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cations with a high citation potential are welcomed. These authors may even be invited by the journal. Reviews should describe, discuss, and evaluate the current level of knowledge of a topic in the field and should guide future studies. The main text of review articles should be begun with an Introduction section and finalized with a Conclusion section. The remaining parts can be named relevantly to the essence of the research. Please check Table 1 for the limitations for Review Articles.

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Scientific plant and animal names should be written in italics in the main text.

When a product, hardware, or software program is mentioned within the main text, product information, including the name of the product, the producer of the product, and city and the country of the company (including the state if in USA), should be provided in parentheses in the following format: "EC meter (Orion Star A212, Thermo Scientific, MA, USA)

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Symposium, Conference and Workshop Papers: Dahlgren, R. A., 1988. Effects of forest harvest on stream-water quality and nitrogen cycling in the Casper creek watershed. In: Proceedings of The Conference on Coastal Watersheds: The Casper Creek Story. May 6, Ukiah, California.

Daganzo, C., 1996. Two paradoxes of traffic flow on networks with physical queues. II.Symposium Ingenieria de los Transportes, Madrid, 22-24 May 1996, pp. 55-62.

Online Document (Web) Reference: FAO. 2006. Rural radio transmissions and rural youth in Mali. http://www.fao.org/sd/dim_kn1/kn1_060202_en.htm (Accessed: 27 February 2006).

Article by DOI: Asakawa, S., Yoshida, K., Yabe, K., 2004. Perceptions of urban stream corridors within the greenway system of Sapporo, Japan. *Landscape and Urban Planning*, in press doi:10.1016/S0169-2046(03)00158-0.

Thesis: Güner, H.T., 2016. The Miocene flores and vegetation of the Yatağan Basin, Western Anatolia. Unpublished Ph.D. Thesis, İstanbul University, Institute of Sciences, p. 185., İstanbul, Turkey.

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ISTANBUL UNIVERSITY CERRAHPASA

Original Article

Variation of tree diameters along road edges: the case of Karacabey linden forest in Bursa, Turkey

Yol kenarları boyunca ağaç çaplarının değişimi: Bursa Karacabey ıhlamur ormanı örneği

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ABSTRACT

Roads have important effects on forest ecosystems including degradation and fragmentation of habitats. However, light availability along the road edge increases which reflects the diversity and amount of plant species. This study is aimed to investigate the road edge effect on tree growing by measuring the differentiation of tree diameters along a sample road located within Linden stands. The study was conducted in Karacabey province of Bursa where Linden has the largest distribution in Turkey. Field data were collected from sample trees selected from 5-meter-wide stripes at road edge and from control zone away from road edge. The tree diameters at breast height (DBH) and trunk core samples were collected from sample trees located in the specified zones. Statistical analysis was conducted to indicate whether there is a differences in DBH and DBH growth values between trees at road edge and ones at control zone. The results indicated that increasing distance from road edge resulted in reduction in the average tree diameters as well as DBH growth values. There was a statistically significant difference between DBH values for trees at road edge and ones at control zone. On the other hand, there was no significant difference between DBH growth values.

Keywords: Diameter growth, linden, road edge effect, road network

ÖZ

Yol ağları, orman ekosistemleri üzerinde habitatların bozulması ve parçalanması gibi önemli etkilere sahiptir. Öte yandan, yol kenarı boyunca ışık mevcudiyetinde görülen artış, bitki türlerinin çeşitliliğine ve miktarını da yansımaktadır. Bu çalışmada, yol kenar etkisinin ağaçların büyümesi üzerindeki etkisini araştırmak amacıyla Ihlamur meşceresinde bulunan örnek bir yol ağı boyunca ağaç çaplarındaki değişim ölçülmüştür. Çalışma, Ihlamurun Türkiye'de en geniş yayılış gösterdiği Bursa'nın Karacabey ilçesinde gerçekleştirilmiştir. Arazi verileri yol kenarındaki 5 metre genişliğindeki şeritlerden seçilen ve yol kenarından uzakta kontrol bölgesinden seçilen örnek ağaçlardan toplanmıştır. Verilerin toplanması sırasında belirlenen bölgelerdeki tüm örnek ağaçların göğüs yüksekliği çapı ölçülmüş ve artım burgusu ile artım kalemleri alınmıştır. Daha sonra, yol kenarındaki ağaçlar ile kontrol bölgesinde yer alan ağaçlar arasında çap ve çap artımı değerlerinde bir farklılık olup olmadığını belirlemek için istatistiksel analiz yapılmıştır. Sonuçlara göre, yol kenarından olan mesafenin arttırılmasıyla, ortalama ağaç çaplarında ve çap artımı değerlerinde azalma görülmüştür. Yol kenarındaki ağaçlar ve kontrol bölgesinde yer alan ağaçlar arasında çap değerleri açısından istatistiksel olarak anlamlı bir fark bulunmuştur. Öte yandan, çap artım değerleri arasında anlamlı bir fark tespit edilmemiştir.

Anahtar Kelimeler: Çap artımı, ıhlamur, yol ağı, yol kenarı etkisi

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INTRODUCTION

Road networks located within the forested areas have important functions in terms of sustainable management of forest resources (Gümüş, 2015). If they are not planned considering ecological constraints roads potentially cause adverse effects on integrity and stability of natural habitats in forest ecosystems by forming edge effects (Eker and Çoban, 2010; Yilmaz et al., 2010; Gülci et al., 2017). There are differences in growth, survival, and reproduction in edge habitats and compared with interior habitat for both flora and fauna (Naghdi et al., 2017). Due to variation in temperature, mois-

ture, and light availability along the edge habitats, populations of species especially the ones requiring higher light conditions tends to increase in fragmented habitats (Picchio et al., 2018).

The effects of road edges on growth of trees vary depending on the various factors such as tree age, tree diameter, distance to road, and road width. Growth rate of large size adult trees are usually higher in forest edges than on forest interior comparing with growth rate of seedlings (Bembenek et al., 2013). Based on the previous studies, there is a positive relationship between annual growth rate and the average tree diameter (Naghdi et al., 2017). The distance from the road plays important role on the growth rate of trees. As the distance from road edges increases, the annual growth rate of trees reduces. Road width also effects the growth rate since the width of the road affect the amount of light availability along the road edge.

Even though there are international studies on the subject of road edge effects on tree growth, this subject has not been studied in Turkey. The main objective of this study was to find an answer to the question on the effect of road network on the variation of tree diameters along a sample road within the Linden stands. The study area was Karacabey province of Bursa where Linden has the largest distribution in Turkey. Linden flowers are one of the most valuable non-wood products that are mainly used in medical and cosmetic industries due to the active substances such as tannins, mucilage, sugar, oils, gum. Besides, boiled Linden flowers are commonly consumed as herbal tea in Turkey to prevent flu and cold, relief chest and bronchi, and relax nervous system (Tuttu et al., 2017). In the field applications, sample road sections were selected within Linden stands, and tree ring widths and DBHs of sample trees were measured from both the road edge and control zone away from road in the forest.

MATERIAL AND METHODS

Study Area

The study area was selected from Yeniköy Forest Enterprise Chief of M.Kemalpaşa Forest Enterprise Directorate (FED) located in the border of Bursa Forestry Regional Directorate (Figure 1). This area hosts one of the largest Linden forests in the world. Within the border of the city of Bursa, there are 700 hectares of Caucasian Linden (*Tilia rubra*) forests and 400 hectares of Silvery Linden (*Tilia tomentosa*) forests. Field data were collected along the sample road section located in the middle of Linden stands. The road was 3-km long with gravel surface and its average with was 4 meters.

Method

Field data were collected from two sample Linden trees selected from 5-meter-wide stripes at the road edge and from control zone which is about 50 meters away from the road edge. In both locations, data was collected from two diameter classes (small; 25-35 cm and large; 35-45 cm). Measurements were repeated for 6 sample road sections with 500 meters length along 3 km-long road section located in the middle of Linden stands (Figure 2). During the data collection, the diameter measurement at DBH and trunk core sample at DBH was collected from all the sample trees located in the specified zones (Figure 3). Tree cores were sanded with

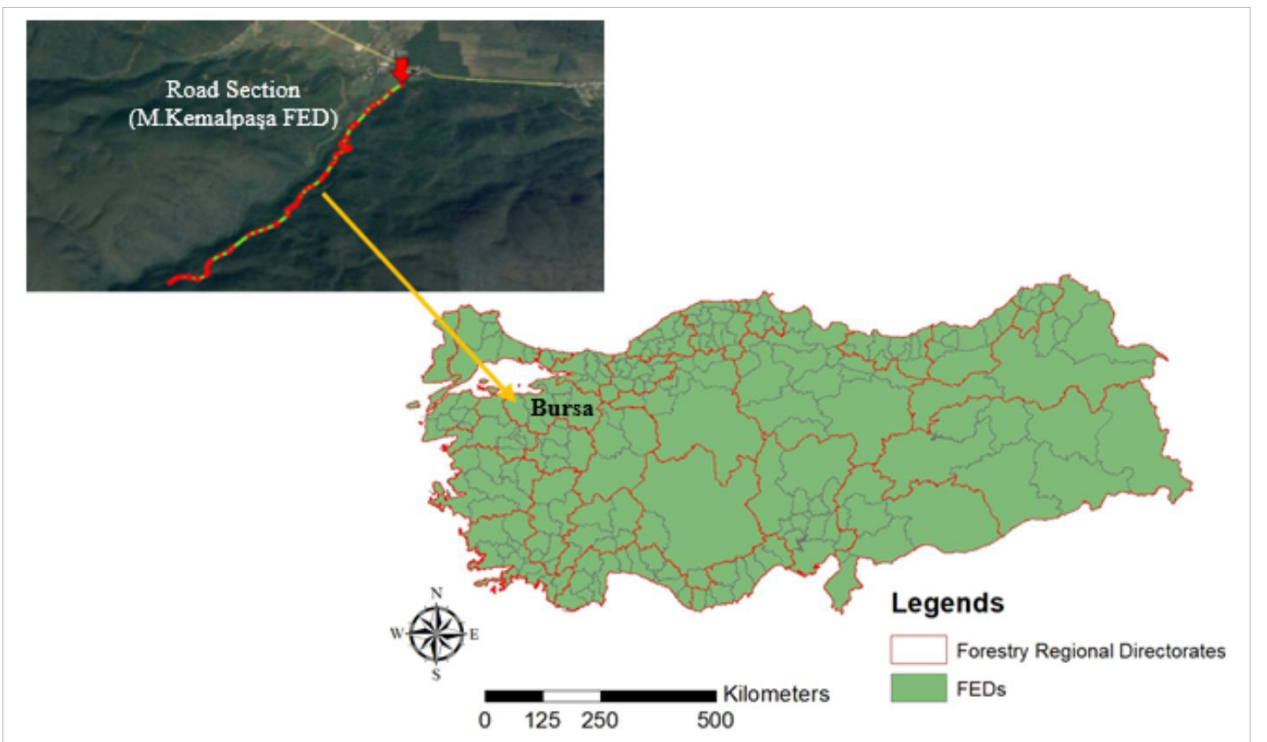

Figure 1. Study area

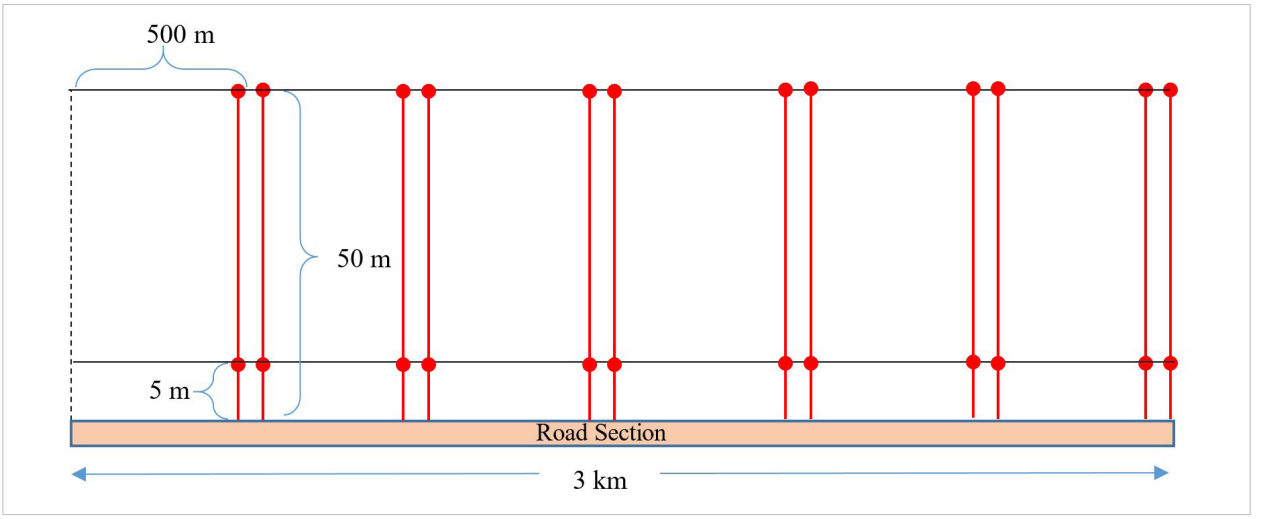

Figure 2. Field data collection pattern along the road section

Figure 3. Diameter measurement (left) and trunk core sample collection (right) in the field

fine sand paper in the open air till they were visible by a magnifying glass. Then, tree ring widths were measured and DBH growth values of sample trees were calculated for last 10 years.

One-way ANOVA analysis was used to assess the significance of observed differences in average DBH and DBH growth under different distances from the roads and two tree diameter classes. Turkey's test was used to compare the DBH and DBH growth value between two distance classes for two diameter classes. The significance level of $\alpha = 0.05$ was applied for statistical analysis using SPSS 16.0. (SPSS Inc., Quarry Bay, Hong Kong).

RESULTS AND DISCUSSION

The road edge effect on tree growing was investigated by measuring the differentiation of tree diameters along road network located within the Linden stands. The results showed that the average DBH of sample trees for the both dimeter classes were higher at the road edge area (Table 1). Thus, increasing the distance from the road, the average diameters tend to reduce (Stempski and Jablonski, 2014). The analysis of variance indicated that there was a statistically significant difference between DBH values in different tree diameter classes for both distance classes ($p<0.001$) (Table 2).

