African Journal of Agricultural Research Vol. 5(9), pp. 916-921, 4 May, 2010
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR09.042
ISSN 1991-637X © 2010 Academic Journals

Full Length Research Paper

Estimating the effects of optimum bucking on the economic value of Brutian pine (*Pinus brutia*) logs extracted in Mediterranean region of Turkey

Hasan Serin*, Abdullah E. Akay and Mehmet Pak

Faculty of Forestry, Kahramanmaraş Sütçü Imam University, 46060 Kahramanmaras, Turkey.

Accepted 25 February, 2010

The recent socio-economic changes have escalated the consumer needs mainly on industrial wood products among other direct use values of forest resources in Turkey. Besides, the economic value of wood based products represents the highest proportion in total economic value of forest resources in Turkish forestry. The most important wood based product type is considered to be logs that are produced by bucking the harvested trees into short lengths depending on log grade, log sizes, and mill delivered prices. Bucking the harvested trees in an optimum way is crucial factor which increases productivity in logging and maximizes the tree value. In this study, the effects of optimum bucking method on the total economic value of Brutian pine (*Pinus brutia*) logs were investigated in mediterranean region of Turkey. The optimum bucking method was implemented during the logging operations of sample Brutian pine stands in three major Forest Regional Directorates (Adana, Antalya and Muğla), which represent the general characteristics of Brutian Pine forest in Mediterranean region of Turkey. The results indicated that using optimum bucking method increased the potential gross value and volume of the harvested trees by 4.7 and 1.64%, respectively, in the region.

Key words: Economic value, log production, optimum bucking, Brutian pine.

INTRODUCTION

The forest resources have been under great pressure due to increasing public demand associated with population growth, industrialization, and economic development (Bishop, 1998). These socio-economic changes have escalated the consumer needs mainly on wood based products (log, telephone poles, mine poles, industrial wood, pulp wood, fiber-particle wood, and sapling wood) among other direct use values of forest resources such as non-wood products (resin, mushrooms, medicine plants etc.), recreational uses (fishing, hunting and camping), and other amenities in Turkey. Besides, the economic value of wood based products represents the highest proportion in total economic value of forest resources in Turkish forestry. In Table 1, the production quantities and economic values of wood based products are pre-sented for coniferous and deciduous tress (GDF, 2009). The most important wood based product type is consi-dered to be logs in terms of quantity and economic value in Turkish forest industry.

For the year of 2008, the proportion of log production was approximately 34.19 and 49.18% of the total quantity and value of wood based products, respectively. The logs are produced by bucking the harvested trees into short lengths mainly depending on sale prices, log sizes (diameter and length), and log grade. The log grade is determined based on surface characteristics (shape, knot size and density, and cracks, bending, and twisting on the logs) (Olsen et al., 1997).

Bucking the harvested trees in an optimum way is crucial factor which increases productivity in logging and maximizes the tree value. Bucking the trees in a way that maximizes the total value of the trees is defined as optimum bucking (Sessions, 1988). The previous researches reported that optimum bucking method can

*Corresponding author. E-mail: hasanserin@ksu.edu.tr. Tel: +90 344 2237666 / 392. Fax: +90 344 2217244.

Abbreviations: FRDs, Forest regional directorates; **FEDs,** forest enterprise directorates; **FECs,** forest enterprise chiefs.

Table 1. The production quantity and economic value of wood based products in Turkey for the year of 2008.

Wood based products	Production quantities		Average unit prices		Economic values	
	Coniferous (m^3)	Deciduous (m^3)	Coniferous (YTR/m^3)	Deciduous (YTR/m^3)	Coniferous (YTR*)	Deciduous (YTR)
Log	3281695	664156	156	161	511944420	106929116
Telephone pole	75129	0	187		14049123	0
Mine pole	468383	53989	129	110	60421407	5938790
Industrial wood	482588	272099	117	105	56462796	28570395
Pulp wood	2333947	73209	92	118	214723124	8638662
Fiber-particle wood	2360294	1456228	58	77	136897052	112129556
Sapling	17857	1510	90	71	1607130	107210
Total	9019893	2521191	--	--	996105052	262313729

*1 Turkish Lira (YTR) = 0.75 USD.

