FORMEC 2010
Forest Engineering: Meeting the Needs of the Society and the Environment
July 11 – 14, 2010, Padova – Italy

ASSESSMENT OF TIMBER HARVESTING MECHANIZATION LEVEL IN TURKEY

Murat Demir, Ebru Bilici

Istanbul University, Faculty of Forestry, Department of Forest Construction and Transportation
34473 Bahcekoy / Sariyer / Istanbul / Turkey
e-mail: mdemir@istanbul.edu.tr

Keywords: harvesting mechanization, forest harvesting, timber transportation, transportation methods, Turkey.

Abstract: *This study is investigating differences of timber transportation methods and harvesting mechanization level progress of Turkey. Furthermore, major problems of timber harvesting in Turkey and the future principles and objectives have been defined. Timber harvesting in Turkey is still carried out by manual methods due to economical, social and environmental constraints. Almost 80% of harvesting activities are mechanized in many developed countries while this value is only 5% in Turkey. Overall ratio of mechanization is relatively low. Approximately percentage of man power, animal power, machine power and skyline harvesting are 72%, 15%, 8% and 5%, respectively. Turkish General Directorate of Forestry's timber harvesting machines total amount is 448 in 1982, 859 in 1998, 457 in 2005 and 376 in 2009. Timber harvesting machines amount has been reduced to 20 tractors (4x4 and assembled shovel), 133 skidding winches, 5 tractors with equipment of snow cleaner, 38 forklifts, 18 loaders, 30 skylines, 61 agricultural tractors, 3 agricultural tractors with shovel, 67 trucks, 1 barking machines as of 2009. In spite of existence of substantial number of harvesters, the amount of modern harvesting processor in Turkey is not sufficient. Different type and marked machine hasn't taken into consideration to improve mechanization and a poor standardization in harvesting is another problem in Turkey. Total machine park amount has been reduced 56.2% between years 1998-2009. Forest main repair shops should be opened over again in Turkey.*

1. Introduction

When making use of the forest ecosystem for various purposes, care must be taken not to spoil the forest structure. To achieve this, forests must be used according to forestry techniques. The preparation and implementation of such plans requires knowledge not only of all the economic, technical, and management characteristics of the forest enterprise involved, but also of the relationships involved in production, transport, and utilization of the forest resource. In today's world where it is possible to use even the smallest crumbs of wood as raw material in industry, it is a real wastage to cause losses in quality and quantity during transportation and harvesting due to various reasons. Transportation planning in forestry is divided into strategic, tactical and operational depending on the length of the planning horizon. The transportation planning is done in several steps. These deals with transportation of logs from harvest areas or terminals (supply points) to industries such as paper mills, pulp mills, saw mills, heating plants and terminals (demand points).The way of applying transportation and harvesting techniques has a significant effect on both the quality and the quantity of finished products. In forestry, transportation of harvested woods from compartments is very difficult, expensive and the time-consuming. Decisions on a strategic level are often influenced by harvesting and road building/maintenance considerations for several years. Forest operations are interventions in a forested ecosystem aimed at achieving certain management goals. These goals might require operations such as site preparation and planting, cultivation or tending of younger stands, timber harvest, timber transportation and road building (Athanassiadis, 2000). Modern forests continue to be dramatically altered by two major anthropogenic disturbances: timber harvesting (Kittredge et al.,2003) and permanent conversion due to land-use change (Riitters et al., 2002). Forest harvesting is an important, ongoing disturbance that affects the composition, structure, and

ecological function of the majority of the world's forests. In forestry, like every kind of production, production works require a productive power. This productive power can be provided by both human power or animal and machines which are used by human beings. Forest harvesting is an important, ongoing disturbance that affects the composition, structure, and ecological function of the majority of the world's forests (McDonald et.al. 2006).