The road edge effect on DBH growth value was investigated by measuring the diameter growth of sample Linden trees at last 10 years for two diameter classes. It was that the average DBH growth of sample trees for the both dimeter classes were higher at the road edge area (Table 3). Therefore, increasing the distance from the road, the average DBH growth value was reduced (Naghdi et al., 2017). Figure 4 and 5 indicates the DBG growth values in two diam-

Table 1. Tree DBH values (cm) between two distance classes for two diameter classes

						95% Confidence Interval for Mean			
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Min	Max
Road Edge (5 m)	Small DBH	12	31.67	2.43	0.70	30.13	33.21	26.00	34.00
	Large DBH	12	39.75	2.34	0.68	38.26	41.24	36.00	44.00
	Total	24	35.71	4.74	0.97	33.70	37.71	26.00	44.00
Control (50 m)	Small DBH	12	29.17	2.55	0.74	27.55	30.79	25.00	33.00
	Large DBH	12	38.83	2.21	0.64	37.43	40.24	36.00	43.00
	Total	24	34.00	5.46	1.15	31.70	36.31	25.00	43.00

DBH: diameters at breast height; Std: standard; Min: minimum; Max: maximum

Table 2. ANOVA analysis of DBH values in different distance classes

		Sum of Squares	df	Mean Square	F	Sig.
Road Edge (5 m)	Between Groups	392.04	1	392.04	69.05	0.00
	Within Groups	124.92	22	5.68		
	Total	516.96	23			
Control (50 m)	Between Groups	560.67	1	560.67	98.42	0.00
	Within Groups	125.33	22	5.70		
	Total	686.00	23			

DBH: diameters at breast height; Sig: significant

Table 3. DBH growth values (mm) between two distance classes for two diameter classes

						95% Confidence Interval for Mean			
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Min	Max
Road Edge (5 m)	Small DBH	12	19.22	4.93	1.42	16.09	22.35	15.54	28.75
	Large DBH	12	18.72	4.16	1.20	16.07	21.36	14.75	29.69
	Total	24	18.97	4.47	0.91	17.08	20.86	14.75	29.69
Control (50 m)	Small DBH	12	17.11	4.73	1.37	14.10	20.11	12.41	26.90
	Large DBH	12	16.17	4.69	1.35	13.19	19.15	11.00	26.00
	Total	24	16.64	4.63	0.95	14.68	18.59	11.00	26.90

DBH: diameters at breast height; Std: standard; Min: minimum; Max: maximum

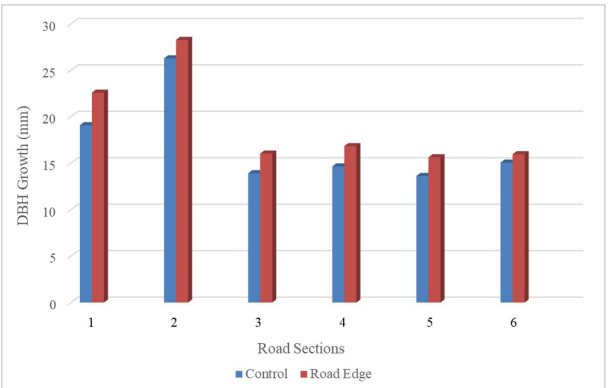

Figure 4. DBH growth values in small diameter class for two road distance classes

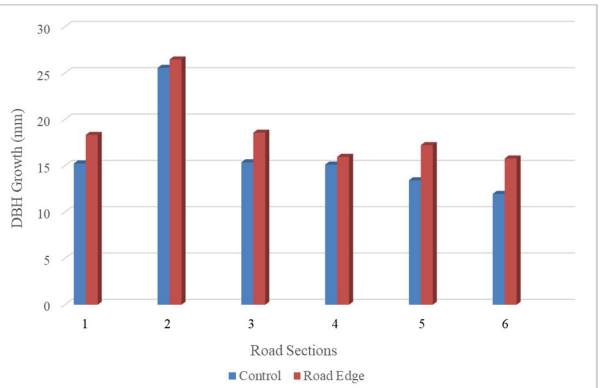

Figure 5. DBH growth values in large diameter class for two road distance classes

Table 4. ANOVA analysis of DBH growth values in different distance classes

		Sum of Squares	df	Mean Square	F	Sig.
Road Edge (5 m)	Between Groups	1.52	1	1.52	0.07	0.79
	Within Groups	457.98	22	20.82		
	Total	459.49	23			
Control (50 m)	Between Groups	5.29	1	5.29	0.24	0.63
	Within Groups	487.57	22	22.16		
	Total	492.87	23			

DBH: diameters at breast height; Sig: significant

Table 5. ANOVA analysis of DBH values in different diameter classes

		Sum of Squares	df	Mean Square	F	Sig.
Small DBH	Between Groups	37.50	1	37.50	6.05	0.02
	Within Groups	136.33	22	6.20		
	Total	173.83	23			
Large DBH	Between Groups	5.04	1	5.04	0.97	0.33
	Within Groups	113.92	22	5.18		
	Total	118.96	23			

DBH: diameters at breast height; Sig: significant

Table 6. ANOVA analysis of DBH values in different diameter classes

		Sum of Squares	df	Mean Square	F	Sig.
Small DBH	Between Groups	26.86	1	26.86	1.15	0.30
	Within Groups	513.22	22	23.33		
	Total	540.08	23			
Large DBH	Between Groups	40.72	1	40.72	2.05	0.17
	Within Groups	436.67	22	19.85		
	Total	477.39	23			

DBH: diameters at breast height; Sig: significant

eter classes for different road distance classes. The results indicated that DBH growth value was higher in small diameter class (25-35 cm). However, one-way ANOVA analysis showed that there was no statistically significant difference between DBH growth values in different tree diameter classes for both distance classes (Table 4).

One-way ANOVA analysis was also used to assess the significance of observed differences in average DBH and DBH growth under two tree diameter classes for different distances from the roads. It was found that there was a statistically significant difference between DBH values in different distance classes for small diameter class ($p<0.05$) while there was no significant difference between DBH values for large diameter class (Table 5). The results also indicated that there was no statistically significant difference between DBH growth values in different distance classes for both tree diameter classes (Table 6).

CONCLUSION

The road edge effect on tree growing was investigated by measuring the differentiation of tree diameters along road network located within the Linden stands. The results indicated that increasing the distance from the road edge causes reduction in the average tree diameters as well as DBH growth values. Thus, the distance from the road plays important role on the growth rate of trees due to mainly amount of light availability along the edge habitats. This finding revealed that tree volume loss due to removal of trees during road construction can be potentially restored through the volume increment of the trees along road network at long run. In this study, the effects of road edge on tree growth was investigated on Linden trees whose flowers are one of the most valuable nonwood products in Turkey. The findings of this study also revealed that the road edges can provide suitable habitats for nonwood spe-

cies. In order to estimate potential impacts of road edges on non-wood products further studies should be conducted on growth, survival, and density of different species along road edges.

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ISTANBUL UNIVERSITY CERRAHPASA

Original Article

Assessing land use change and moving sand transport in the western Hodna basin (central Algerian steppe ecosystems)

Batı Hodna havzasında arazi kullanım değişiminin ve kum taşınımının değerlendirilmesi (Merkez Cezayir bozkır ekosistemleri)

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ABSTRACT

The application of land use and land cover change (LULC) techniques for identifying the state of the environment is both a suitable tool and cost-effective. The study was conducted in the western part of the Hodna Basin (province of M'sila, Algeria). In this study, we combined remotely sensed data and ground truth observations to analyze the trends of LULC and their drivers during the 30 years from 1984 to 2014. In addition, we evaluated the sand transport using wind data. We assessed LULC using the supervised image classification method. The results indicated that rangelands experienced a considerable decrease with 50,000 hectares. This shrinkage in rangelands cover is associated with an expansion in bare soil cover with an increase of 57,000 hectares. Furthermore, woody vegetation and sand experienced a decrease in their cover. However, there is an increase in agriculture area. The analysis of land cover of sand indicated a decrease in the area of this class, and the assessment of wind data revealed that within the study area there is a transition zone of moving sands. The dynamic of LULC was mostly conducted by the anthropogenic and overgrazing factors. These drivers have a considerable role in the patterning of different types of land cover in the investigated landscape. We can conclude that the LULC technique used for the assessment of the environmental state identified a regressive trend of ecosystem values and a process of land degradation which implies the need for implementation of sustainable management practices.

Keywords: Drivers, land use/ land cover, sand transport

ÖZ

Arazi kullanımı ve arazi örtüsünün değişimi (LULC) teknikleri ile çevre durumunun tespit edilmesi uygun bir yöntem olmakla birlikte maliyeti de düşüktür. Bu çalışma, Hodna Havzası'nın (Mila il eyaleti, Cezayir) batı kısmında gerçekleştirilmiştir. Bu çalışmada, 1984-2014 yılları arasındaki 30 yıllık uzaktan algılama verileri ve arazi gözlemleri birleştirilerek, arazi kullanımı ve arazi örtüsünün değişimleri (LULC) analiz edilmiştir. Ayrıca, rüzgâr verileri kullanılarak kum taşınımı durumu da değerlendirilmiştir. Görüntü sınıflandırma yöntemini kullanarak LULC tekniği ile birlikte değerlendirmeler yapılmıştır. Elde edilen sonuçlara göre mera alanlarının 50000 hektar ile önemli bir düşüş yaşadığını göstermiştir. Mera alanlarındaki bu azalmanın çıplak toprak örtüsündeki 57000 hektarlık artış ile ilişkili olduğu görülmüştür. Ayrıca, odunsu bitki örtüsü ile kaplı alanlarda bir azalma ve tarım alanlarında da bir artış gerçekleşmiştir. Kum ile kaplı alanların incelenmesi ve rüzgar verilerinin değerlendirilmesi ile çalışma alanı içerisinde hareketli kumların bir geçiş bölgesi bulunduğu ortaya koyulmuştur. Arazi kullanımı ve arazi örtüsünün değişimlerinin (LULC) çoğunlukla antropojenik ve aşırı otlatma faktörlerinden kaynaklandığı görülmektedir. Bu arazi etki faktörleri, arazideki farklı tipteki arazi örtüsü modellerinde de önemli rol oynamaktadır. Çevresel durumun değerlendirilmesinde kullanılan LULC tekniğinin, ekosistem değerlerinde azalma eğilimi olduğunu ve sürdürülebilir yönetim uygulamalarına duyulan ihtiyacı ortaya koyan bir arazi bozulma sürecini tanımladığı sonucuna varılmıştır.

Anahtar Kelimeler: Arazi etki faktörleri, arazi kullanımı, arazi örtüsü, kum taşınımı

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INTRODUCTION

Monitoring land use and land cover change (LULC) is an important issue for management and planning (Ateşoğlu, 2015; Fathizad et al., 2015) especially in arid and semi-arid regions characterized by harsh environmental conditions (Boydak and Çalişkan, 2015) as well as socioeconomic restrictions (Çalişkan and

Boydak, 2017). In addition, the misuse of natural resources can lead to land degradation (Gökbulak et al., 2018). LULC studies are often focused on vegetation as a comparator, this vegetation is in continuous transformation, the changes due to the human activities represent a great challenge for the researchers, the decision-makers and the planners (Manning et al., 2009). These changes are the main drivers of habitats deterioration and biodiversity loss (Abdi et al., 2018).

The steppe rangelands of Algeria are experiencing dramatic transformations under the effect of climate change and human-induced activities. These transformations are the result of complex and continuous interactions between the local population, environmental drivers and natural resources (Fathizad et al., 2015). These steppe ecosystems are located between important geomorphologic complexes; the Sahara, the Saharan Atlas, the Hodna Mountains, and the Hodna Basin. Moreover, these ecosystems reflect great ecological importance marked by endemic species (Bahlouli et al., 2012). The density of the population in steppe rangelands and high plateau expressed a remarkable evolution from 36.7 habit./km^2 in 1977 to 60.0 habit./km^2 in 1998 (Kateb, 2003). Furthermore, the survival of this population is concentrated on pastoral activities (mainly sheep farming), where the number of sheep has increased from 17.6 million heads in 2000 to 21.4 million heads in 2009. This situation has a direct effect on the LULC in steppe rangelands.

The application of land use and land change techniques for the assessment and analysis of the change in arid and semi-arid environments has been studied previously (Badreldin and Goossens, 2014) indicated that vegetation cover decreased dramatically and more than 50% of the land was bare ground over the 11 years from 1999 to 2010. In their study, (Abdul Rahaman et al., 2017) used a Markov chain approach for the modeling of LULC and found that forest and vegetation cover decreased under the effect of population growth. Whereas, the study conducted in Yuli County (China) by (Zhou et al., 2011) revealed that natural processes were the main driver of changes, and human activities have a minor effect on the environment.

The emergence of new technologies such as remote sensing facilitates the work of managers in evaluating and proposing effective solutions for decision-makers (De Leeuw et al., 2010; Willis, 2015). This is especially so where the monitoring focuses on the landscape scales. This evaluation requires the use of human and material resources for its realization, which could be time-consuming and costly. Remote sensing technology provides useful information to evaluate the trends in environmental change and facilitates the comparison of spatiotemporal data (Zoungrana et al., 2015).

In arid and semi-arid environments, wind erosion is a determinant process in landscape modeling. Indeed, the surface wind is the climatic component most responsible for erosion, trans-

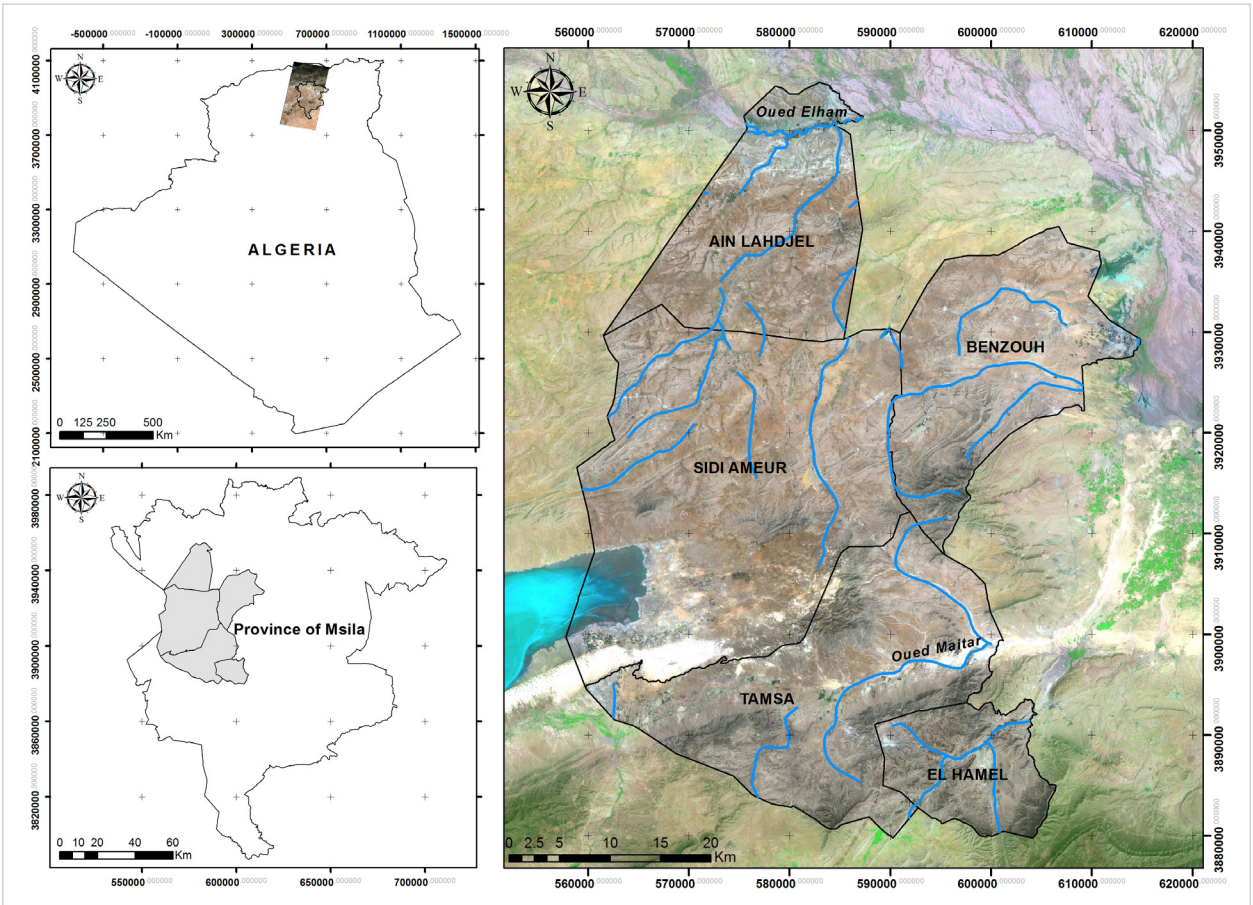

Figure 1. Study area location map (System coordinates WGS 1984 UTM Zone 31N)

Table 1. The four scenes representing two dates 1984, and 2014, for LULC

Period	Acquisition date	Image identity	Satellite	Path/row
1984/Scene1	18/04/1984	LT51950351984109XXX02	Landsat 5	195/35
1984/Scene2	18/04/1984	LT51950361984109XXX02	Landsat 5	195/36
2014/Scene1	21/04/2014	LC81950352014111LGN00	Landsat 8	195/35
2014/Scene2	21/04/2014	LC81950362014111LGN00	Landsat 8	195/36

Table 2. Description of LULC classes

Classes	Description
Woody vegetation	Land covered by forest, plantation, trees, small trees, bushes.
Sand	Area covered by sands and dunes
Bare soil	Area with no vegetation
Agriculture	Land covered by agriculture
Alluvium	Land covered by alluvium
Rangeland 1	Land covered by dense grasslands, dominated by perennial grasses
Rangeland 2	Area covered by open vegetation, generally dominated by annual plants
Urban	Urban and built-up
Chott	Area covered by a salt lake in arid and semi-arid regions.

port of moving-sand, loess sediments, and finally the accumulation of sand dunes and bodies (Boulghobra, 2016). The sand transport aptitude is principally controlled by wind velocity and frequency where the effective wind exceeds 6 m/s and spreads the prevailing wind according to a privileged direction (Bagnold, 1941). The accumulation of moving-sand on urban areas and socioeconomic installations (roads, railroads, palm-date, land reclamation, etc.) is a serious hazard threatening the natural resources of the local population and consequently all sustainable development effort (Boulghobra, 2016). Understanding the encroaching-sand risk in a region is an essential task for predicting impacts and attenuating damages, which requires the quantification of drifting-sediment rate, transport direction from the source to deposition zones, and the characterization of the studied region in terms of wind regime and energy.