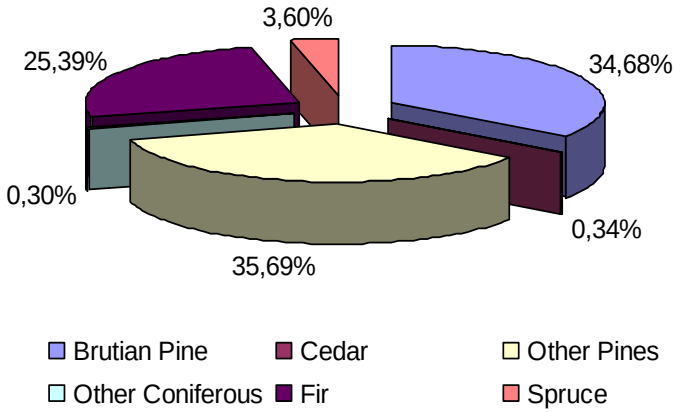

Figure 1. The proportion of log production for various species as percentages of over all log production obtained from coniferous trees in Turkey.

increase tree values up to 22% (Akay et al., 2009). In order to determine the optimum bucking combination with maximum total value, large number of alternative combinations should be evaluated for a single tree. In Turkey, the bucking decisions are mostly made by the loggers at stand based on their work experiences without searching for suitable combinations. However, it is expected that implementing optimum bucking method can considerably increase the total economic value of log production in forest industry. Optimum bucking problems with many solutions can be solved using modern optimization methods such as network analysis, linear programming, dynamic programming, and heuristic techniques (Laroze and Greber, 1997). Wang et al. (2004) developed a network analysis based model to search for optimum bucking solution among number of alternative bucking combinations. In some of the previous studies, linear programming and dynamic programming have been generally integrated to formulate optimum bucking problems (Sessions et al. 1989b, Laroze and Greber, 1997). Besides, heuristic techniques such as Genetic Algorithm and Tabu search have provided promising results in several optimum bucking studies (Laroze, 1999; Kivinen, 2004). In this study, the dynamic programming based optimum bucking method was implemented on sample Brutian pine stands in three major Forest Regional Directorates (FRDs). The results of optimum bucking method were compared with the traditional bucking method actually applied in the region. Then, the effects of optimum bucking method on the total economic value of Brutian pine (*Pinus brutia*) logs were estimated for Mediterranean Region of Turkey.

MATERIALS AND METHODS

Bucking application

The bucking applications were conducted during the summer of 2008. Thus, the wood production data for the year of 2008, provided by General Directorate of Forestry (GDF), were considered in this study. In 2008, 83.17% of the log production was obtained from coniferous trees while 16.83% was from deciduous trees in Turkey (GDF, 2009). In coniferous trees, the major source of logs was Brutian pines (34.68%) followed by firs, other pine species, and spruces (Figure 1).

The proportion of log production from Brutian Pines was about 28.84% of overall log production in Turkey. The main range of Brutian pines covers the Mediterranean and Aegean coasts of Turkey (Boydak et al., 2006). Approximately 67.97% of the Brutian pine productions were carried out in the several FRDs of Mediterranean Region including Antalya (24.20%), Muğla (14.88%), Mersin (11.74%), Adana (9.22%), Isparta (5.46%), and Kahramanmaraş (2.47%). FRDs of Antalya, Muğla and Adana represent the general characteristics of Brutian Pine forests in Mediterranean region of Turkey. Besides, Brutian Pine production in these three FRDs was about 71% of overall Brutian pine production in Mediterranean Region. Thus, in this study, the optimum bucking applications were performed during the harvesting operations in Brutian Pines stands located in Forest Enterprise Directorates (FEDs) of Alanya, Fethiye, and Saimbeyli in FRDs of Antalya, Muğla, and Adana, respectively.

The study areas were located in Forest Enterprise Chiefs (FECs) of Demirtaş, Fethiye, and Saimbeyli in the FEDs of Alanya, Fethiye, and Saimbeyli, respectively. The general information and the locations of the study areas are indicated on Table 2 and Figure 2,

Table 2. The general information about the study areas.