In forestry, like every kind of production, production works require a productive power. This productive power can be provided by both human power or animal and machines which are used by human beings. Forest transportation should be considered in two stages. The first one is called primary transportation, which covers all activities from felling to the landings, and the second one is called secondary transportation, which covers hauling activities between landings and sawmills. Secondary transport stage is involving the main stage of transport of timbers, generally realized by trucks on forest roads. Primary transportation is moving timber from the harvesting site to the landing area. Cutting, bucking, skidding, landing and unloading are some of major activities of primary transportation. Based on the results of several studies, non-mechanized (manual) cutting and skidding are relatively inefficient and more expensive than that of mechanized techniques. However the increasing of forest product that is formed our country recently, now harvesting has been still made with old patterns, such as sliding, throwing, circling transport with human, skidding with animals on direct ground. Besides specials forest tractors and skylines are used in some areas (Aykut et.al. 1997). The extraction of forest products from compartments is a very difficult, expensive and time-consuming operation. This problem is very important because the forests of Turkey are located in mountainous areas. The extraction of forest products without loss of quality and quantity is an important problem.

Until recently, the forests in Turkey have encountered excessive interventions at diverse levels and densities in order to meet the country's needs for firewood. These detrimental interventions started generally in forest lands which provided easy access or transportation, and continued for long causing damage to some parts of the natural structure of our forests. Thus, only those forests located on rough lands could conserve their natural forms. This situation made it clear that these forests should be developed and improved with a view to continuously benefit from them economically. The term "*mechanization*" which is defined in the dictionaries as "*all of the activities that help to create a new good or service*" correspond in forestry transportation to activities such as cutting the raw material of wood, hauling, transporting and stacking it. In order to perform this harvesting rationally, requirements such as conformance to rules, safety, and affordability, which make up the basis of engineering discipline, must be met. The productivity of forestry mechanization depends on many factors: machine type, tree size, intensity of thinning, number of trees per hectare, terrain conditions, operator skills (Lageson, 1997; Nimz, 2002; Karha, 2003), silviculture treatment (Eliasson et al., 1999; Eliasson, 2000; ; Glode and Sikstrom, 2001; Hanell et al., 2000) and distances between skid roads (Harstedt, 2000; Mederski, 2006). In order to make full use of modern technology, forest trees which, for long years carry along the efforts of nature and human beings to reach the time for being cut, must be transported from the place they have been cut to the main transportation (secondary transport) near the forest road keeping its original volume and quality intact and without harming the other trees, youth, the forest soil, in short the forest ecosystem. At that stage, with each step towards mechanization, labor loss shall be prevented, hauling costs shall be reduced, natural balance and forest soil shall be preserved, while obtained more products with higher quality (Demir, 2010).

2. Materials and Methods

2.1 Site Description

Turkey, with 97% of its land area in Asia and 3% in Europe, is located between 42° 06'-35° 51' N latitude and 25° 40'-44° 48' E longitude (Figure 1). Turkey is surrounded by the Mediterranean, the Black Sea, the Sea of Marmara, and the Aegean Sea, has an area of 77846000 hectares and 8333 km of coastline. This substantial size, along with large distances of over 1600 km from east to west and from 475 to 650 km from north to south, as well as properties such as location, relief, and climate, have caused the formation of different geographical regions within the country's boundaries. As of the end of 2004, the total forest

area in Turkey was 21188747 hectares, or 27.22% of the country's area. Timberland (productive) forests occupy 15439595 hectares and account for 73% of the total forest area, while coppice forests occupy 5749152 hectares and account for 27% of the total forest area (Anonymous, 2008; GDF, 2009). According to 2004 data, coniferous forest occupies 53.9% of total forest area and deciduous forest 46.1%. (Demir and Hasdemir, 2005; Demir, 2007; GDF, 2009; Demir, 2010).