This study used the post-classification method to assess the LULC in the western part of the Hodna Basin resulting from supervised classification over 30 years. Mainly, this study has three specific objectives: (1) to quantify and analyze the LULC classes from 1984 to 2014 (2) to qualify if the current situation is stable, unstable or neutral (no change) (3) to assess the aeolian hazard by quantifying sand transport rate and direction using wind data and the universal formulae of Fryberger and Dean (1979).

MATERIALS AND METHODS

Study Area

The study was conducted in the central steppe rangelands of Algeria, in the western part of the Hodna Basin (Province of M'sila) (Figure 1). The average annual temperature is between 17°C and 21°C, and average annual rainfall ranges from 200 to 400 mm. The largest amount of rainfall occurs during spring and autumn which account for 31.88% and 34.22% respectively (climatic data of Boussaâda station from the Algerian National Office of Meteorology 1988-2014). Livestock grazing is the main land use system in this area. Soils are calcareous brown, and encrusted gypsum soils (Halitim, 1988). The steppe of perennial grass *Stipa tenacissima* L. represents the most important part of the landscape.

Satellite Data

The satellite images were obtained from the United States Geological Survey (USGS), which is a web-based portal for acquiring data. The acquired multi-temporal data was needed for change detection analysis, to provide information on the quantity and possible reason for the change, especially in a semi-arid and arid environment because of the limitation of natural resources (Badreldin and Goossens, 2014). Our study is based on satellite images of two dates (1984, and 2014). A mosaic of two Landsat scenes was used to cover our study area. We acquired the scenes of the year 1984 using the Landsat 5 Thematic Mapper (TM). For the year 2014 we used the images provided by Landsat 8 Operational Land Imager OLI. The spatial resolution for all images used is 30 x 30 m. Satellite images can be downloaded free of charge from the USGS website (http://glovis.usgs.gov/) (Table 1). We ensured that the study area included in the satellite images was cloud free. Furthermore, the acquired satellite images dates corresponded to the spring season, reflecting the maximum growth of vegetation.

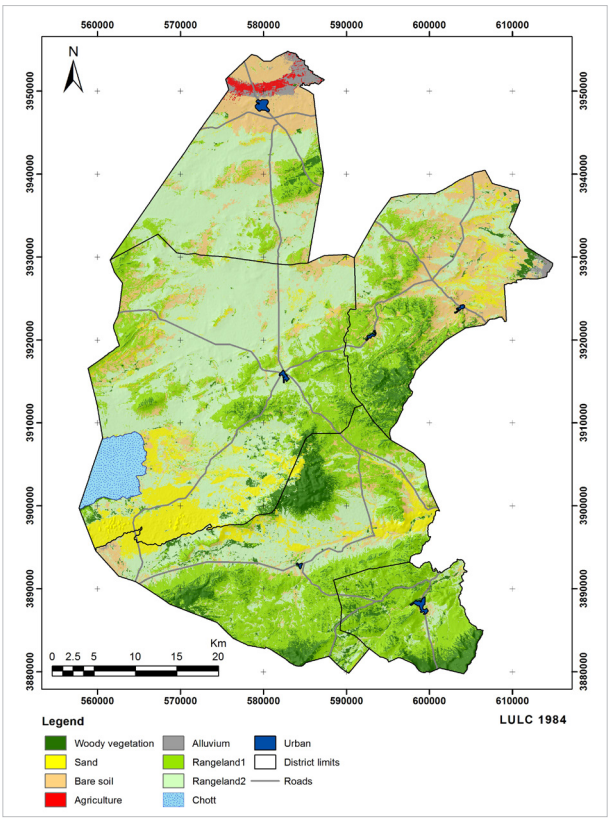

Figure 2. Land use and land covermap of 1984

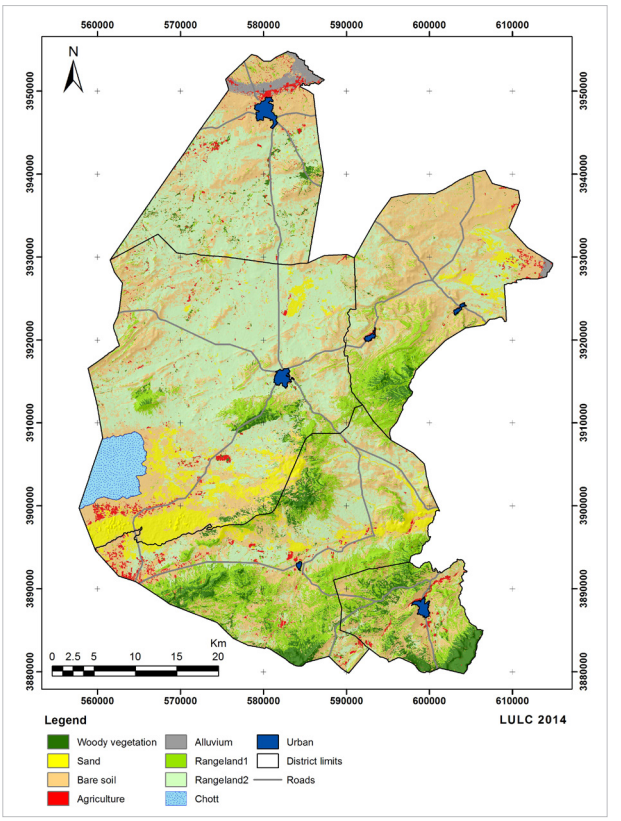

Figure 3. Land use and land covermap of 2014

Ground Truth

The study area was surveyed in a previous project of the National Fund of Research during 2010-2013 (Mostephaoui et al., 2013) and during this study in 2014. The necessary information and data were collected to identify different land cover areas (area of interest), and according to these data, we conducted the image classification and accuracy assessment processes.

Image Preprocessing

The images acquired by the satellites are influenced by several agents, which affect image quality and accuracy. Therefore, it will be necessary to perform several correction operations, including geometric corrections based on ground control points. The radiometric correction was performed using the dark object subtraction model (Pons et al., 2014; Zhang et al., 2018). Finally, the images were georeferenced to the Universal Transverse Mercator (UTM) projection WGS 1984 Zone 31N.

Supervised Classification

Before classifying the images, we proceeded to the extraction of the part of images that covered our study area. This was possible using a shape file covering five districts of the province of M'sila, namely Aïn El Hadjel, Benzouh, Sidi Ameur, Tamsa, and El Hamel corresponding to our zone of study. This operation was carried out using the ENVI 4.4 software (Exelis Visual Information Solutions, Boulder, Colorado, USA). The maximum likelihood algorithm was used for the implementation of the supervised classification. We classified the satellite images into seven classes of land use; Woody vegetation, Sand, Bare soil, Agriculture, Alluvium, Rangeland1 (not degraded) and Rangeland2 (degraded). In addition, two other classes: Urban and Chott, the latter two classes were determined using a mask for each class and were not included in the classification (Table 2). The problems of misclassified areas and overlapping classes were overcome before the classification (Amarnath et al., 2017).

Post-Classification Comparison

The effective use of remotely sensed data is determined by the accuracy assessment (Lyons et al., 2018). The accuracy assessment is an important factor for successful change detection research (Badreldin and Goossens, 2014). Moreover, this can be helpful for the analyst to identify changes of interesting land use (class) (Tewkesbury et al., 2015). The error matrix is considered the most recognized method for assessing the accuracy of the classification (Badreldin and Goossens, 2014; Lyons et al., 2018). The accuracy assessment is achieved by the measurement of overall accuracy (Mubako et al., 2018) and the Kappa coefficient which is an important parameter in this process (Metelka et al., 2018).

Wind Data and Sand Transport

Hourly wind data from the nearest meteorological station of Boussaâda (Lat. 35.3; Long. +4.2; Alt. +459 m) are available for

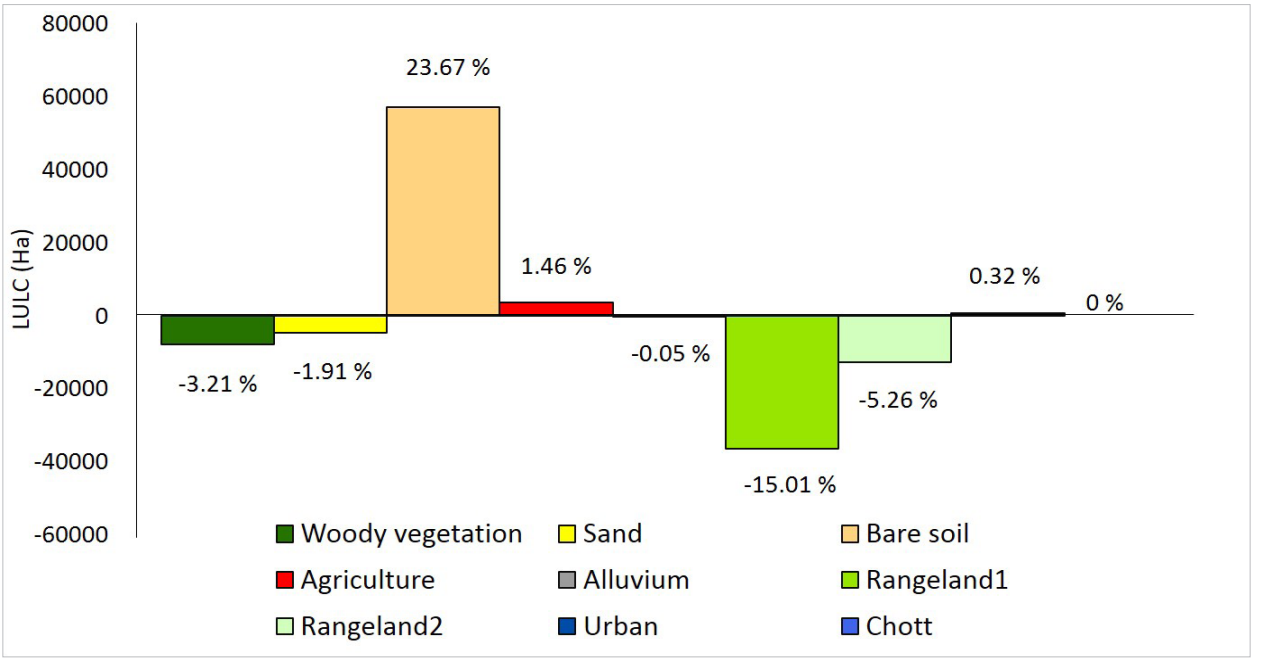

Figure 4. Land use and land coverchange from 1984 to 2014

Table 3. Classification of wind energy and wind regime according to Fryberger and Dean (1979)

Drift Potential (VU)	Energy of wind environment	Ratio RDP/DP	Wind variability	Wind regime
≤ 200	Low	≤ 0.3	High	Complex
200 – 400	Medium	0.3 – 0.7	Medium	Bimodal
≥ 400	High	≥ 0.7	Low	Unimodal

a ten-year period of continuous recording (2006–2015) with a temporal resolution of 8 records per day (45.154 values in total); wind data values are expressed as speed (m/s) and direction (degree clockwise).

Based on speed/direction wind data, the weighting model of Fryberger and Dean (1979) is widely used for assessing the rate and direction of sand transport. The formula expressing the Drift Potential (DP) is presented as follows:

$DP=V^2 (V-Vt)t$ (1)

DP : Rate of sand drift on vector unit (1 VU=0.07 m^3/m)
V : Average wind velocity
Vt : Threshold wind velocity (6 m/s)
t : Effective wind occurrence (%)
$V^2(V-Vt)$: Weighting factor that depends on wind strength

In addition to the sand drift potential, three parameters could be derived from the equation of Fryberger and Dean (1979):

The Resultant Drift Potential RDP which corresponds to the magnitude of sand transport, the Resultant Drift Direction RDD which represents the direction of sand movement, these two parameters could be calculated as suggested by Al-Awadhi et al. (2005) :

$$RDP = \sqrt{C^2 - D^2} \quad (2)$$

Where:

$C=\sum(VU)\ \sin(\partial)$ (3)

$D=\sum(VU)\ \cos(\partial)$ (4)

VU is the corresponding DP for each direction (among 16 directions) in vector unit, and is the midpoint of the wind classes.

$RDD=atan(C / D)$ (5)

The ratio RDP/DP (ranging from 0 to 1) which expresses the variability of wind direction, where lower values (close to 0) indicate strong directional variability and higher values indicate lower variability (values close to 1). Depending on the DP value, wind environment can be classified in terms of energy (transport sand transport aptitude), while the wind regime of the region is identified in function of the ratio RDP/DP (Table 3).

In this study, the sand transport parameters are calculated and interpreted by applying the equation of Fryberger and Dean (1979) on wind data from the station in Boussaâda for the temporally significant period 2006–2015.

RESULTS AND DISCUSSION

LULC During 30 Years

The 1984 LULC map indicates the pastoral character of the study area. The steppe rangelands constitute the most important part of the study area - 68%. On one hand, the north and north-west part are characterized by degraded rangelands (Rangeland 2) representing 96,878.16 hectares, which is equivalent to 40% (Table 4). On the other hand, the southern part is characterized by rangelands in good condition (Rangeland 1) covering 68,736.06 hectares (28%). In the extreme south-east part we find Fernan mountain (1600 a.s.l) covered by forest vegetation (Woody vegetation), with a combination of Aleppo pine and holm oak. In addition, the Halfa grass *Stipa tenassicima* L. the woody vegetation represents 9% of the total LULC map for 1984. The valley of Oued Maitar is a corridor for sandy wind movements. The western part is characterized by the presence of dunes in the south of Chott Chergui. The Agriculture occupies an area of 1,004 hectares and is concentrated in the northern part of the study area near Oued El Ham where water is more abundant (Figure 2). The accuracy assessment indicated that the overall accuracy for the image classification of the year 1984 is evaluated as 97.21%. The Kappa coefficient value of this year is 0.96 (Appendix 1).

The 2014 LULC map shows that 48% of the total area was occupied by rangelands. In this map, there was an increase in the cover of Urban class, especially in the north. The city of Ain Lahjel represents the largest agglomeration in the study area. While the LULC of Agriculture remains in a constant state indicating the development of rainfed agriculture in the direction of Oued Maitar, in the northern part it benefits from the contributions of Oued L'Hem (Figure 3). The degraded rangelands represented 34% of the total area, and the rangelands in good condition represented 13%. In this year, the bare soil class increased remarkably, representing 36 % (Table 4). The accuracy assessment results of the year 2014 reported that the overall accuracy was 97.02% and the Kappa coefficient was 0.96 (Appendix 2).