Selected FRDs	FEDs	FECs	Average ground slope (%)	Average elevation (m)	Average tree diameter (cm)	Average tree height (m)
Antalya	Alanya	Demirtaş	28.68	709.86	41.89	16.07
Muğla	Fethiye	Fethiye	17.60	406.77	42.87	16.47
Adana	Saimbeyli	Saimbeyli	61.40	912.97	35.37	16.87

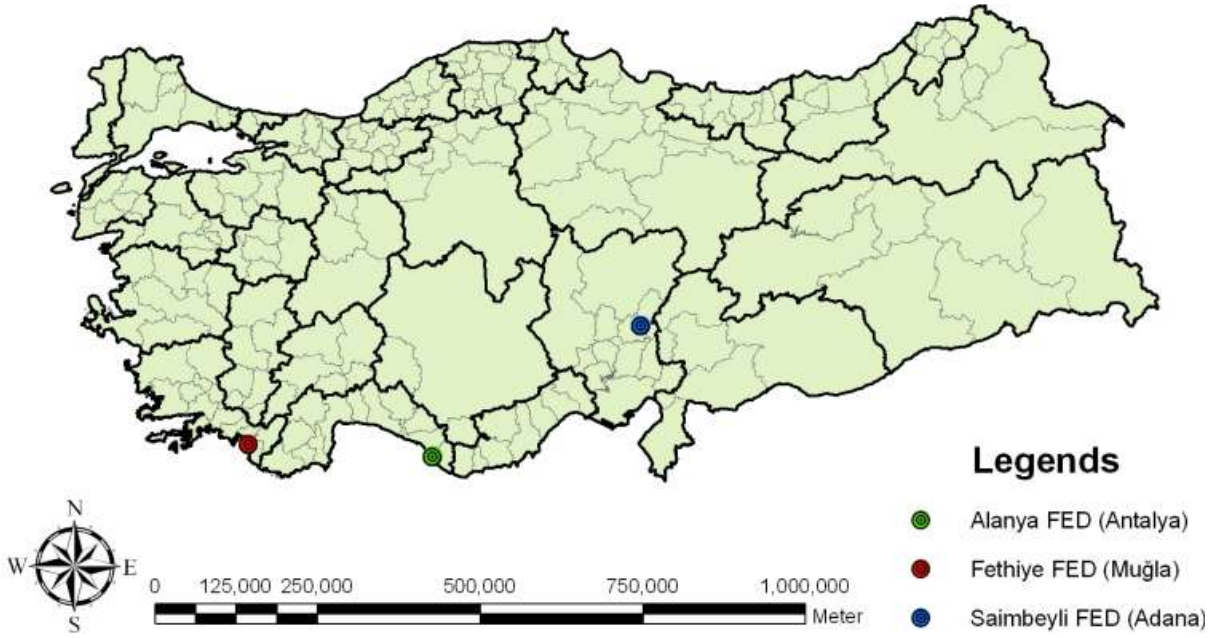

Figure 2. The locations of the study areas.

respectively. The data obtained for optimum bucking solutions in FRDs of Antalya, Muğla and Adana were used to represent the data for FRDs of Mersin, Isparta, and Kahramanmaraş, respectively. The quantities of total log production obtained from Brutian Pines in these FRDs of Antalya, Muğla, Adana, Mersin, Isparta, and Kahramanmaraş were 145368, 114565, 122000, 184734, 111891, and 41400 m^3, respectively (GDF, 2009). During the harvesting operations, 30 sample trees (that is to approximate a normal distribution) were randomly selected from each study area and then the size (that is length, diameter) and log grades of the sample trees were recorded to run optimum bucking method. After bucking the sample trees by using traditional bucking method, dimension and grade information for the logs of each sample tree were also recorded for comparison purposes. The average log price for each log grade with various length-diameter classes was obtained from the FEDs based on the most recent auctions.

Optimum bucking method

The log size (that is diameter and length) and log grade information should be accurately determined to be used in optimum bucking solution. Log grades can be determined based on the look-up tables which indicate the grading rules for the commercial tree species (Bozkurt and Goker, 1981). The success of the optimum bucking method also depends on accurate and current information about the market prices for each log grade (Sessions et al., 1988a).

In this study, single tree based optimum bucking algorithm was used to systematically search for the optimum bucking solutions (Akay et al., 2009). This algorithm utilized the dynamic programming method where tree is represented as a network of arcs (Sessions et al., 1988b). In network system, possible bucking points are considered as “nodes” and each “arc” between nodes is considered as the length of a possible log (Figure 3). Each arc represents the value of logs produced from the tree (Sessions, 1988). The algorithm searches for the “path” of arcs that yields the maximum value from the tree. The log volume was computed by using sectional area at the mid point of a log and log length. Then, the log value was computed by multiplying the log volume with the average unit price.