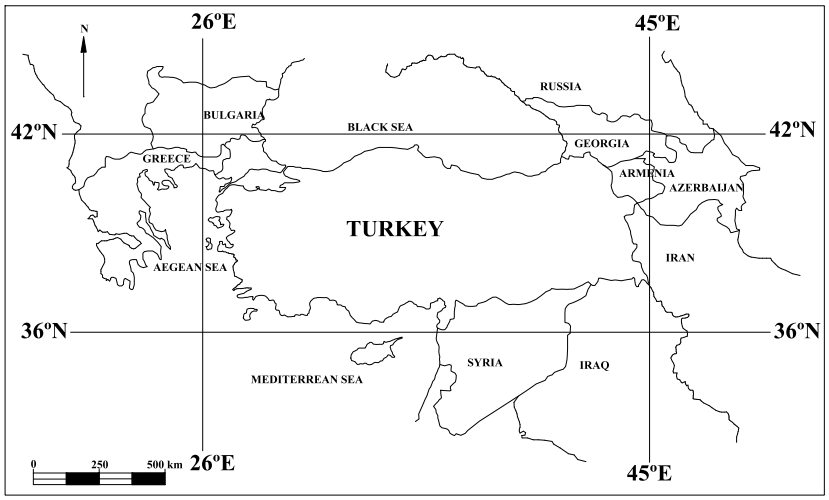

Figure 1. The location of Turkey.

2.2 Hauling Standards in Turkey

Productive forests are generally found in mountainous areas which have 40-80% gradient in Turkey. Timber harvesting studies are usually practiced with tractor winches that have double or single drums. Timbers are skidded directly on surface with the shape of cable harvesting by tractor winches. Another way of timber harvesting is to benefit from skylines. Tractors are used in areas that have 30-35% slope gradient. But skylines are used in areas that have 55-75% slope gradient (Demir/Ozturk, 2005a; Demir/Ozturk, 2005b). Primary transportation is moving timber from the harvesting site to the landing area. Cutting, bucking, skidding, landing, and unloading are some of the major activities of primary transportation. Based on the results of several studies, non-mechanized (manual) cutting and skidding are relatively inefficient and more expensive than that of mechanized techniques. Primary transportation is generally 25-50% of total cost of the harvesting activities (Acar/Yoshimura, 1997; Aykut *et.al.*,1997). In Turkish forestry, the timber logging expenditures capture the majority of the total forestry expenditures after general administrative expenditures. Taken into consideration the timber production per unit costs (with current price); 16% of total unit costs is harvesting costs (cutting/felling etc.), 31% of them is extraction cost (bunching/skidding etc.) and 30% of them is transportation cost (loading/hauling etc.) (Anonymous, 2001; Yoshimura/Acar, 2004). Therefore, application of mechanization of skidding such as introduction of grapple skidder or using feller-buncher in cutting phase of harvesting will not only reduce total cost but also increase productivity.

In Turkey, forest products are hauled in three different ways. These are:

Hauling with man-power: The method of hauling forest products using manpower is done in the flat areas and in areas with slight slope in Turkey. Hauling consists of throwing the forest products down the mountain slopes, sliding them and handling them.

Hauling with animal-power: In Turkey, the method of hauling forest products using animal power makes wide use of draft animals (horse, cow, water buffalo and mule, etc.). Forest products are hauled by skidding directly over the ground using animal power.

Hauling with machine-power: The method of hauling forest products using machine power is applied under difficult conditions where manpower and animal power are not sufficient. Forest products are

hauled by skidding directly over the ground using forest and farm (agricultural) tractors and special forest tractors.

Besides, forest products are hauled by short, middle and long skylines types. These skyline types are Koller K300, URUS MIII and Gantner. These skylines are using especially East Blacksea Region in Turkey. Forest tractors are used in different region of Turkey and forest tractors types are MB Trac 800/900/1000/1100 and farm tractors types are Steyr 768, Ford, M.Ferguson, Tumosan and Universal in Turkey. These tractors go into the yarder side with skidding roads and strips. Tractors are used in two ways in these areas. The first way is; while tractors are staying on the road, to draw the timber up to the road, which is found under road or on the road, with the help of winch line. The second way is; to timber haulage directly on the surface, with skidding, while tractor in entering up to yarder side. MB Trac 800/900/1000/1100 tractor types are being used especially at mountainous areas in Turkey. Inforest areas which has 30-35% gradient, MB Trac forest tractors can work comfortably. But farm tractors can work generally in areas which has a gradient until 30%. The movement capacity of forest tractors is higher than the movement capacity of farm tractors. Forest tractors have many axle heights. Because of this they move more comfortably in skidding strips and roads (Ozturk et al. 2007).