Drivers of LULC Change

The Land Use Stability / Instability Analysis is very important for policymakers who may have better planning for future land use (Fathizad et al., 2015).The results show that the period from 1984 to 2014 (Figure 4) was marked by a decrease in the area of degraded rangelands and rangelands in good condition. The non-degraded rangelands (Rangeland 1) lost half of their area during this period. Consistently, the area of bare soil increased significantly from 30,634.38 ha in 1984 to 87,846.21 ha in 2014,

Figure 5. The cultivation of steppe rangelands initially covered by *Stipa tenacissima* L. and *Artemisia herba-alba* Asso

Table 4. Areas of different classes for 1984 and 2014

Years	1984		2014		Change
Classes	Hectares	Percentage %	Hectares	Percentage %	Percentage %
Woody vegetation	21 746.25	8.99	13 962.24	5.78	-3.21
Sand	20 276.01	8.39	15 663.60	6.48	-1.91
Bare soil	30 634.38	12.67	87 846.21	36.34	23.67
Agriculture	1 004.22	0.42	4 540.41	1.88	1.46
Alluvium	2 001.60	0.83	1 897.53	0.78	-0.05
Rangeland1	68 736.06	28.43	32 443.02	13.42	-15.01
Rangeland2	96 878.16	40.07	84 156.03	34.81	-5.26
Urban	29.46	0.01	797.1	0.33	0.32
Chott	456.6	0.19	456.6	0.19	0

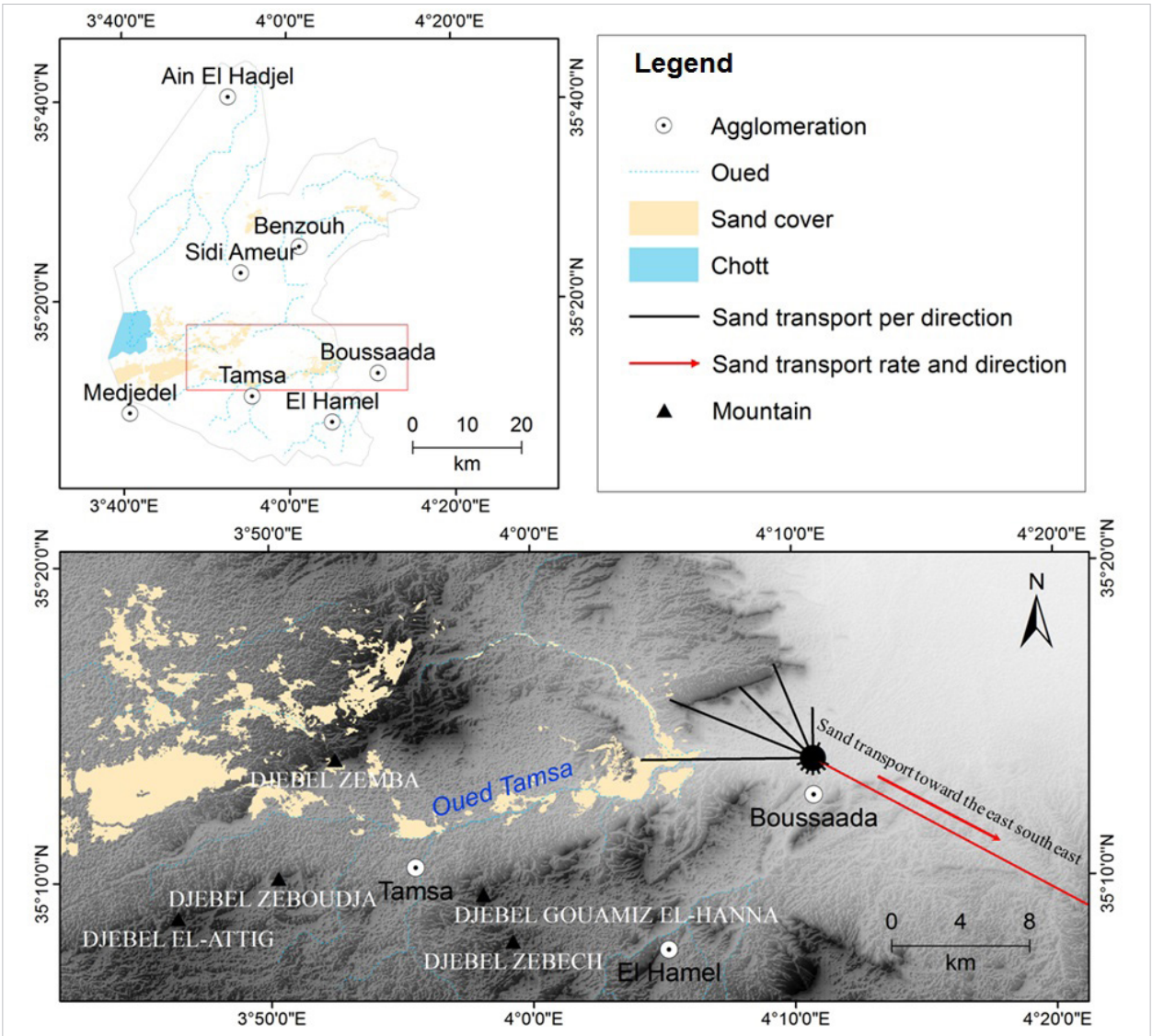

Figure 6. Sand cover distribution and transport direction in the region of Boussâda. Note that sand transport mainly comes from the western sectors and is generally oriented east southeast

Table 5. Seasonal and directional pattern of sand transport and its parameters in the region of Boussaâda for the period 2006–2015

Sand transport parameters	Directions	Autumn	Winter	Spring	Summer	Decade (2006-2015)
DP (UV)	N	10	15	24	9	58
	NNE	3	5	5	4	17
	NE	0	0	1	1	3
	ENE	0	0	1	0	2
	E	2	1	3	2	8
	ESE	2	2	4	3	11
	SE	1	0	6	6	12
	SSE	1	0	9	4	15
	S	2	2	4	8	16
	SSW	2	3	5	3	13
	SW	1	1	4	5	11
	WSW	3	10	10	6	30
	W	31	80	74	11	195
	WNW	31	76	73	4	185
	NW	14	52	47	4	117
	NNW	16	50	59	6	130
	All directions	120	298	330	76	824
RDP (UV)	-	85	245	224	17	571
RDD (degree)	-	300	300	301	258	290
RDP/DP	-	0.71	0.82	0.68	0.22	0.61

N: the north; NE: the northeast; NNE: the north-northeast; E: the east; ENE: the east-northeast; ESE: the east-southeast; S: the south; SE: the southeast; SSE: the south-southeast SW: the southwest; SSW: the south-southwest; WSW: the west-southwest; W: the west; WNW: the west-northwest; NW: the northwest; NNW: the north-northwest; DP: the Drift Potential; RDP: the Resultant Drift Potential; RDD: the Resultant Drift Direction

this is consistent with the findings of (Mohamadi et al., 2016) where the bare lands increased. Moreover, vegetation cover had a determinant effect on desertification (Heidarizadi et al., 2017), the low vegetation cover can directly lead to land degradation. This degradation can be explained by the combination of human and animal activities as well as the climatic factor by the irregularity of the precipitations and the arid climate that marks the study area.

Indeed, the study area is a region with a pastoral vocation; the pastoral activity exerts continuous pressure on the resources of the study area. In arid and semi-arid areas of North Africa, overgrazing is generally considered the main driver of degradation of natural ecosystems (Merdas et al., 2017; Slimani et al., 2010). The pressure of grazers is not limited to the steppe rangelands, but forest grazing is very common in this area, and this is confirmed by the presence of grazing tracks in the forests and even the existence of settlements.

In arid regions, the vegetation cover is less dense, the bare or partially exposed soil becomes vulnerable to the erosive action of water, which can remove or reduce the thickness of the topsoil and consequently the decrease in soil capacity. Mostephaoui et al. (2013), indicated that the soil loss in El Hamel district is estimated at 7 t/ha/yr. This value is considered as a low potential erosion risk (Benchettouh et al., 2017). However, there is also a loss of vegetation cover with the soil, especially where the vegetal cover consists of woody vegetation.

The rapid increase of the population caused a conquest of new lands by clearings in the short and medium term. The latter became an easy task, firstly because of mechanization (tractor plowing) which destroys the perennial vegetation and allows the appropriation of large areas. Secondly because of the total openness and facilitation of vehicle movement within the forest (Kerrache, 2011).

The cultivation of the steppe (Hourizi R., Hirche A., 2017; Yerou, 2013) by uncontrolled extension of the cereal crop, outside the traditional areas reserved for this purpose, was developed without taking into account the microclimate, the soil or the existing vegetation (Figure 5). The only criteria preventing this extension were the topography and the presence of stones on the surface (Mahyou et al., 2016).

Precipitation can have a positive effect on the quality of steppe rangelands. On the other hand, a decrease in the amount of rainfall can have a negative effect on the health of the vegetation. In arid conditions with low rainfall, rangelands in good condition can be converted into degraded rangelands. According to the National Meteorological Office, there was no rainfall recorded in April for 2014. An earlier study conducted by Merdas et al. (2017) reported a high stocking rate in the same study area. Overgrazing and population growth combined with harsh environmental conditions (shortage of rainfall) are the drivers of LULC technology in the study area. These results indicate a situation of instability due to the degradation of natural environments.

Sand Transport

As shown in Table 5, seasonal rates of sand transport (drift potential) range from 76 VU during summer to 330 VU during spring. The net values of sand transport (RDP) oscillate between 17 VU (1.2 m^3/m) during the summer season and 245 VU (17 m^3/m) during winter. The sand transport direction (RDD) is almost uniform during autumn, winter, and spring (300 degrees). This means that sand is effectively moving according to the wind blowing from the west-northwest (WNW) toward the east southeast (ESE), except for during the summer where the RDD is about 258 degrees and consequently sand movement is directed to the east northeast (ENE). The ratio RDP/DP ranges from 0.22 in summer and 0.82 in winter, this means that sand is moving from different directions (high directional variability) during summer, compared to the other seasons which manifest sand movement according to one privileged direction (low directional variability).

For the period considered (2006–2015), the drift potential DP, resultant drift potential RDP, the resultant drift direction RDD and the ratio RDP/DP are respectively about 824 VU, 40 m^3/m, 290 degrees and 0.61. This indicates that the region of Boussâda is a high-energy wind environment, where important volumes of sand grains are almost uniformly transported toward the east southeast according to a Unimodal wind regime (Figure 6).

CONCLUSION

The analysis of the changes showed that the most important regressive evolution is that of the rangelands. This class represents an indicator of the good functioning of the ecosystem in the past. The loss of 50,000 ha to bare soil indicates a stage of advanced degradation of the ecosystem. It shows that the state of stability is very much related to the class of undegraded rangelands. This finding of land-use transition can be considered an effective way for future scenarios. This reflects the importance of the conservation and rational management of steppe ecosystems. The region of western Hodna is a high energy wind environment, where significant sand fluxes from western source zones are permanently transported toward the east-southeast sectors and, this could endanger socio-economic installations downwind. Sand risk mitigation and management strategies are highly recommended.

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Appendix 1: Confusion Matrix 1984
Overall Accuracy = (13345/13728) 97.2101%
Kappa Coefficient = 0.9648
Ground Truth (Pixels)

Class	Woody vegetation	Sand	Bare soil	Agriculture	Alluvium	Rangeland1	Rangeland2	Total
Unclassified	0	0	0	0	0	0	0	0
Woody vegetation	1992	0	0	0	0	101	5	2098
Sand	0	2453	7	0	0	0	74	2534
Bare soil	0	43	877	0	0	10	11	941
Agriculture	0	0	0	336	0	0	0	336
Alluvium	0	0	0	3	611	0	0	614
Rangeland 1	118	0	0	0	0	2807	0	2925
Rangeland 2	0	3	1	0	0	7	4269	4280
Total	2110	2499	885	339	611	2925	4359	13728

Appendix 2: Confusion Matrix 2014
Overall Accuracy = (11204/11548) 97.0211%
Kappa Coefficient = 0.9635
Ground Truth (Pixels)

Class	Woody vegetation	Sand	Bare soil	Agriculture	Alluvium	Rangeland1	Rangeland2	Total
Unclassified	0	0	0	0	0	0	0	0
Woody vegetation	890	0	2	1	0	32	0	925
Sand	0	2906	24	0	0	0	19	2949
Bare soil	8	21	2056	0	9	15	19	2128
Agriculture	2	0	16	372	2	2	0	394
Alluvium	1	0	4	1	1532	0	0	1538
Rangeland 1	128	0	28	1	0	854	0	1011
Rangeland 2	0	1	8	0	0	0	2594	2603
Total	1029	2928	2138	375	1543	903	2632	11548

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ISTANBUL UNIVERSITY CERRAHPASA

Original Article

Essential wood oil of *Cupressus sempervirens* varieties (*horizontalis* and *pyramidalis*)

Cupressus sempervirens (Servi) varyetelerinin (horizantalis ve pyramidalis) odunlarındaki uçucu bileşikler

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ABSTRACT

The essential oils isolated from the woods of *Cupressus sempervirens* var. *horizantalis* and var. *pyramidalis* harvested from natural and cultivated locations in Turkey were characterized by GC-MS analyses. Fifty-one compounds, representing 91.9-95.7% of the oil composition, were identified. The oils obtained from two varieties wood exhibited quite similar composition. Sapwood and heartwood oils were mainly composed of oxygenated monoterpenes (43.7-72.4%), sesquiterpenoids (8.7-36.5%) and diterpenoids (2.2-10.4%). The major compounds were carvacrol methyl ether (38.2-62.6%), α-cedrol(15.7-34.3%), manool (1.75-9.83%), terpinen-4-ol acetate (0.82-4.15%) and bornylacetate (0.26-4.62%). Compared to other Cupressus species, *Cupressus sempervirens* wood can be classified as a carvacrol methyl ether rich species. As a result, the wood oil of Cupressus species can be characterized by the presence of two compounds: α-cedrol and carvacrol or carvacrol methyl ether.

Keywords: Cedrol, carvacrol methyl ether, *Cupressus sempervirens* varieties, monoterpenes, wood essential oil

ÖZ

Türkiye de doğal olarak yetişen ve yetiştirilen *Cupressus sempervirens* (servi) 2 varyetesinin odunlarından izole edilen eterik yağlardaki bileşikler Gaz Kromatografi-Kütle Spektroskopi cihazıyla belirlenmiştir. Taze odunlardan elde edilen eterik yağların analizleri sonucu 51 bileşik tanımlanmış olup, bu bileşikler eterik yağın %91,9-95,7'sini oluşturmaktadır. Çalışmada 2 farklı varyete odunu, öz ve diri odun ayrımı yapılarak incelenmiştir. Sonuç olarak 2 varyete odunu benzer bileşim göstermiştir. Öz ve diri odunların eterik yağ bileşimlerinde oksijenli monoterpenler (%43,7-72,4), oksijenli seskiterpenler (%8,7-36,5) ve diterpenoidler (50,82-4,15) bulunmuştur. Eterik yağlarda en fazla bulunan bileşikler sırasıyla, karvakrol metil eter %38,2-62,6, α-sedrol %15,7-34,3, manool %1,75-9,83, terpinen-4-ol asetat % (0,82-4,15 ve borneil asetattır (%0,26-4,62). Diğer servi odunlarının eterik yağ bileşimleri ile kıyaslandığında *Cupressu sempervirens* odunu, en fazla karvarol metil eter içeren tür olarak tanımlanabilir. Sonuç olarak servi odunlarını karakterize eden 2 terpen türü bileşik olduğu söylenebilir: bunlar alfa-sedrol ile karvakrol metil eter veya karvakroldür.

Anahtar Kelimeler: *Cupressus sempervirens* varyeteleri, karvakrol metil eter, monoterpenler, odun uçucu bileşenleri, sedrol

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INTRODUCTION

Cupressus sempervirens, or Mediterranean Cypress, grows over a wide natural range in the Mediterranean region. In Turkey, Cypresses grow in cemeteries or are cultivated for ornamental purpose. There are two varieties of *Cupressus sempervirens* in Turkey, - *horizontalis* and *pyramidalis*. In Turkey, some of the existing natural stands of *C. sempervirens* var *horizontalis* are found in the Taurus mountains region, Koprulu Kanyon Natural Park (Goker, 1992).