The algorithm considers various constraints including minimum and maximum log lengths and minimum log diameter at the mid point of a log. In the study, the minimum acceptable log length and log diameter were 2 m and 19 cm, respectively. Due to limiting capabilities of using traditional logging methods in the region, the maximum acceptable log length was 4 m.

In this study, logging cost, transportation cost, and stumpage payments were not considered; however, the extra cost of using optimum bucking method was taken into account. The optimum bucking algorithm should be installed into the handheld computers to apply the optimum bucking method during the bucking operation at stands. Therefore, depreciation cost of these handheld computers and the cost of time spend on running the method was considered as the extra cost of using optimum bucking method.

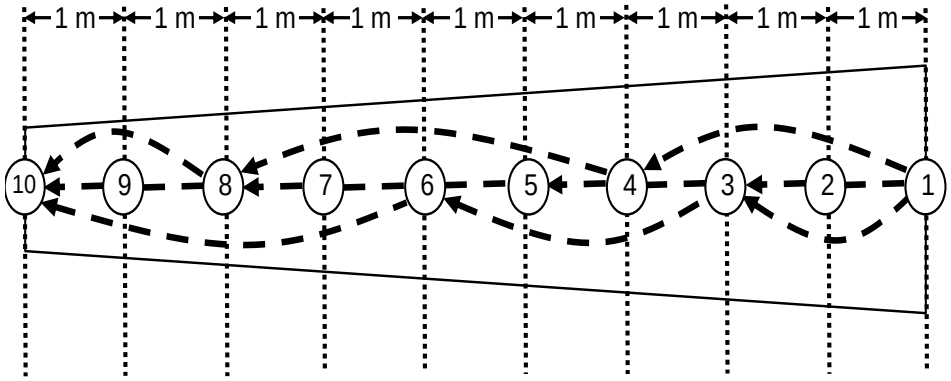

Figure 3. Network system for a sample tree with possible nodes and arcs.

Nodes, representing possible bucking points

Arcs, representing lengths of the bucked logs.

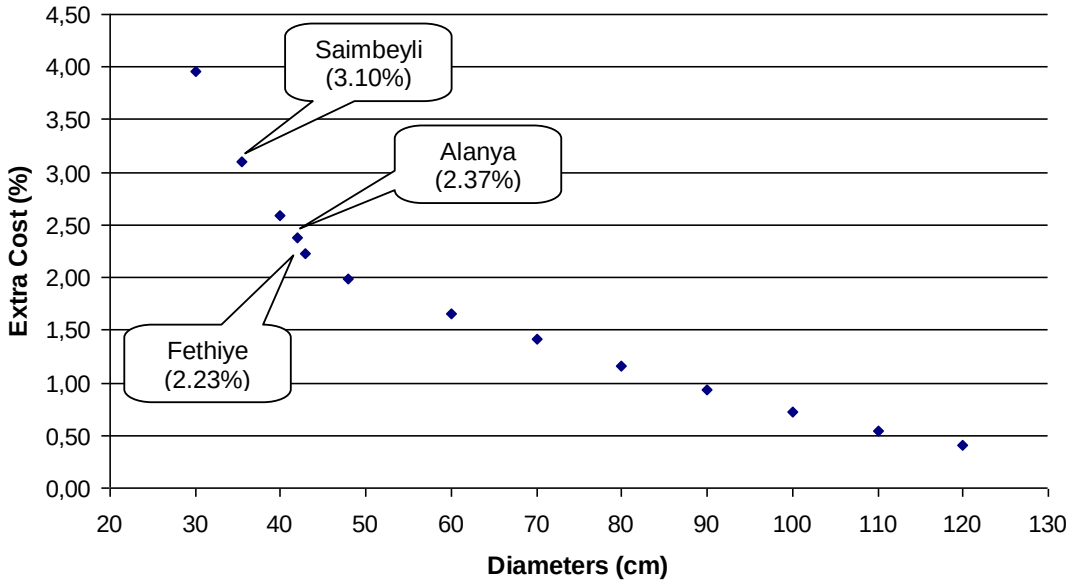

Figure 4. The extra cost of using optimum bucking as a proportion of tree value for different tree diameters (Adapted from Sessions et al., 1989a).