3. Results and Discussion

The average slope of Turkey's forests is 50%-60% and overall ratio of mechanization is relatively low. Approximate percentages of man power, animal power, machine power and skyline harvesting are 72%, 15%, 8%, and 5%, respectively (Figure. 2) (Erdaş/Acar, 1993).

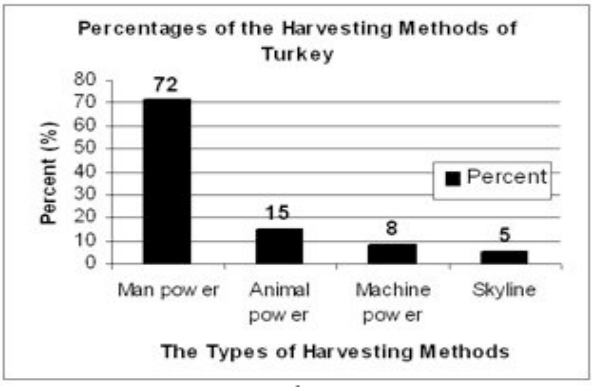

Figure 2. Approximate percentages of the harvesting methods in Turkey (Erdaş/Acar, 1993).

Mechanization on harvesting has begun with use long distance winch skylines in Turkey in 1949. Wyssen, Baco and Hintereger marked 21 set skylines widely used in the northeast forests of Turkey. Furthermore, attain to standard of production in developed countries has been going on in Turkey. It is believed that mechanization of timber harvesting will be improving in near future in Turkey (Aykut/Demir, 1999; Hasdemir, 2001).

The level of harvesting mechanization in developed countries is higher than Turkey. While mechanical harvesting is about 86% in Austria that is similar to Turkey, this ratio is about 9% in Turkey. Traditional forest harvesting is gradually being replaced by the use of harvesters, skidders and forwarders. This machinery is very popular in Scandinavia and is also in wide use in other European countries (Lageson, 1997). In Sweden, harvesters dominate thinning operations and do almost 100% of clear cutting. In most of Germany up to 30% of clear cutting is done by harvesters, but in the area of Brandenburg it has reached 70%. The high cost of purchasing forest machinery and its use are compensated for with high productivity (Gruner, 2001).

Timber harvesting machines amount has been improved from the point of view type and amount between 1949 and 1982. In 1982, machine amounts has reached to 27 mobile skylines, 43 skidding winches, 85 forklifts, 55 loaders 152 tractors, 71 trucks and totally 448. (Demir/Ozturk, 2005c) (Figure 3-4-5).

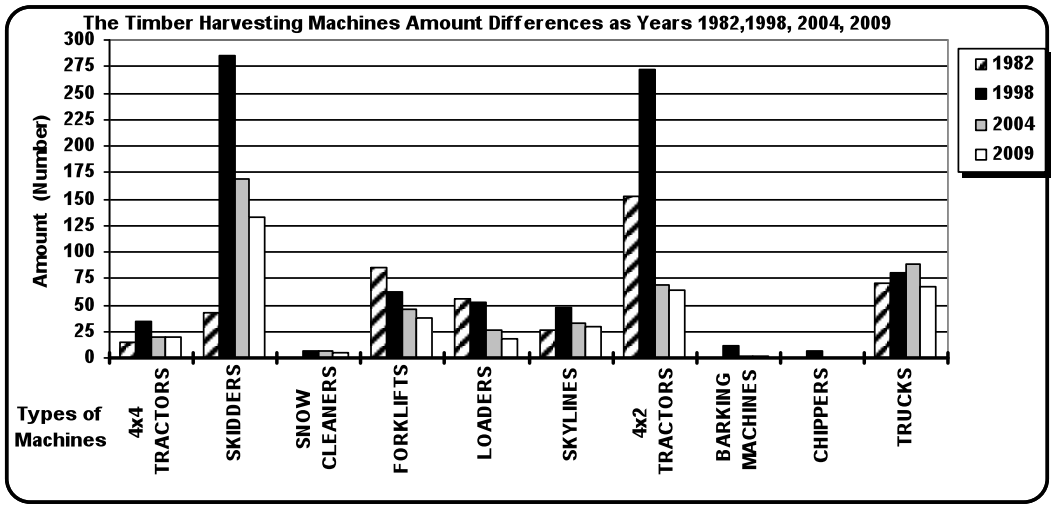

Figure 3. The mechanical park amount differences as years of Turkey (Demir, 2010).