A literature survey shows that there are many papers reporting the composition of essential oils (EO) from the leaves and cones of *Cupressus sempervirens*. Previously, our team investigated the essential leaf oil of two varieties *C. sempervirens* (Uçar et al., 2007). Following this, the neurobiological

effects of extracts from the same varieties were studied (Tumen et al., 2012). The leaf oil composition of *Cupressus sempervirens* samples from other countries, such as Iran (Emami et al., 2006; Asgary et al., 2013), Algeria (Mazari et al., 2010), Egypt (Ibrahim et al., 2009) and Tunisia (El Hamrouni-Aschi et al., 2013) have also been reported. The data relating to essential oil composition of Cupressus woods is very limited. While some literature available on other Cupressus woods such as *Cupressus atlantica* (Barrero et al., 2005), *Cupressus arizonica* (Amri et al., 2014) and *Cupressus tonkinensis* (Thaia et al., 2013), to the best of our knowledge, no reports are available on the essential wood oil compositions of *C. sempervirens* var. *horizantalis* and var. *pyramidalis*. Due to prohibitions on tree felling and its identity as something sacred, cutting down this tree is forbidden in our country.

The aim of this study is to identify the composition of essential wood oils from two varieties of *Cupressus sempervirens*, to show the chemical differences between sapwoods and heartwoods and to fill the gaps in our knowledge of the wood of this species.

MATERIAL AND METHODS

One sample (T2BahCem) from Cupressus *sempervirens* var. pyramidalis was cut from a cemetery as snow turndown, the other two samples (T1Belg, T2Belg) were harvested from Belgrad forest, two samples (T11, T12) of var. *horizantalis* were also taken from Koprulu kanyon. The fresh woods were immediately taken to laboratory and the barks were removed then sapwoods and heartwoods were separated. The fresh woods were then chipped. For the heartwood samples about 200 g of fresh chips were put in a balloon and 3 L of distilled water were added. The hydro distillation continued for approximately 3 hours. The distillate was extracted with petroleum ether than injected into GC-MS.

Analyses were carried out on the GC-MS (Shimadzu, QP 5050A; Shimadzu, Japonya) instrument to identify and quantitate the compounds in the oils.

The identification of most compounds was based on the libraries NIST 21, NIST 107 and WILEY 229. A private MS-data (Uçar library) library and Adam's library (2007) was also used to identify some compounds. Analyses were carried out on 30 m nonpolar fused silica DB-1 and DB-5 columns (0.25 mm, 0.25 µm film thickness), with a helium flow rate of 1.0 mL/min and split ratio of 10:1. The following temperature program was maintained: 5 min at 60°C, 3°C /min to 120°C, 5°C /min to 200°C, 10°C /min to 260°C and 8 min at 260°C.

Compound identification was also verified by comparing the RI (Kovats indices) relative to C5–C24 n-alkanes obtained in a nonpolar DB-5MS column, with those provided in the literature Adams (2007) and Wiley library.

RESULTS AND DISCUSSION

The essential oil constituents from sapwoods and heartwoods of the two varieties *C. sempervirens* are shown in Table 1. Fifty-one constituents were identified in all oils, accounting for 91.9-95.7% of the total oil composition. A comparison of the EO profile of the two *C. sempervirens* varieties of woods showed slight quantitative differences but no qualitative. No differences were observed in the composition of heartwood and sapwood in the same variety whereas variations in the percentages of various components in the essential oils from sapwood and heartwood were detected. Oxygenated monoterpenes dominated the composition of the oils with a content of between 43.7 and 72.4%, followed by sesqui-terpene and terpenoids with content ranging from 8.7 to 36.5%. An interesting finding was the amount of diterpenoids which were higher than monoterpene hydrocarbons in the oils with content 2.2-10.4%, monoterpene hydrocarbons constituents have minor amounts 1.0-3.4%.

Carvacrol methylether (38.2-62.6%), an oxygenated monoterpene, had the highest amount of identified compounds (Figure 1). Other major oxygenated monoterpenes were terpinen-4-ol acetate (0.82-4.15%), bornylacetate (0.26-4.62%), carvacrol (0.09-0.87%), borneol (0.06-1.3%) and terpineol-4 (0.36-1.0%). The only monoterpene hydrocarbon with an amount greater than 1% was limonene (0.09-1.12%).

Furthermore, the second major compound, in sesquiterpenoids fractions of oils, was α-cedrol (15.7-34.3%), followed by the lesser amount α-cedren (0.61-1.48%). Besides monoterpenoids and sesquiterpenoids, diterpenoid compound, manool was also detected at an appreciable level (1.75-9.83%) for oils.

The first study on *C.sempervirens* wood was performed by Piovetti et al. (1981). The petroleum ether extract of wood contained - as the major compounds- carvacrol methyl ether (24.2%), cedrol (16%), 1,7-diepi-β-cedren (2.73%) and β-cedren+β-elemene (1.4%). In the same study, the wood oil of *C.dupreziana* was also investigated and it was discovered that the oil dominated carvacrol methyl ether (61.78%), cedrol (12.28%) and α-cedren (3.85%). Other than this, there is no data available relating to the wood oils of this species. Comparing our results with the previous report revealed some quantitative differences e.g. a higher amount of carvacrol methyl ether and cedrol were detected in our study.

Additionally, our results can be compared with the essential oils of other Cupressus woods. Table 2 shows main compounds in the essential oils of different Cupressus wood alongside our results.

Rushforth et al. (2003) studied the variation among Cupressus species from the eastern hemisphere based on DNAs and they reported that *C. sempervirens, C. dupreziana* and *C. atlantica* form a distinct group. A similar result can be obtained from our study: the resemblance in the chemical composition of *C. sempervirens* and *C. dupreziana* were clearly observed (Table 2). Due to the fact that wood of *C. atlantica* dominated α-cedrol and methyl thymol which is an isomer of carvacrol, *C. atlantica* can be included in this group. Considering the major compounds identified in the wood oil of Cupressus species in Table 2, it is possible to differentiate the species as follow:

Table 1. Composition of volatile compounds in two varieties of *Cupressus sempervirens*

			var. *horizantalis*				C. *sempervirens* var. *pyramidalis*					
			SAP-		HEART		SAPWOOD			HEARTWOOD		
			T11	T12	T11	T12	T2BahCem	T1 Belgr	T2Belg	T2BahCem	T1 Belgr	T2Belg
No	Compound	RI	%	%	%	%	%	%	%	%	%	%
1	tricyclene	923	0.02	0.00	0.08	0.01	0.00	0.01	0.00	0.00	0.06	0.05
2	a-pinene	934	0.04	0.07	0.09	0.04	0.01	0.04	0.06	0.04	0.05	0.04
3	camphene	947	0.02	0.01	0.07	0.01	0.00	0.01	0.05	0.00	0.07	0.04
4	b-pinene	969	0.01	0.00	0.01	0.00	0.04	0.01	0.01	0.07	0.00	0.00
5	myrcene	986	0.20	0.16	0.49	0.38	0.03	0.10	0.39	0.05	0.19	0.31
6	a-terpinene	1010	0.35	0.30	0.36	0.36	0.18	0.14	0.07	0.26	0.19	0.24
7	p-cymene	1013	0.17	0.16	0.15	0.14	0.09	0.18	0.51	0.03	0.10	0.14
8	b-phellandrene	1021	0.02	0.02	0.03	0.02	0.05	0.03	0.07	0.04	0.01	0.02
9	limonene	1023	0.18	0.09	0.38	0.12	0.35	0.18	1.12	0.20	0.36	0.28
10	g-terpinene	1052	0.35	0.28	0.32	0.31	0.22	0.15	0.14	0.20	0.15	0.21
11	cymenene	1074	0.23	0.23	0.34	0.28	0.31	0.29	0.83	0.11	0.13	0.17
12	a-terpinolene	1080	0.70	0.56	1.87	1.26	0.22	0.23	0.93	0.30	0.32	0.44
13	camphor	1116	0.20	0.00	0.69	0.00	0.30	0.05	0.14	0.04	0.07	0.05
14	camphene hydrate	1129	0.05	0.00	0.02	0.00	0.01	0.10	0.09	0.01	0.06	0.03
15	borneol	1147	0.91	0.06	0.55	0.19	0.14	0.65	0.42	0.20	1.03	0.53
16	cymenol	1160	0.06	0.04	0.16	0.14	0.94	0.06	0.05	0.23	0.14	0.30
17	terpineol -4	1161	0.60	0.57	0.52	0.75	1.00	0.92	0.42	0.72	0.36	0.46
18	a-terpineol	1171	0.14	0.10	0.12	0.17	0.21	0.12	0.13	0.17	0.11	0.13
19	neodihydrocarveol	1217	0.02	0.00	0.09	0.12	0.33	0.12	0.00	0.20	0.05	0.11
20	carvacrol ME	1231	60.2	55.4	61.1	59.5	35.0	50.2	62.6	53.8	38.2	49.2
21	carvenone	1233	0.10	0.10	0.20	0.16	0.20	0.01	0.07	0.10	0.05	0.05
22	bornyl acetate	1269	1.79	0.31	1.23	0.26	0.61	4.49	1.03	0.31	4.62	1.91
23	carvacrol	1280	0.41	0.36	0.27	0.68	0.87	0.15	0.20	0.76	0.21	0.09
24	terpinen-4-ol Ace	1284	2.55	2.45	4.14	4.11	2.52	2.38	0.82	4.15	2.88	3.22
25	ME-2isoprop-5-methoxybenzene	1286	0.13	0.15	0.00	0.20	0.20	0.11	0.19	0.40	0.20	0.30
26	eugenol	1327	0.02	0.00	0.02	0.03	0.14	0.01	0.02	0.03	0.01	0.04
27	g-terpinylacetate	1330	0.85	0.80	0.80	0.92	0.51	0.77	0.19	1.02	0.70	0.80
28	a-terpinyl acetate	1332	0.44	0.39	0.57	0.55	0.46	0.46	0.23	0.60	0.44	0.43
29	b-elemene	1383	0.00	0.23	0.02	0.17	0.06	0.17	0.11	0.17	0.25	0.24
30	zingiberene	1397	0.04	0.05	0.04	0.04	0.01	0.04	0.05	0.05	0.05	0.04
31	a-cedrene	1400	1.38	0.93	1.67	0.70	0.61	1.06	0.68	0.75	1.48	1.09
32	b-cedrene	1406	0.45	0.25	0.48	0.20	0.21	0.25	0.28	0.20	0.45	0.27
33	b-caryophyllene	1407	0.05	0.04	0.05	0.05	0.10	0.05	0.07	0.05	0.05	0.03
34	widdrene	1418	0.08	0.45	0.06	0.32	0.42	0.41	0.06	0.33	0.09	0.33
35	b-farnesene	1446	0.08	0.16	0.06	0.11	0.04	0.16	0.03	0.11	0.06	0.12

Table 1. Composition of volatile compounds in two varieties of *Cupressus sempervirens* (continued)

			var. *horizantalis*				C. *sempervirens* var. *pyramidalis*					
			SAP-		HEART		SAPWOOD			HEARTWOOD		
			T11	T12	T11	T12	T2BahCem	T1 Belgr	T2Belg	T2BahCem	T1 Belgr	T2Belg
36	epi-a-cedrene	1467	0.09	0.06	0.10	0.03	0.03	0.04	0.04	0.03	0.08	0.03
37	b-selinene	1472	0.10	0.12	0.01	0.14	0.08	0.16	0.11	0.13	0.21	0.22
38	b-himahalene	1486	0.00	0.00	0.00	0.00	0.18	0.27	0.74	0.00	0.00	0.00
39	b-bisabolene	1495	0.08	0.06	0.06	0.03	0.02	0.08	0.02	0.04	0.08	0.04
40	bsesqphellandrene	1507	0.09	0.08	0.11	0.06	0.39	0.13	0.06	0.07	0.12	0.06
41	a-cedrol	1587	17.8	25.0	15.7	16.8	34.3	21.8	6.05	21.0	31.4	25.8
42	cedr-8-en-15-ol	1642	0.07	0.04	0.07	0.06	0.14	0.16	0.50	0.05	0.14	0.03
43	hexadecanoic acid	1944	0.13	0.06	0.02	0.00	1.38	0.31	4.95	0.00	0.00	0.00
44	procerin	1961	0.02	0.01	0.01	0.12	0.00	0.00	0.00	0.38	0.23	0.20
45	dehydroabietane	2039	0.00	0.02	0.00	0.00	0.02	0.06	0.39	0.00	0.01	0.00
46	manool	2047	3.40	5.51	2.22	4.85	9.83	4.51	1.75	6.26	6.24	6.36
47	linoleic acid	2107	0.03	0.02	0.00	0.00	0.05	0.16	1.82	0.01	0.00	0.00
48	oleic acid	2114	0.05	0.02	0.01	0.01	0.30	0.01	0.80	0.00	0.01	0.01
49	totarol	2282	0.05	0.05	0.00	0.00	0.07	1.70	2.61	0.01	0.03	0.01
50	ferruginol	2297	0.01	0.00	0.00	0.00	0.06	0.07	0.17	0.00	0.04	0.02
51	agathadiol	2328	0.03	0.01	0.00	0.04	0.04	0.00	0.00	0.10	0.10	0.07
	Sum		94.7	95.7	95.2	94.3	93.3	93.6	92.1	93.8	91.9	94.5

Table 2. Main compounds in the essential oils of different *Cupressus* woods

Species (part)	Origin	Major Constituents	References
C. *sempervirens* var. *horizantalis*	Turkey	Carvacrol methyl ether 55.4-61.1%, α-cedrol 15.7-25%, manool 2.22-5.51%, terpinen-4-ol acetate 2.45-4.14%	Our work
C.*sempervirens* var. *pyramidalis*	Turkey	Carvacrol methyl ether 35.4-62.6%, α-cedrol 21-34.3%, manool 1.75-9.83%, terpinen-4-ol acetate 0.82-4.15%	Our work
C. *dupreziana* wood		Carvacrol methyl ether (61.78%), cedrol (12.28%) and α-cedren (3.85%).	Piovetti et al., 1981
C.*sempervirens* var. *horizantalis* branches		α-pinen (46.2%) and δ-caren (22.7%)	Asgary et al., 2013
C. *macrocarpa* heartwood	USA	Carvacrol 82%, terpineol-4-ol 5.58% and nootkatin 5.86%	Lui, 2009
C. *macrocarpa* heartwood		Carvacrol 94.4%,	Zhang et al., 2012
C.*sempervirens* var. *numidica* wood	Tunusia	α-pinen (54.3%, 69.9%), δ-3-caren (11.8 %, 2.8%), carvacrol methyl ether (1.7%, 1.3%), and cedrol (3.7%, 2.3%)	El Hamrouni-Aschi et al., 2013
C. *arizonica* branches		α-pinen 74.6%, myrcene 5.3%, δ-3-caren 4.0%, β-pinen 3.7% and methyl carvacrol 2%	Flamini et al., 2003
C. *arizonica* var. *glabra* wood		α-pinen 40.7%, limonene 3.2 % and umbellulone 2.9%	Abbas et al., 2013
C. *arizonica* wood	Tunisia	α-pinen 76.6%, δ-3-caren 2.3%, limonene 2.6% and cedrol 1.5%	Amri et al., 2014
C.*atlantica* wood		cedrol 45.1%, methyl thymol 15.6% and manool 9.8%	Barrero et al., 2005
C. *funebris* wood		α-cedrol 43.9-72.8%, α-cedren 0.7-3.4%, β-cedren 0.3-2.1% and manool 2.7-7.6%	Adams and Li 2008.
C. *funebris* wood	China	α-cedren 16.9%, cedrol 7.6% and β-cedren 5.7%	Carroll et al., 2011
C. *tonkinensis* wood		α-pinen 42.5%, myrcene 10.2% and cedrol 9%	Thaia et al., 2013

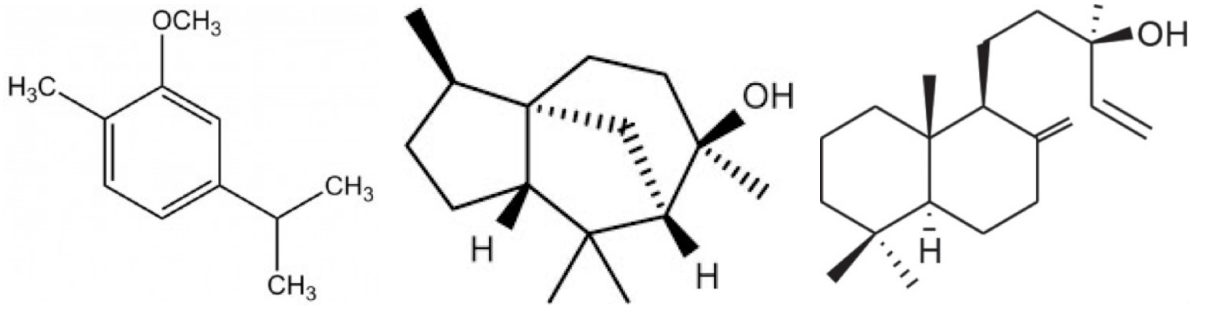

Figure 1. Chemical formula of the main compounds in the essential oil of *Cupressus* woods

First Group: methyl carvacrol and carvacrol rich essential oils; *C.sempervirens* var. *horizontalis*, var. *pyramidalis* (our results), *C. dupreziana* (Piovetti et al., 1981) and *C. macrocarpa* (Lui, 2009; Zhang et al., 2012) may be *C. atlantica* (Barrero et al., 2005),

Second Group: including Cedrol and α-cedren rich essential oil; *C. funebris* (Adams and Li, 2008; Carroll et al., 2011) and *C. atlantica* (Barrero et al., 2005),

Third Group: α-pinen rich essential oil; *C. arizonica* (Flamini et al., 2003; Abbas et al., 2013; Amri et al., 2014), *C. sempervirens* var. *numidica* (El Hamrouni-Aschi et al., 2013) and *C. tonkinensis* (Thaia et al., 2013).