According to the previous studies where handheld computers were utilized in optimum bucking applications, the extra cost of using optimum bucking was a proportion of tree value and varied as a function of tree diameter. Sessions et al. (1989a) reported that the extra cost of using optimum bucking was 0.4 and 2.0% of the tree value for two average diameter classes of 120 and 48 cm coniferous trees, respectively. These results were adapted in this study to generate Figure 4, which indicates the estimated extra cost of using optimum bucking as a proportion of tree value for different tree diameters from 30 to 120 cm. Based on Figure 4, the extra cost of optimum bucking method was estimated as 2.37, 2.23 and 3.10% of the tree values for the bucking applications in FEDs of Alanya, Fethiye, and Saimbeyli, respectively (Figure 4). Finally, the overall gain of using optimum bucking method on production of Brutian Pine logs extracted in Mediterranean region of Turkey was computed depending on the following formula:

$$\sum_{i=0}^{N} p_i \left(1 - c_i\right) V_i \left(1 + v_i\right) - t_i V_i \qquad (1)$$

Where,

i = FRDs in Mediterranean Region (i = 1, 2, 3….n)

N = Total number of FRDs considered in the study (N = 6)

p_i = Value of Brutian Pine logs bucked by optimum bucking (YTR/m^3) in FRD i

c_i = Extra cost of optimum bucking as a percentage of tree value in FRD i

V_i = Total log production from Brutian Pines in FRD i (m^3) v_i = The percentage of volume gain due to using optimum bucking in FRD i

t_i = Value of Brutian Pine logs bucked by traditional bucking in FRD i (YTR/m^3)

Table 3. The parameters used in estimating potential economic value gain of using optimum bucking method in FRDs of Mediterranean region.

FRDs	Volume gain	Average unit value (YTR/m^3)		Extra cost	Total volume	Total value gain
	(%)	Traditional	Optimum	(%)	(m^3)	YTR
Antalya	0.94	179.49	186.70	2.37	145368	653952.05
Muğla	2.89	161.58	173.67	2.23	114565	1503585.07
Adana	1.32	147.50	157.62	3.10	122000	884483.64
Mersin	0.94	179.49	186.70	2.37	184730	831025.82
Isparta	2.89	161.58	173.67	2.23	111891	1468490.70
K.Maraş	1.32	147.50	157.62	3.10	41400	300144.45

The unit value of Brutian pine logs for both optimum and traditional bucking methods and extra cost of optimum bucking as a percentage of tree value for FRDs of Mersin, Isparta, and Kahramanmaras were represented by the data obtained during the optimum bucking solutions in FRDs of Antalya, Muğla, and Adana, respectively.

RESULTS AND DISCUSSION

The bucking patterns generated by optimum bucking method were different than the patterns generated by traditional bucking method in all of the tree application areas. The statistical analysis indicated that there was a significant difference for the average lengths of bucked logs between two bucking methods ($p < 0.005$). The average log lengths produced by optimum bucking method was about 38% longer than the logs produced by traditional bucking method.

The previous studies reported similar results in which optimum bucking method tended to generate longer log lengths resulting increases on value and volume gains (Wang et al., 2004). The results also indicated that there was no significant difference for volume and value yield of bucked trees between two bucking methods for the tree application areas ($p > 0.05$). However, the volume and the potential net unit values of trees bucked by using optimum bucking method were greater comparing with the trees bucked by traditional bucking method in all of the tree application areas.

The optimum bucking method resulted in 2.89, 1.32, and 0.94% of volume gains in FEC of Fethiye, Saimbeyli, and Alanya, respectively. The highest net unit value gain was produced during the optimum bucking application in the FEC of Fethiye in (8.12%), followed by FEC of Saimbeyli (4.92%), and FEC of Alanya (2.51%). In a similar study conducted on Taurus Fir stands in Mediterranean region, Yenilmez (2009) found that optimum bucking method increased the total volume and value of sample trees by about 4.0 and 9.0%, respectively. The overall gain of using optimum bucking method on production of Brutian Pine logs extracted in Mediterranean region of Turkey was estimated depending on unit value of logs produced by both bucking methods, total log production, the percentage volume gain due to using optimum bucking method, and extra costs of optimum bucking as a percentage of tree value. Table 3 indicates the parameters used in estimating potential economic value gain of using optimum bucking method in FRDs of Mediterranean Region.

The results indicated that the highest total value gain was produced in FRD of Muğla (1503585.07 YTR) followed by Isparta (1468490.70 YTR), Adana (884483.64 YTR), Mersin (831025.82 YTR), Antalya (653952.05 YTR), and Kahramanmaraş (300144.45). The overall total value of Brutian Pine logs bucked by traditional bucking method was estimated as approximately 119,941,551 YTR, it was found as 125583232 YTR when using optimum bucking method.