Timber harvesting machines amount has also improved between 1982 and 1998. Turkish General Directorate of Forestry have 35 tractors (4x4 and assembled shovel), 286 skidding winches, 6 tractors with equipment of snow cleaner, 63 forklifts, 53 loaders, 47 skylines, 260 agricultural tractors, 12 agricultural tractors with shovel, 11 barking machines, 80 trucks, 7 chippers and totally 859 in 1998 (Figure 3-4-5).

Between 1998 and 2004, timber harvesting machines amount has been reduced to 56.2% and machines park has 19 tractors (4x4 and assembled shovel), 169 skidding winches, 6 tractors with equipment of snow cleaner, 46 forklifts, 26 loaders, 32 skylines, 65 agricultural tractors, 4 agricultural tractors with shovel, 2 barking machines, 88 trucks and totally 457 in 2004 as illustrated in Figure 3-4-5.

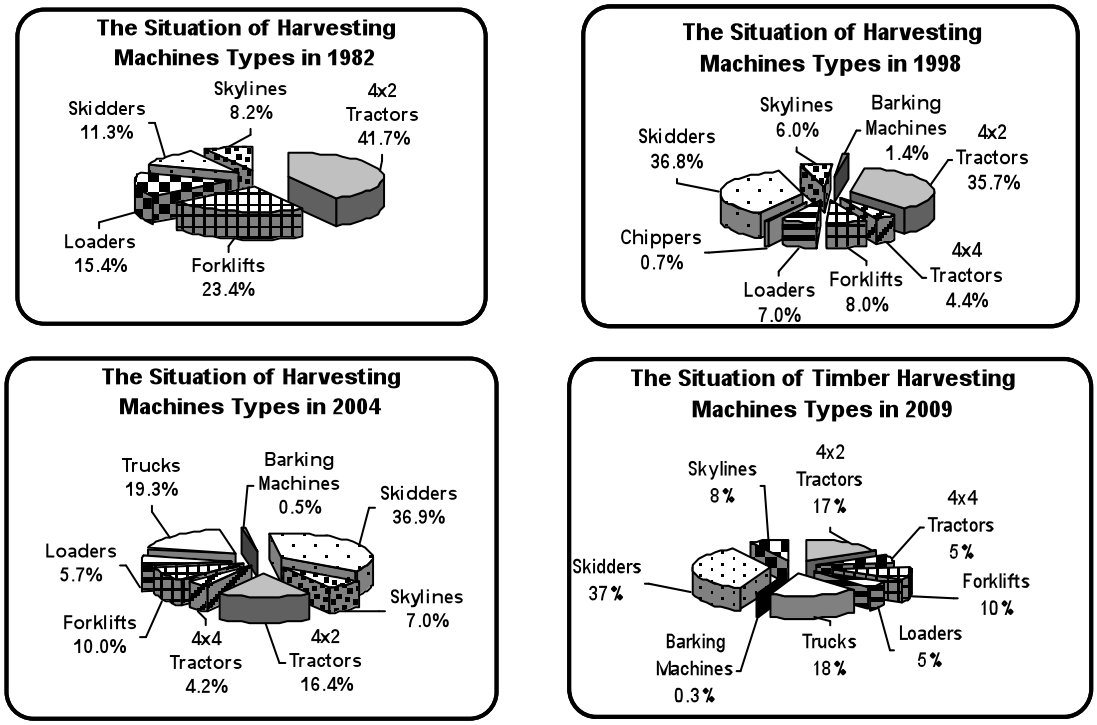

Figure 4. The situation of harvesting machines types differences as years 1982,1998, 2004, 2009 (Demir, 2010).