When the above mentioned literatures was taken into consideration, it was noticed that all of the Cupressus wood oils contained more or less α-cedrol and carvacrol or carvacrol methyl ether.

CONCLUSION

The wood oils of Cupressus varieties were investigated by separating sapwood and heartwood which contained similar compounds. The percentages of these compounds were very distinct and the major components in the oils were carvacrol methyl ether, α-cedrol, manool and terpinen-4-ol acetate.

As a result the wood oil of Cupressus species can be characterized by the presence of two compounds: α-cedrol and carvacrol or carvacrol methyl ether. A similar result was reported previously by Piovetti et al. (1981) which stated that the presence of carvacrol methyl ether, cedrol together with α-cedren seems to be a characteristic feature of Cupressaceae.

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ISTANBUL UNIVERSITY CERRAHPASA

Original Article

The effects of recreational demand characteristics on space preference in urban forests

Kent ormanlarında rekreasyonel talep özelliklerinin mekan tercihine etkileri

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ABSTRACT

Natural areas are important in meeting the needs of people in recreation. While these areas are planned, care should be taken to create a sustainable space to protect the natural environment and meet the needs of visitors. It is also important to observe visitors to provide quality recreation facilities that meet the needs and demands of visitors while protecting nature. The types of functional areas used by visitors, the kinds of routes preferred by reaching these areas, the most or least visited places, and the kinds of activities preferred by different groups to determine the flow and density of the area provide the necessary information to plan these areas in a better way. Knowing this preference makes it easier to meet the demand of visitors. In the present study, the spatial distribution of visitors in Kocaeli Urban Forest was investigated to reveal the flow of visitors. The effect on the spatial distribution of road attributes with spatial features has been revealed. Furthermore, the relationship between the visit and the spatial distribution characteristics was analyzed. Finally, the study was revised completely, and suggestions were made about the urban forest.

Keywords: Recreation, spatial behavior, spatial distribution, urban forest, visitor flow

ÖZ

Doğal alanlar insanların rekreasyon ihtiyacını karşılamada önemlidir. Bu alanlar planlanırken, ziyaretçi ihtiyaçlarını karşılaması ve doğal çevreyi koruması amacıyla sürdürülebilir bir alan oluşturmaya dikkat edilmelidir. Doğayı korurken aynı zamanda ziyaretçilere ihtiyaç ve taleplerini karşılayan kaliteli rekreasyon olanakları sunabilmek için ziyaretçileri gözlemlemek önemlidir. Ziyaretçilerin hangi tür fonksiyonel alanları kullandığı, bu alanlara ulaşırken ne tarz rotaları tercih ettiği, en çok veya en az hangi yeri ziyaret ettiği, farklı grupların ne çeşit aktiviteleri tercih ettiği, alan içindeki akışı ve yoğunluğu saptamak, bu alanların daha iyi planlanması için gerekli bilgiyi sağlar. Bu tercihleri bilmek, ziyaretçi taleplerinin karşılamasını kolaylaştırır. Bu çalışmada, ziyaretçi akışını ortaya koymak amacıyla Kocaeli Kent Ormanı'nda ziyaretçilerin mekansal dağılımları incelenmiştir. Spatial Features ile yol özelliklerinin mekansal dağılım üzerine etkisi ortaya konmuştur. Ayrıca ziyaret ve Visitor Characteristics ile mekansal dağılım arasındaki ilişki incelenerek, önerilerde bulunulmuştur.

Anahtar Kelimeler: Kent ormanı, mekansal davranış, mekansal dağılım, rekreasyon, ziyaretçi akışı

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INTRODUCTION

Urbanization, as it does in the world, continues to increase in our country as well. Recreation has become the basic need of people with increasing population and urbanization. The lack of natural areas negatively affects the physical and mental health of the society (Uslu and Ayaşlıgil, 2007). It is important to bring the positive impacts of forests on community health to the service of urban people for a healthy community structure. Along with this understanding, efforts to establish urban forests in our country gained momentum (Kiper and Öztürk, 2011). Social function supremacy constitutes the basis for urban forests (Tyrväinen et al., 2005), and these areas have gained importance in outdoor recreation. It is difficult to define outdoor recreation exactly (Hansen, 2013). However, there are four basic elements that are common to all definitions: its impact on human well-being, its outdoors realization in natural and cultural landscapes, its inclusion of activities, and its exclusion of competition (Hansen, 2013).

The interaction between nature and man has been a research topic for a long time, and its positive effects on human beings were proven (Tsunetsugu et al., 2013). In the survey conducted by the Pro-

file of Mood States, participants showed that they felt bad about themselves as a result of staying 15 min in the urban environment, and that they spent time in the green areas to get rid of these adverse physiological effects (Tsunetsugu et al., 2013). This getaway to the green is also combined with a variety of physical activities, such as commonly jogging during brisk walking, trekking, and cycling. Whereas cultural and personal characteristics are of importance in defining a symbolic environment (Marwijk et al., 2007), environmental perception and socio-economic status also become more of an issue (Marwijk et al., 2007). The physical and social environments (the so-called symbolic environment) are inseparably related and must be examined together (Marwijk et al., 2007). The symbolic environment may be appropriate for different visitors (Elands and Marwijk, 2008). Therefore, it is necessary to monitor the visitors in recreation areas (Muhar et al., 2002). Arnberger (2003) added new factors to the perception of the crowd, such as different types of visitors, direction of the movement of the visitors, and the presence of leashed or unleashed dogs (Taczanowska, 2009). While physiological properties, such as the size and the type of the area, and visitor infrastructure are effective in recreational use (Taczanowska, 2009), characteristics, such as spatial orientation and direction finding, are also influential. While road signs and signposts affect the course choice preferences of the visitors (Taczanowska, 2009), superior landscape features, landscape viewing areas, recreation grounds, information centers, huts, and attractions are influential on visitor behavior (Taczanowska, 2009).

The identification of visitor characteristics through visitor observations is as important as the establishment of an inventory of biophysical properties of the area (Arnberger and Hinterberger, 2003). The systematic and continuous data collection process of visitor characteristics ensures the development of alternate planning models, thus achieving goals and targets in a short time with accurate estimations by noticing the changing levels of impacts resulting from user–resource interaction. In addition, understanding spatial behaviors makes the job of planners rather easier. Information on the aspects of recreational area usage level, recreational area visit characteristics, and recreational area visitor features is supplied with the identification of visitor characteristics (Kaptanoğlu, 2010).

In addition to the human–environment interaction in the recreation areas, spatial behavior of the visitors was not put forward yet (Cole et al., 2005). Nevertheless, recently, theoretical and applied researches on the spatial behavior of human beings are increasing (Gimblett and Skov-Petersen, 2008). Understanding the spatial distribution is the basis for defining the visitor profile and improving the visitor management (Lyon et al., 2011). The analysis and monitoring of the visitor flow is a key to understanding the visitor behavior required for the effective management of protection and recreation (Muhar et al., 2002; Orellana et al., 2011). To do so, it is necessary to obtain detailed information about the use of space and the preferences of different groups (Orellana et al., 2011). One of the most important aspects of the visitors' spatial behavior is their movements in the recreation area, in other words, their flow in the field. It is necessary to know the visitor's travel behavior, including route selection, destination selection, travel frequency, activity plans, his or her behavior during the trip, and pre-trip route decision,

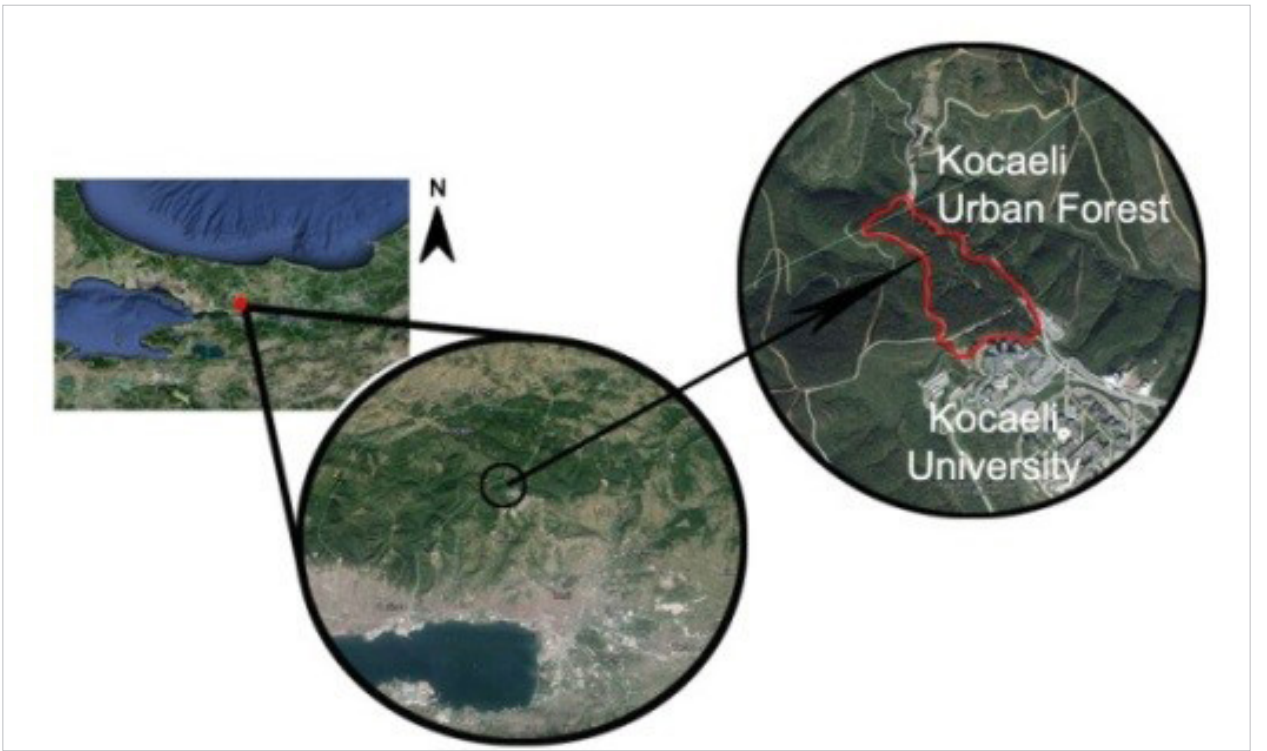

Figure 1. Kocaeli Urban Forest location (Google Earth image dated 10/21/2014)

when planning the transportation (Golledge and Gärling, 2003). Monitoring the visitors' movements helps us to learn about their preferences. Knowing these preferences facilitates balancing supply and demand.

By looking at the increasing demand for recreation and green areas, this research is aimed at determining the spatial distribution of the visitors in the area by identifying the functional areas used in the Kocaeli Urban Forest scale; the visitor density on the routes between the functional areas; which of the features are important with respect to road length, road type, road width, and so on in their preferences when visitors select these routes; and whether existing or non-existing in the area, the kind of things that affect them positively or negatively. The present study provides an insight on visitor density, spatial orientation, and preference in outdoor recreation areas. The investigation of visitor requirements and expectations, together with physical space and usage relationship, will enable the planning and design of these spaces according to today's conditions.

MATERIAL AND METHODS

Research area

Kocaeli is in Çatalca–Kocaeli Section of Marmara Region, and it has a population of 1,722,795 (TUİK, 2015). The climate forms a transition between the Mediterranean and the Black Sea climate (Kocaeli Metropolitan Municipality (KBB), 2015). It is one of the industry and trade cities. Kocaeli Urban Forest was established in 2005 with the practice of "A Forest in Every City" (OGM, 2008) of the General Directorate of Forestry (OGM). It is located in İzmit Province, on the old highway of İzmit–İstanbul, near Kocaeli University and Kocaeli University Medical Faculty (Figure 1) (Şahinbaş, 2010). It is 10 km away from İzmit city center. Its current area is 20 ha and is planned to be extended to 100 ha in the following years (OGM, 2008). It is a plantation site established by planting, and wildlife is newly developing on this area. Topal (2014) identified a total of 19 different bird species in the urban forest.

Obtaining the variables and data used in the study

Three types of information form the basis to determine the spatial distribution of the visitors. These are "visit characteristics," "visitor characteristics," and "spatial features" (Figure 2).

Visit characteristics include "quantitative" and "qualitative" data. Visitor characteristics cover socio-demographic characteristics, the type and level of past experience, the knowledge of the wild conditions and regulations, the preferences for the environmental conditions encountered, and management practices and attitudes toward them (Watson et al., 2000). Basic quantitative and qualitative information regarding the visitors of the sample area requires the recreational use in the area to be systematically monitored (Muhar et al., 2002).

Although, in the recent period, high resolution spatio-temporal data collection method has gained importance in determining the spatial distribution regarding the visitor density (Cole, 2005; Skov-Petersen, 2005), in the study, observation, questionnaire,

Table 1. The methods and resources for the collection of visit, visitor, and spatial data.

Method	Source	Date	Data type
Interviews	Authorities		Visitor profile and activity, area history, use by month, use during the day, satisfaction, dissatisfaction.
	Visitors		Visitor profile and activity, area history, use by month, use during the day, activities required to be in the area, satisfaction, dissatisfaction, inadequacies.
Observation	Observer	04/26/2015, 04/29/2015 05/13/2015, 05/24/2015	Visitor's group size, count, sex, directions to go, company of children and dogs, whether the dog's leash.
Questionnaire	Visitors	01/24/2015, 01/31/2015 02/03/2015, 02/05/2015 02/06/2015, 02/12/2015 02/18/2015, 02/19/2015 02/20/2015, 02/21/2015 03/17/2015, 03/25/2015 03/26/2015, 04/03/2015 04/04/2015, 04/06/2015 04/12/2015, 04/14/2015 04/16/2015, 04/18/2015 05/05/2015, 05/09/2015 05/18/2015, 05/22/2015	*Visit characteristics:* Visit day-time, arrival time, duration of visit, duration of the trip, group size, company of children/dog, whether the dog's leash, days and months came to the area, purpose of arrival, activities done in the area, the frequency of encounters with other visitors, the reason for choosing a route, trip conditions, walking time to reach your destination in the forest, presence of constructions-buildings, benches and tables, diner-restaurant, shop-buffet, road signs, warning signs-signboard, explanation signboard, presence of limiters that limit passage, destruction of vegetation cover.
			Visit characteristics: Mode of transport, access time, regular come, frequency of visits, satisfaction, dissatisfaction, satisfaction degree, the frequency of doing sports, sports committed, sex, age, education, occupation.