Conclusion

In this study, the optimum bucking method was implemented during the logging operations of sample Brutian Pine stands in three major Forest Regional Directorates (Adana, Antalya, and Muğla) to investigate the effects of optimum bucking method on the total economic value of Brutian Pine logs in Mediterranean Region of Turkey. The data obtained from optimum bucking solutions in FRDs of Antalya, Muğla, and Adana was used to represent the data for FRDs of Mersin, Isparta, and Kahramanmaraş, respectively. These FRDs represent the general characteristics of Brutian Pine forest in Mediterranean region of Turkey.

The results indicated that using optimum bucking method increased the potential gross value and volume of the harvested trees by 4.7 and 1.64%, respectively, in the region. The net unit value gains produced in FRDs of Muğla-Isparta, Adana-Kahramanmaraş, and Antalya-Mersin were 13.12, 7.25 and 4.5 YTR/m^3, respectively. Based on the results from this study, it is highly anticipated that applying optimum bucking method can significantly increase the total economic value of log production in Turkey, where the bucking decisions are currently performed based on loggers' experiences.

ACKNOWLEDGEMENT

This study is funded by The Scientific and Technological Research Council of Turkey (TUBITAK) with the project number 108O125.

REFERENCES

Akay AE, Serin H, Pak M, Yenilmez N (2009). Optimum tree-stem bucking of Brutian pine (*Pinus brutia*) trees in Antalya, Turkey. Third International Faustmann Symposium. "Forest Economics in a Dynamic and Changing World". 28 - 31 October. Almanya.

Bishop JT (1998). The Economics of Non-timber Forest Benefits: An Overview. IIED Gatekeeper Series, London. p. 18.

Bozkurt Y, Goker Y (1981). Utilization of Forest Products. Text Book. Istanbul University. Faculty of Forestry, Publication No: 2840: 297.

Boydak M, Dirik H, Çalikoğlu M (2006). Biology and Silviculture of Turkish Red Pine (*Pinus Brutian*). 1 st Edn., OGEM-VAK, Ankara, ISBN: 975-93943-4-0. p. 253.

GDF (2009). General Directorate of Forestry. Forest Production and Marketing Department. The Evaluation of Production and Marketing Activities in 2009.

Kivinen VP (2004). A genetic algorithm approach to tree bucking optimization. Forest Sci. 50(5): 696-710.

Laroze AJ, Greber BJ (1997). Using Tabu Search to Generate Stand-Level, Rule-Based Bucking Patterns. Forest Sci. 43(2): 367-379.

Laroze AJ (1999). A linear programming, tabu search method for solving forest-level bucking optimization. Forest Sci. 45(1): 108-116.

Olsen E, Stringham B, Pilkerton S (1997). Optimal Bucking: Two Trials with Commercial OSU BUCK Software. Oregon State University, College of Forestry, Forest Research Laboratory. Res. Contribution 16: 32.

Sessions J (1988). Making better tree bucking decisions in the woods: an introduction to optimal bucking. J. For. 86(10): 43-45.

Sessions J, Garland J, Olsen E (1988a). BUCK: A computer program for optimal tree bucking. The Compiler. 6(3): 0-13.

Sessions J, Layton R, Guangda L (1988b). Improving tree bucking decisions: A net-work approach. Compiler 6(1): 5-9.

Sessions J, Garland J, Olsen E (1989a). Testing computer-aided bucking at the stump. J. Forestry 87(4): 43-46.

Sessions J, Olsen E, Garland J (1989b). Tree Bucking for Optimal Stand Value with Log Allocation Constraints. For. Sci. 35(1): 271-276.

Türker MF, Öztürk A, Pak M (2003). Total Economic Value of Forest Resources in Turkey, XII World Forestry Congress, Congress Proceedings, A- Forests for People, Section A2a, Paper number 0410, September 21 to 28, 2003, Quebec City, Canada.

Wang J, LeDoux CB, McNeel J (2004). Optimal tree-stem bucking of northeastern species of China. Forest Products J. 54(2): 45-52.

Yenilmez N (2009). Applying a Single Tree Level Optimum Bucking Method During Cut-To-Length Logging. M.Sc. Thesis. KSU, Faculty of Forestry, Kahramanmaraş. Turkey. p. 126.