions of an AS-365 Dauphin II (Eurocopter, 2007)

with 60% utilization rate). The interest costs can be calculated by multiplying the interest rate (18%) by the average annual investment (Akay and Sessions, 2004).

The costs of insurance, taxes and storage are computed as a function of the initial purchase prices. The total rate of these three factors is estimated as 11.5%. The main operating cost components include maintenance and repair costs, fuel cost and lubricant cost. The maintenance and repair cost can be estimated as a percent of depreciation. Wang *et al*. (2005) suggested that the maintenance and repair rate was 100% of the depreciation of the helicopter. Fuel and lubricant costs can be computed based on hourly fuel consumption rate (314 kg h^{-1}), weight of fuel per liter (0.84 kg L^{-1}) and local unit prices.

RESULTS AND DISCUSSION

In Turkish forestry, the trees have to be bucked into short lengths logs (3-4 m) due to current harvesting methods and low road standards. Producing short logs significantly reduces the potential profits from the logs. However, longer logs can be produced if aerial harvesting methods such as helicopter logging can be implemented in productive forests with commercially important tree species. Helicopter logging can also be used in extraction of mature trees in environmentally sensitive areas where road construction and logging operations are restricted.

In this study, the analysis of helilogging was performed for the AS-365 Dauphin II model helicopter based on a hypothetical example. The hourly cost of the AS-365 Dauphin II helicopter was estimated as \$1950 h^{-1} (Table 3) using the machine rate method. Fuel cost was the most important factor affecting the machine rate. The high purchase price increased the costs of interest, insurance, taxes and storage, value of the average annual investment, depreciation cost and maintenance and repair costs. The average annual investment and depreciation cost was greatly affected by the economic life of the helicopter. Interest, insurance, taxes and storage costs were the second highest cost component due to the high interest rate and taxes in Turkey.

By using the machine rate (\$ h^{-1}) and hourly production rate (m^3 h^{-1}), the unit cost (\$ m^{-3}) of helilogging can be computed. The production rate is a function of payload capacity and average cycle time. In a

Table 3: The hourly cost components of the helicopter

Cost components	Costs ($ h^{-1})
Ownership costs	
Depreciation costs	112.50
Interest, insurance, taxes, and storage costs	640.38
Operating costs	
Maintenance and repair costs	112.50
Fuel costs	934.52
Labor costs	150.00
Total machine rate	1949.90

helilogging study by Wang *et al.* (2005), the average cycle was found to be as 3.29 min in which fly empty, prebunch, hook, fly loaded, release, unhook and delay/refuel times were 0.56, 1.04, 0.87, 0.57, 0.02, 0.22 and 3.00 min, respectively. This indicated that the loaded fly time is about 2% greater than the unloaded fly time in that study.

Based on cycle time data from Wang *et al.* (2005), a production rate was estimated for the AS-365 Dauphin II helicopter. For the flight distance of 2 km and average cruise speed of 269 km h^{-1}, fly unloaded and fly loaded times were 0.89 and 0.91 min, respectively. The total time of other cycle time elements (i.e., prebunch, hook, release, unhook and delay/refuel times) obtained from Wang *et al.* (2005) were 2.16 min. Therefore, the total cycle time estimation was 3.96 min, including fly unloaded and fly loaded times.

With the average payload utilization rate of 60%, the production rate of the AS-365 Dauphin II with an average payload capacity of 1.6 m^{-3} (i.e., 1000 kg≈1 m^3) was computed as 14.54 m^3 h^{-1}. This resulted in a unit cost of $134.11 m^{-3} for helilogging using the AS-365 Dauphin II helicopter. The unit cost estimate is high compared with helilogging studies reviewed in this paper due to the low production rate. However, this result may still generate an acceptable net profit in Turkey since the average unit price of the high quality and l onger logs can be over $200 m^{-3} based on the tree species, the regions and market demand. The lower payload capacity of the AS-365 Dauphin II played an important role in the unit cost of helilogging. Utilizing the full payload capacity of the helicopter would increase the production rate and lower the unit cost during a helilogging operation.

CONCLUSION

Applying helilogging in Turkish forestry could be economically viable and technically feasible based on the simple analysis used in this study. In some situations, helilogging can be the only option in implementing timber extraction in environmentally sensitive areas and in steep and difficult terrain in Turkey. Helilogging operations may also provide logging managers with the following advantages:

- Reducing damage to residual trees and forest vegetation, especially during selection cutting systems in uneven aged mixed forests
- Minimizing sediment yield to streams and protecting water resources by reducing forest road construction
- Providing access to remote forested areas and difficult terrain
- Maximizing logging productivity by providing a high production rate
- Increasing the quality and price of the logs by allowing extraction of longer logs, which can not be transported otherwise due to low-standard forest roads in Turkey
- Ensuring safer working environment for the loggers

In implementing helilogging, logging managers should also be aware of the following potential disadvantages:

- Permitting logging operations in environmentally sensitive and steep areas
- Involving high investment to utilize a helicopter and Increasing the unit cost of timber extraction operations
- Requiring skilled, well-trained and experienced personnel (i.e., pilots and technicians) who might be foreign rather than domestic labor
- Reducing road densities in the long run which may lead to an increase in the cost of forest management
- Leaving large amount of low quality logs in the woods after extracting only high quality logs

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