Timber harvesting machines amount has been reduced to 14 tractors (4x4 and assembled shovel), 133 skidding winches, 5 tractors with equipment of snow cleaner, 38 forklifts, 18 loaders, 30 skylines, 61 agricultural tractors, 3 agricultural tractors with shovel, 67 trucks, 1 barking machines and totally 376 in 2009 (Figure 3-4-5).

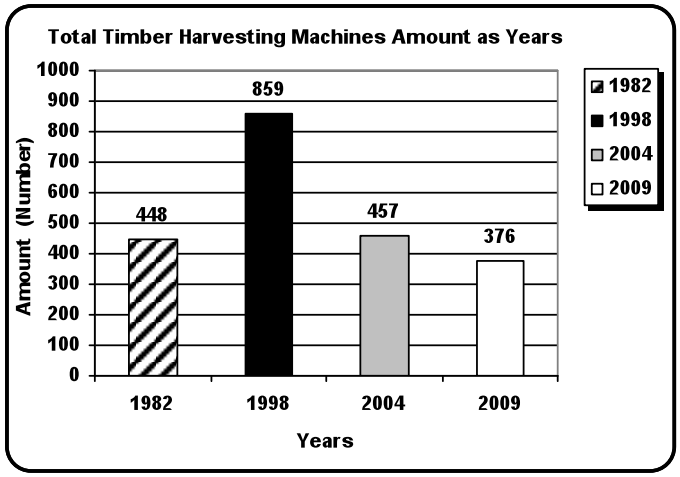

Figure 5. Total timber harvesting machines amount as years.

In spite of existence of substantial number of harvesters, the amount of modern harvesting processor in Turkey is not sufficient. Different type and marked machine hasn't taken into consideration to improve mechanization and a poor standardization in harvesting is another problem in Turkey. Besides, these timber harvesting machine generally uses subjective and out of aim because of technical inexperience. In 1998, the Directorates of Main Forest Machines Repair Shops closed down (Hasdemir/Ozturk 1997). Also closing of repair shops due to suffer harm effected situation of timber harvesting machine. To repair, to maintenance and to obtain spare part of these machine are forced (Demir/Gandaseca, 2005; Hasdemir et al. 2007; Ozturk/Senturk 2004).

Although this is well known, forest roads have in fact been planned primarily to satisfy the requirements of forest harvesting and timber transportation. Forest roads have been planned and constructed according to road density (m/ha) and yield/forest area (m^3/ha) criteria to meet the needs of Turkish forestry. However, forest road density should be determined according to all aspects of forestry operations. One of these aspects is in effect forest protection and fire fighting. All the research done in Turkey has stated that forest road density may be 20 m/ha. Total identified forest road needs in Turkey are 201810 km, of which 143251 km, or 70.98%, had been constructed by the end of 2006. As shown in Table 1, 70.98% of forest roads, 69.80% of firebreaks, 52.24% of major repairs, 51.67% of paving, 58.28% of bridges, and 64.82% of forest road structures which were planned to be constructed by the end of 2006 had in fact been completed. It is intended that the construction of all planned forest roads and the completion of all associated structures will be achieved within 20 years. As a result, today, a substantial part of the forests of Turkey have been provided with forest roads constructed on the basis of an overall plan, and transportation by truck on such roads has often been the one and only choice (Demir, 2010).

Table 1. Current status of forest roads in Turkey (2006) (GDF, 2007)

Type		Forest Roads Needed	End of the Year 2006		Constructed Roads (%)
			Constructed	Under Construction	
New forest road construction	km	201810	143251	58559	70.98
Fire breaks	km	25544	17832	7732	69.80
Major repairs	km	61100	31923	29177	52.24
Pavement	km	54724	28277	26447	51.67
Bridge	m	23500	13697	9803	58.28
Forest roads structures	km	50000	32412	17588	64.82

4. Conclusions

Within the scope of this brief study, the following remarks can be concluded about applications of mechanized timber harvesting techniques in Turkey. First of all, harvesting plans should be analyzed based on today's forest conditions before any solid decisions are made. Turkey is a developing country; it may look as efficient way to use manual harvesting methods at the time. However, it is important that consider long term-harvesting plans which will require mechanization so that total harvesting cost will be reduced in long term. Therefore, initial investments should be considered for mechanization. Road conditions must be improved with regard topographic and silvicultural factors. Slope of primary and secondary roads should be clearly analyzed and combined with harvesting area and final destinations (Demir, 2010).