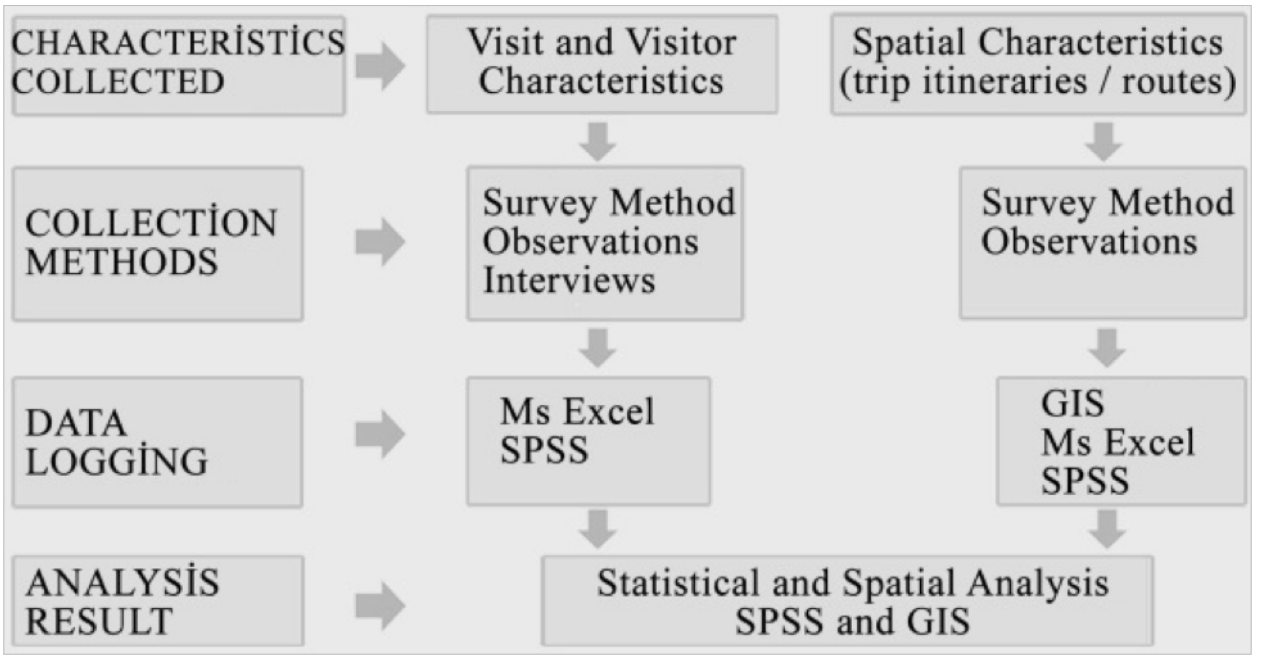

Figure 2. The methods used in the present study

Table 2. General structure of the data entered in the software

Data	Resource	Data type	
Visit characteristics	Questionnaire, observation	Non-spatial data	SPSS, MS Excel
Visitor characteristics	Questionnaire, observation	Non-spatial data	SPSS, MS Excel
Spatial features		Spatial data	ArcGIS/ SPSS
Routes	Questionnaire, observation	Spatial data	ArcGIS/ SPSS

SPSS: Statistical Package for the Social Sciences; MS: Microsoft; ArcGIS: Arc Geographic Information System

and interview methods, which are the most frequently used ones in data acquisition (Erkkonen and Sievänen, 2002; Gimblett and Skov-Petersen, 2008; Taczanowska, K., 2009), were preferred since there was data loss due to peak closure during the use of these technologies in urban forests (Table 1). A total of 864 individuals were observed in the area for 4 days.

A questionnaire form of 31 questions was prepared for the survey method. Questions aim at eliciting the information about visit and visitor characteristics.

In addition, a map was added to the survey for acquisition of the information about the routes visitors use on the area. For the creation of the map, one digital map from KBB and one raster map were provided from İzmit Forest Management Directorate. Those raster maps were digitized in AutoCAD and ArcGIS 10.1 environment. With the overlap of the maps and the checks made in the field, the changes resolved, and a new map was produced. Visitors were asked to mark the route they follow and the points where they pause the activity on the map. Most of the spatial features are based on the route information that the visitors pointed to on the map. The disadvantage of this method is the inability of the visitors to precisely remember the routes that they travel around or the likelihood of marking different locations on the map due to their mistakes in map reading (Daniel, 2002).

A total of 637 individuals selected by simple random method in the urban forest were surveyed (Sandal and Karademir, 2013). A total of 30 pre-evaluation surveys were conducted before the questionnaire study. Surveys were conducted during the two seasonal periods of Winter and Spring; 5-month period covering January, February, March, April, and May for a total of 24 days during weekdays and weekends.

Methods of evaluation

Similar responses to open-ended questions were grouped to facilitate the entry of the data obtained from "Observations and Surveys" into programs.

On the other hand, to facilitate data entry and analysis of "route information," 54 road segments were created by separating the roads in the urban forest from each other at intersection points. The collection of the features belonging to the segments is the basis for spatial features. For this reason, the spatial features of the segments were either obtained from the maps or determined as a result of checks made in the area and entered into base maps prepared through the Geographical Information System (GIS). "Segment lengths," "segment widths," "segment paving materials," "segment slopes," "stand closure," and "land-

scaping structures on the segment," such as signboard, fountain, rain shelter, camellia, picnic table, garbage can, hut, Mescit (prayer room), and restroom, are the properties that belong to segments and that were entered into the GIS database. Visits-, visitors-, and spatial features-related data were transferred to the relevant programs specified in Table 2.

Data were analyzed using Statistical Package for the Social Sciences (SPSS) 22 program (SPSS IBM Corp.; Armonk, NY, USA) for the data entry of the questionnaires and for the statistical analysis of relationship (Kaptanoğlu, 2006). The Kolmogorov–Smirnov test (one sample K–S) was applied for the test of the convenience of the data to the normal distribution.

Percentage distribution was determined by frequency analysis for the evaluation of visit and visitor characteristics. Factor analysis was applied to group the factors related to visit characteristics, visitor characteristics, and route characteristics.

For the analysis of these, all related variable groups correlation (Pearson correlation) and for two different variable groups, one-way analysis of variance (ANOVA) were performed.

Visitor density on the routes between the function fields and functions in urban forest and whether the road segment features (spatial features), such as segment slope, length, width, paving material, landscape structures existing on it, and its closure, are important or not when the visitors selected those routes were examined by hypothesis tests.

Interrelated relationship between the path segment properties and distribution of the visitors to the path segments was analyz-

Table 3. Frequency percent of visit characteristics

Data	Category	Percentage (%)	Data	Category	Percentage (%)
Admission hours	8.00–10.00	7.4	Group size	Single (1 person)	3.8
	10.00–12.00	18.3		Binary group (2 people)	26.7
	12.00–14.00	44.9		Small group (3–4 people)	29.8
	14.00–16.00	26.1		Middle group (5–10 people)	27.9
	>16.00	3.3		Large group (>10 people)	11.8
Duration of visit	<1 h	20.1	Days came to the area	Weekday	43.3
	1–2 h	40.3		Weekend	20.4
	3–4 h	23.9		Weekday and weekend	36.3
	>4 h	15.7			
Duration of the trip	Did not walk around	17.1	Company of children	Yes	19.9
	5–10 min	5.2		No	80.1
	15–20 min	16.7	Company of dog	Yes	3.8
	30 min	14.3		No	96.2
	Approximately 1 h	24.3			
	>1 h	22.4			
The reason for choosing a route	Interesting	6.1	Months came to the area	January	29.8
	Aesthetic-landscape beauty	10.1		February	38.1
	Naturalness	4.3		March	33
	Unemployment	6.7		April	64.3
	Security	2.6		May	70.4
	Location-accessibility	31		June	57.2
	Suitability of park facilities to function	6.1		July	35.6
	Thermal comfort	0.9		August	30.1
	Goal-oriented	14.8		September	30.1
	Inadequacy of other facilities	2.9		October	24.8
	Failure of other facilities	2		November	20.4
	Random	12.5		December	20.8

ed by the method of correlation, which is one of the hypothesis tests, by regression, by one-way ANOVA, and by independent samples t-test. The significance levels of the relationship in the analysis are as follows: p≤0.05: existence relationship, p≤0.01: strong relationship, and p≤0.001: very strong relationship.

RESULTS

Visit characteristics

The most frequent admission hours to the city forest are 12.00–14.00, whereas the least visited hours are the ones after 16.00 h.

Table 4. Frequency percent of visitor characteristics

Data	Category	Percentage (%)	Data	Category	Percentage (%)
Mode of transport	Public service vehicle	31.4	Access time	1–to 10 min	34.6
	By walking	35.2		11 to 20 min	34.6
	Car/motor	30.3		21 to 40 min	20.1
	Bicycle	0.3		41 to 60 min	6.5
	Other	2.8		>60 min	4.2
Age (year)	<18	9.1	Education	Uneducated	0.2
	18–30	70.3		Primary school	3.9
	31–40	14.6		Secondary school	6.8
	41–50	4.4		High school	67.7
	51–60	4.4		Associate degree	3.1
	>60	1.6		Bachelor's degree	14.6
				Post graduate	3.6
Frequency of visits	Every day	2.8	Satisfaction	Naturalness	50.4
	At least 2 times a week	8.3		Quiet-calmness	17.2
	Once a week	14.1		Aesthetic-landscape beauty	3.3
	Monthly	19.4		Entering motor vehicles	0.5
	At least 2 times a month	8.6		Functionality	2.6
	Quarterly	12.1		Adequate existence of park facilities	23.4
	Semi-annually	11.1		Wellness	1.3
	Annually	11		Entry free	0.9
	One-off	12.5		Location-accessibility	0.4
Occupation	Student	61	Dissatisfaction	Neglect	37.4
	Retired	1.4		Security	13.6
	Civil servant	1.9		Lack of night security	0.8
	Health sector	5.5		Visitor behaviors	7.2
	Education-science-research	4.3		Facility inadequacy	5.3
	Engineering-architecture	3.9		Sports field and playground inadequacy	0.3
	Technician-technician	3.6		Neglected sports field and playground	1.1
	Transportation-services	3.4		Inadequacies	6.9
	Business-economy-trade	2.2		Having unplanned areas	4.2
	Jobs that do not qualify	10.4		Vehicle entry	1.9
	Unemployed	2.4		Pergola and picnic tables neglected	2.2
Sex	Female	50.2		Seating units are close	1.9
	Male	49.8		Thermal comfort	0.6
				The presence of stray animals	16.6

Most of the visitors spent 1–2 h in the area, and minority of the others spent ≥4 h. Visitors stayed on the routes for at most approximately 1 h, at least 5–10 min. The reason for visitors' choosing the route that they visit is location-accessibility the most, and thermal comfort is the least. The urban forest was visited by small groups the most, and by individual visitors the least. Most visitors come to the area on weekdays. Overall, 80.1% of the visitors have children with them, and 3.8% have dogs. May is the time when the visitors come to the area the most, whereas October is the least (Table 3).

Visitor characteristics

Visitors mostly walked to the city forest, and bicycles were the least common mode of transport. Overall, 70.3% of the visitors are at the age range of 18–30 years, 61% are students, 50.2% are females, 49.8% are males, and 67.7% are high school graduates. It takes most of the coming visitors 1–20 min to reach the area. Whereas the visitors are most pleased with the urban forest's naturalness and its ability to meet the facility requirements, they feel discomfort about dilapidation and the presence of stray animals (Table 4).

Relationship between visit and visitor characteristics

There is a positive relationship between group size and duration of the visit. The duration of the visit extends as the group size increases. That is, there is a significant difference in visit times of different sized groups (p=0.000, F=29.238). As the group size increases, the duration of the visit extends. There is a negative relationship between group size and children's presence near the visitors, duration of the trip, age, loiter, and walking. There is a significant difference between the groups of different sizes and children's presence (p=0.000, F=8.402). As the group size decreases, children's presence near the visitors increases. As the group size increases, duration of the trip, visitor's age, loiter, and walking are reduced. There is a negative relationship between children's presence near the visitors and admission hours, duration of visit, and group size; there is a positive relationship between arrival frequency. Visitors with children usually arrive at the area early in the morning; here, they do not spend a long time, and their arrival frequency is higher than the visitors without children. There is a positive relationship between duration of the visit and duration of the trip and duration of arrival. As the duration of the visit increases, the duration of the trip extends;

Table 5. Relationship between visit and visitor characteristics

Properties	Admission hours	Group size	Children's presence	Duration of visit	Duration of the trip	Arrival frequency	Frequency of visits	Age	Hiking, walking
Group size			–0.133	0.367	–0.092			–0.190	–0.184
	Sig. (2-tailed)		0.001	0.000	0.021			0.000	0.001
Children's presence	Pearson cor.	–0.113	–0.113		–0.099		0.132		
	Sig. (2-tailed)	0.002	0.001		0.006		0.00		
Duration of visit	Pearson cor.					0.069	0.191		
	Sig. (2-tailed)					0.041	0.000		
Residence closeness	Pearson cor.	0.091					0.137		
	Sig. (2-tailed)	0.011					0.000		

p=0.00: very strong relationship, p≤0.01: strong relationship, p<0.05: existence of the relationship, –: negative relationship

Table 6. Percentage of visitors coming purposes and correlation of visit duration

Coming aim	Major effect (%)	Moderate effect (%)	Neutral (%)	Minor effect (%)	No effect (%)	Duration of visit
Residence closeness	28.4	10.8	15.2	6.4	39.1	
Sports/movement/health	19.9	14.3	16.6	15.1	34.1	
Nature-landscape passion	20.3	17.4	19	10.4	33	
Visiting the city forest	22.3	14.1	18.7	11.1	33.6	
Recreation (for hobby)	20.6	16.2	19	11	33.3	p=0.033, r=0.073
Blow off steam	48.7	22.3	8.5	4.1	16.5	
Socialness	25.6	22.6	16.6	6	29.2	p=0.002, r=0.117
Being alone in the land	18.8	8.6	12.6	14.3	45.7	p=0.025, r=–0.078
Other	11.8	4.1	6.9	3.1	73.8	

p=0.00: very strong relationship, p≤0.01: strong relationship, p<0.05: existence of the relationship, –: negative relationship

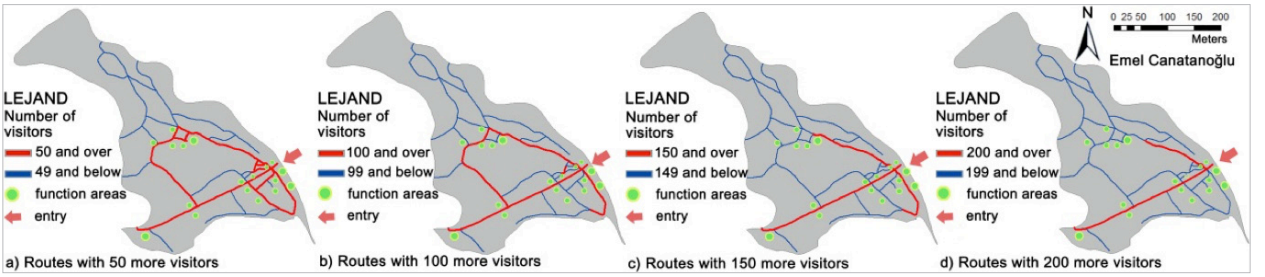

Figure 3. Visitor density of the routes in Kocaeli Urban Forest

Table 7. Percentage of activities made by visitors and correlation of trip duration

Activities	Frequently	Occasionally	None	Duration of the trip
Trip-walking	45.7	39.7	14.5	p=0.000, r=0.174
Brisk walking	10	33.1	56.7	p=0.008, r=0.096
Mountain hiking	12.7	25.4	61.7	p=0.001, r=0.125
Running	9.7	20.6	69.5	
Classic cycling	6.4	14	79.4	
Mountain biking	4.6	6.1	89.2	p=0.010, r=0.093
Mountain biking (for the race)	3.6	3.3	92.9	
Herb-mushroom picking	3.8	12.6	83.6	p=0.029, r=0.075
Picnicking (barbecue)	37.2	30.5	32	
Picnicking (e.g., sandwich)	37.4	33.8	28.6	p=0.027, r=0.077
Taking photos	40.3	31.7	27.8	p=0.004, r=0.106
Bird watching	6.8	14.3	78.7	
Walking dogs	4.1	5.3	90.3	p=0.024, r=0.078
Sledging	14.3	10.7	74.8	p=0.030, r=0.075

p=0.00: very strong relationship, p≤0.01: strong relationship, p<0.05: existence of the relationship, –: negative relationship

Table 8. Correlation between the number of visitors on the routes and road segment features

Factor	Length	Slope	Material	Width	Canopy closure
Visitor number	0	0	0	***	*

***: very strong relationship (p=0.00), **: strong relationship (p≤0.01), *: existence of the relationship (p<0.05), 0: no relationship (p>0.05)

those who come from far places spend longer times in the area. There is a positive relationship between those who arrive because the area is close to their residence, admission hours, and arrival frequency (Table 5).