Total timber harvesting machines amount has been improved 91.7% between years 1982 and 1998 and these amount reduced 56.2% between years 1998 and 2009. In 1998, the decision made to close down the Directorates of Main Forest Repair Shops should be reconsidered and possibilities to make these Directorates function more effectively should be researched. Forest main repair shops should be opened over again in Turkey. Level of mechanization should be determined for all of the country and then machines park should be standardized. Forest villagers should be included in logging plan, and their involvement may play important in long form in mechanized harvesting. Government should arrange credit to finance initial cost of mechanized harvest equipment owned by local forest villagers. Training of villager should be achieved in the form of short workshop (Demir, 2010).

5. Acknowledgements

The present work was supported by the Fund of Istanbul University, Project number is UDP-6362. The author would like to express special thanks to the Research Fund of Istanbul University.

6. References

Acar H.H. and Yoshimura T. (1997). A study on the productivity and cost of cable logging in Turkey. Journal of Forest Research 2, 199-202.

Anonymous, (2001). Turkish forest commission report. The Prime Ministry State Planning Organization of The Republic of Turkey Publication Number: 2531/547, Ankara, Turkey.

Anonymous, (2008). Afforestation and Erosion Control Mobilisation Action Plan (2008-2012). Republic of Turkey, Ministry of Environment and Forestry, 25 pp., Ankara.

Athanassiadis, D. (2000). Energy consumption and exhaust emissions in mechanized timber harvesting operations in Sweden. The Science of the Total Environment 255, 135-143.

Aykut T., Acar H.H. and Senturk, N. (1997). An investigation on the comparison of Koller K300, Urus M III and Gantner skylines used for extraction from compartment in Artvin region. Review of the Faculty of Forestry, University of Istanbul, 47, A2.

Aykut, T. and Demir, M. (1999). The wishes, conditions, profits of forestry mechanization and situation of the timber mechanization in Turkey. Review of the Faculty of Forestry, University of Istanbul, 47(B1-4).

Demir, M. and Gandaseca, S. (2005). The usage of tractors in timber extraction and situation of timber harvesting mechanization of Turkey. International Seminar on Synergistic Approach to Appropriate Forestry Technology for Sustaining Rainforest Ecosystems. University of Putra Malaysia, March 05-07th 2005, Bintulu, Sarawak, Malaysia.

Demir, M. and Hasdemir, M. (2005). Functional planning criterion of forest road network systems according to recent forestry development and suggestion in Turkey. American Journal of Environmental Sciences 1(1), 22-28.

Demir, M. and Ozturk, T. (2005a). Investigation and situation of timber harvesting mechanization of Turkey and the usage of tractors in timber extraction. American Journal of Environmental Sciences 1(2), 97-101.

Demir, M. and Ozturk, T. (2005b). The situation and evaluation of forest harvesting methods in Turkey. American Journal of Applied Sciences 2(2): 499-503.

Demir, M. and Ozturk, T. (2005c). Investigation and situation of timber harvesting mechanization of Turkey and the usage of tractors in timber extraction. International Scientific Conference, Ecological, Ergonomic and Economical Optimization of Forest Utilization in Sustainable Forest Management, Page 119-126, ISSN 0239-9342, June 15-18th 2005, Krakow, Poland.

Demir, M. (2007). Impacts, management and functional planning criterion of forest road network system in Turkey. Transportation Research Part A: Policy and Practice 41(1), 56-68.

Demir, M. (2010). Investigation of Timber Harvesting Mechanization Progress in Turkey. African Journal of Biotechnology 9(11), 1628-1634.

Eliasson, L., Bengtsson, J., Cedergren, J. and Lageson, H. (1999). Comparison of a single-grip harvester productivity in clear- and shelterwood cutting. Journal of Forest Engineering 10 (1), 43–48.

Eliasson, L. (2000). Effects of establishment and thinning of shelterwoods on harvester performance. Journal of Forest Engineering 11 (1), 21–27.

Erdas, O., Acar, H.H. (1993). The harvesting wood in Turkey especially difficulties on cutting, extraction and transporting and its effects to forest industry. Orenko 93 Symposium, Karadeniz Technical University, Trabzon, Turkey.

GDF, (2009). Turkish General Directorate of Forestry web page, from www.ogm.gov.tr , (Access date is between 2005-2009).

Glode, D., Sikstrom, U. (2001). Two felling methods in final cutting of shelterwood, single-grip harwester productivity and damage to the regeneration. Silva Fennica 35 (1), 71–83.

Gruner, R. (2001). Waldarbeit in Brandenburg. Forsttech. Inf. 12, 130–135.

Hanell, B., Nordfjell, T. and Eliasson, L. (2000). Productivity and costs in shelterwood harvesting. Scan. J. For. Res. 15, 561–569.

Harstedt, T. (2000). Thinning with a single grip harvester equipped with a long boom. M.Sc. thesis.

Hasdemir, M. and Ozturk, T. (1997). To close of main forest repair shops are sum up over again. Review of Turkish Forest Engineers, 34(6), 31-32.

Hasdemir, M. (2001). Mechanization problems on harvesting in Turkey. The Third Balkan Scientific Conference, Study, Conservation and Utilization of Forest Resources, Volume IV, pp. 235-240, ISBN 954-90896-5-7, Sofia, Bulgaria.

Hasdemir, M., Öztürk, T. and Demir, M. (2007). Problems and suggestions of timber harvesting and transportation in Turkish forestry. International Symposium on Bottlenecks, Solutions, and Priorities in the Context of Functions of Forest Resources, Proceedings of Oral Presentation, Page: 341-352, ISBN 978-975-9060-44-2, October 17-19th, 2007, Istanbul, Turkey.

Karha, K. (2003). Alternative harvesting systems in mechanised thinning. Final Report of HARKO Project (1999–2001). Summary. www.tts.fi

Kittredge, D.B., Finley, A.O. and Foster, D.R. (2003). Timber harvesting as ongoing disturbance in a landscape of diverse ownership. Forest Ecology and Management 180, 425–442.

Lageson, H. (1997). Effects of thinning type on the harvester productivity and on the residual stand. Journal of Forest Engineering 8 (2), 7–14.

McDonald, I.R., Motzkin, G., Bank, M.S., Kittredge, D.B., Burk, J. and Foster, D.R. (2006). Forest harvesting and land-use conversion over two decades in Massachusetts. Forest Ecology and Management 227, 31-41.

Mederski, P.S. (2006). A comparison of harvesting productivity and costs in thinning operations with and without midfield. Forest Ecolology and Management 224, 286-296.

Nimz, R. (2002). Einbeziehung der Leistungsfahigkeit des Fahrers in Produktivitätsmodelle für Harvester. Treffen der ‘‘Sektion Forsttechnik’’ des Verbandes Deutscher Forstlicher Versuchsanstallen. Sopron, B, 1–5.

Ozturk, T. and Senturk, N. (2004). Evaluation of timber extract of machines in Turkey. An International Scientific Conference, Forest Engineering: New Techniques, Technologies and the Environment, ISBN 5-7763-2435-1, October.5th-10th.2004, Lviv, Ukraine.

Ozturk, T., Demir, M. and Hasdemir, M. (2007). Work organization of timber production in Turkey. International Mountain Logging and 13th Pacific Northwest Skyline Symposium, Page 283, April 1-6th 2007, Oregon State University, Corvallis, Oregon, United States of America.

Riitters, K.H., Wickham, J.D., O’Neill, R.V., Jones, K.B., Smith, E.R., Coulston, J.W., Wade, T.G. and Smith, J.H. (2002). Fragmentation of continental United States forests. Ecosystems 5, 815–822.

Yoshimura, T. and Acar, H.H. (2004). Occupational safety and health conditions of forestry workers in Turkey. Journal of Forest Research 9, 225-232.