Visitors mostly come to the urban forest to relieve tension and because of the closeness of the area to their residence. There is a positive relationship between the duration of the visit, socialness, and recreation when the duration of the visit and their purpose of visit are examined (for hobby); there is a negative relationship between being able to be lonely in nature/loneliness (Table 6). Visitors most often went for a walk-hike in the urban forest and took photos. As the number of trips on the routes increases, so does the number of visited segments, and the spatial distribution spreads throughout the area from the entrance. There is a relationship between the duration of the visit on the routes, trips-hikes, mountain hiking, brisk walking, mountain bike riding, taking photos, picking plants-mushrooms, picnicking, walking the dog, and sledging (Table 7).

Relationship between road segment features and distribution of the visitors to the road segments

The reasons why the visitors choose the routes they visit rank in order, from the most to the least as location-accessibility, goal-focused, random, aesthetic-landscape beauty, loneliness, attraction, function suitability of the facility, naturalness, inadequacy of the other facilities, security, dilapidation of the other facilities, and thermal comfort. The visitor density on the routes in the city forest was investigated (Figure 3). The segments where the number of visitors is >50 (a), 100 (b), 150 (c), and 200 (d) were highlighted in red (Figure 4). As the visitors density along the routes increases, the number of heavily used routes decreases and heads back toward the entrance area. The most heavily

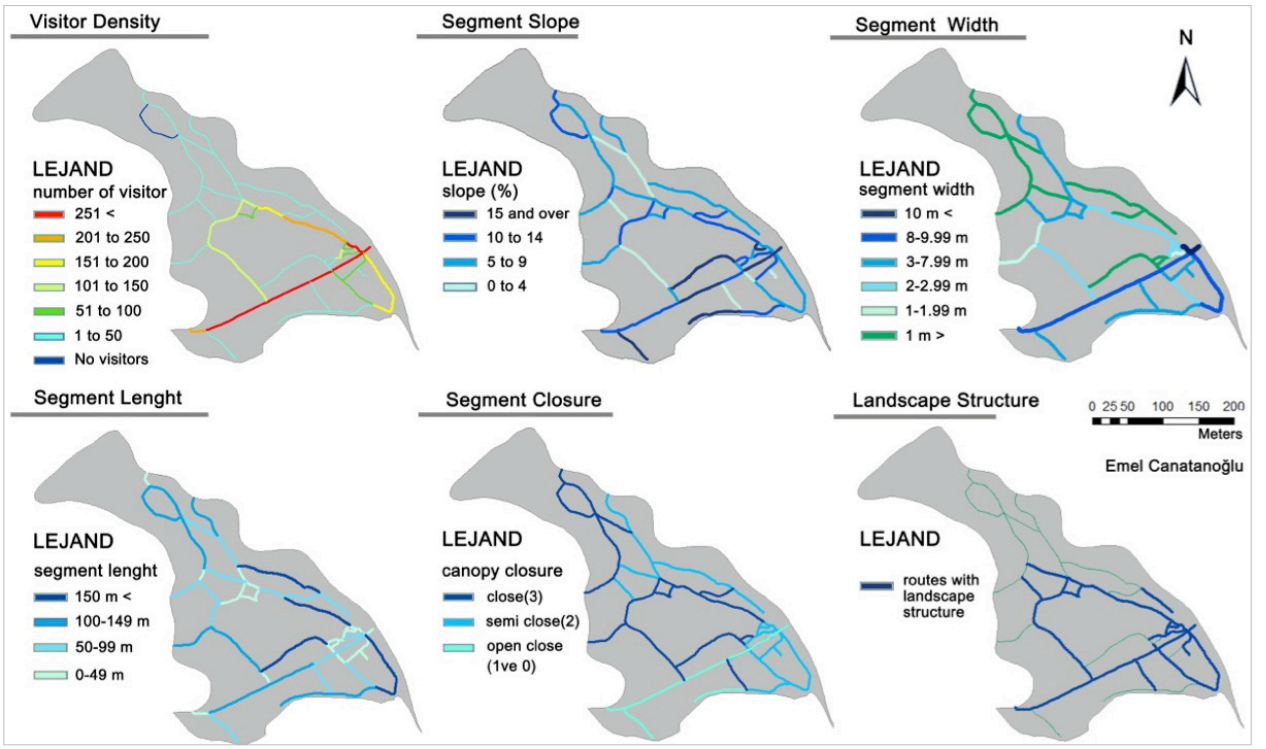

Figure 4. Relationships between road segment features and visitor density in Kocaeli Urban Forest

used segments are the ones that are close to the entrance area (location-accessibility) and the ones that provide access to the function areas (target-orientedness). In this case, there is a relationship between the visitor density along the routes and the reasons for the visitors for choosing those courses. The visitor density along the routes and the route features are shown in Figure 5.

There is a very strong positive relationship according to the analysis of the correlation between the distribution of the visitors to the routes and the route segment width (p=0.00, r=0.815). As the route segment width increases, the number of visitors along the routes also increases. According to the regression analysis, since p=0.00, the segment width affects the number of visitors along the routes positively. Of the variation in visitor density (R^2=0.665), 66% is explained by the change in segment width. Some other variables are effective for the part of the remaining 34%. A 1-unit change in the road segment width causes an average of 40 units (B1=40.649) change in visitor density. There is a positive relationship between the visitor density on the road segments and the segment closures (p=0.023, r=0.309). As the closure on the routes increases, so does the visitor density. There is no relationship between visitor density and slope, road segment length, and road segment paving material on the routes through urban forests (Table 8).

The most visited segments are divided into four zones according to the survey and observation results (Figure 5). Of the four zones, the relationship between visit and visitor characteristics was investigated (Table 9).

There is a strong positive relationship *between the first zone* and the number of visitors in April (p=0.008, q=0.105) and in September (p=0.006, q=0.110) and visitor age (p=0.002, q=0.125), whereas there is a positive relationship between the number of visitors in March (p=0.015, q=0.096). There is a strong positive correlation between duration of stay in the area (p=0.003, q=–0.120), group size (p=0.001, q=–0.136), and picnicking (barbecue) (p=0.002, q=–0.122); there is a very strong negative relationship between picnicking (sandwich) (p=0.000, q=–0.152), whereas there is a negative correlation between the duration of the trip in the area (p=0.031, q=–0.085) and visiting the area for the nature-landscape passion (p=0.043, q=–0.080).

There is a very strong positive relationship between the second zone and admission hours (p=0.000, q=0.165), duration of the trip in the area (p=0.000, q=0.393), pathway conditions (p=0.000, q=0.158), and visitors in January (p=0.000, r=0.194) and in February (p=0.000, q=0.225); there is a strong positive relationship between visiting the area for the purpose of trip and walking (p=0.001, q=0.137), taking photos (p=0.002, q=0.123), and sledging (p=0.004, q=0.113), whereas there is a positive correlation between mountain hiking (p=0.017, q=0.095), the number of visitors in July (p=0.013, q=0.099), and the number of visitors in December (p=0.022, q=0.091). There is a very strong negative correlation between group size (p=0.000, q=–0.152) and the number of visitors in May (p=0.000, q=–0.189), whereas there is a strong negative correlation between arriving for the purpose of residence closeness (p=0.007, q=–0.107). There is also a very strong negative correlation between the first zone and gender (p=0.037, q=0.083). There is a significant differ-

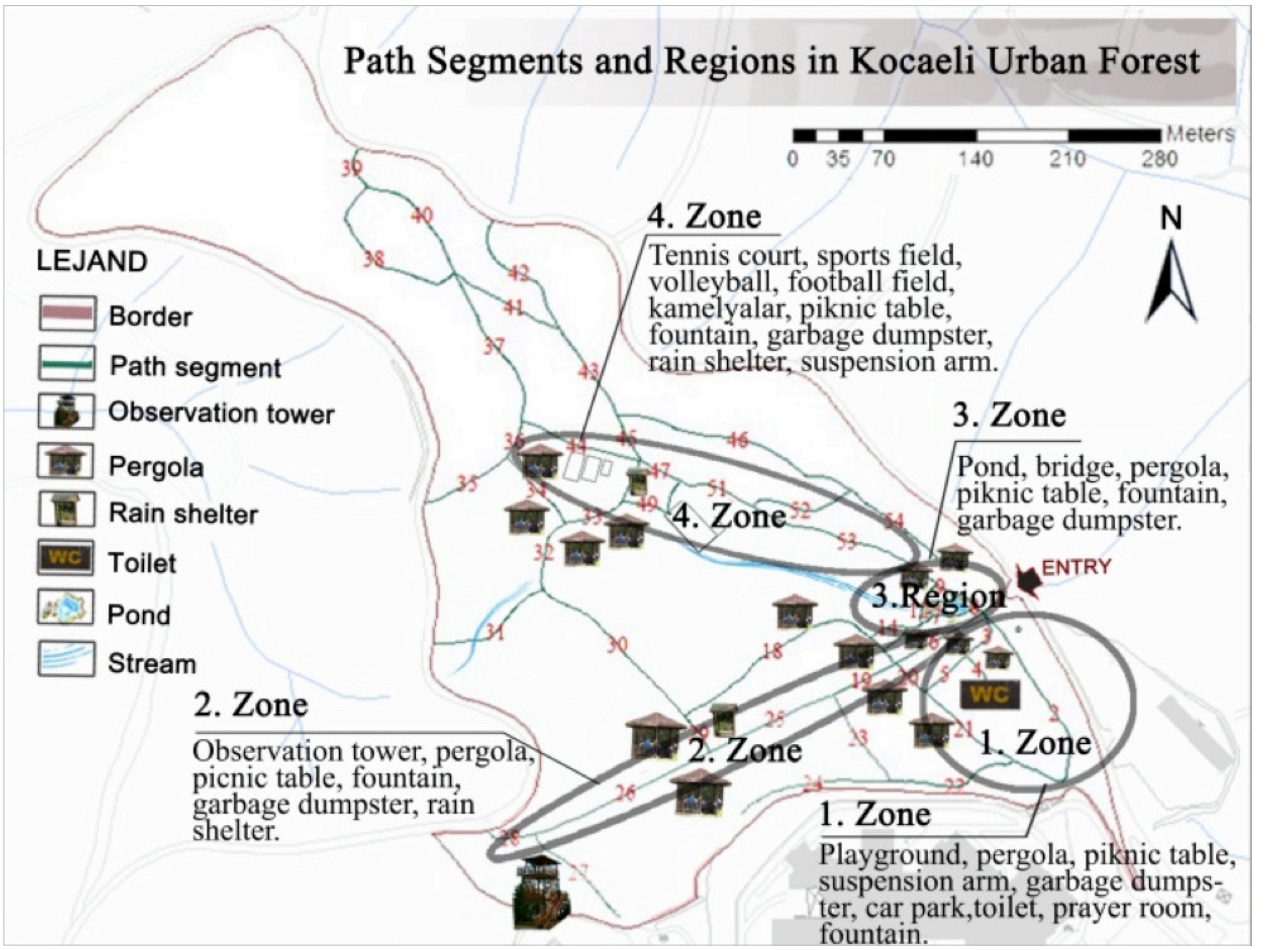

Figure 5. Intensively used road segments and zones in Kocaeli Urban Forest

ence (p=0.037, t=2.089) between the male and female groups according to the independent t-test. Male visitors are more in sight in the second zone.

There is a very strong positive correlation between the third zone and the duration of the stay (p=0.000, q=0.238) and group size (p=0.000, q=0.142); there is a strong positive relationship between the number of visitors in June (p=0.008, q=0.106) and duration of the trip in the area (p=0.001, q=0.131); there is a positive correlation between visits for the purpose of sports-movement-health (p=0.049, q=0.078), visitors in April (p=0.036, q=0.060), and visitors in May (p=0.045, q=0.079). There is a very strong negative correlation between the number of visitors in February (p=0.000, q=−0.153); there is a strong negative correlation between the number of visitors in January (p=0.003, q=−0.117); there is a negative correlation between admission hours (p=0.044, q=−0.080) and age (p=0.026, q=−0.088).

There is a very strong positive correlation between the fourth zone and the duration of the stay (p=0.000, q=0.241), the number of the visitors in April (p=0.000, q=0.145), and the number of the visitors in May (p=0.000, q=0.131); there is a strong positive relationship between the group size (p=0.001, q=0.134) and duration of the trip in the area (p=0.005, q=0.113); there is a positive correlation between visits for the purpose of sports-movement-health (p=0.046, q=0.079), mountain hiking (p=0.032, q=0.085), jogging (p=0.024, q=0.089), and the number of visitors in June (p=0.016, q=0.095). There is a very strong negative correlation between the admission hours (p=0.010, q=−0.102) and the number of visitors in February; there is a negative correlation between the age (p=0.018, q=0.094). There is also a very strong negative correlation (p=0.000, q=−0.151) with gender. There is a significant difference (p=0.000, t=3.682) between the male and female groups according to the independent t-test. Male visitors are more in sight in the fourth zone. There is also a strong negative correlation (p=0.000, q=−0.151) whether visitors have their children with them or not. There is a significant difference (p=0.000, t=3.857) between the groups with and without children according to the independent t-test. Visitors with children are less available in the fourth zone.

Preferences of most of the visitors regarding the road/route/environment conditions are as follows: the pathways in the urban forest should be visited wearing sport shoes; road signs, warning signs, and legend signs must be as many as possible; there must be access restrictions only in important places; perhaps

Table 9. Relationships between visit–visitor characteristics and intensively used zones

Visit/visitor characteristic		1st zone	2nd zone	3rd zone	4th zone
Admission hours			***	–*	–**
Duration of visit		–**		***	***
Group size		–**	–***	***	**
Company of children					–***
Coming aim	Residence closeness		–**		
	Sports/movement/health			*	*
	Nature-landscape passion	–*			
Activities	Trip and walking		**		
	Mountain hiking		*		*
	Running				*
	Picnicking (barbecue)	–**			
	Picnicking (e.g., sandwich)	–***			
	Taking photos		**		
	Sledging		**		
Months	January		***	–**	
	February		***	–***	–**
	March	*			
	April	**		*	***
	May		–***	*	**
	June			**	*
	July		*		
	September	**			
	December		*		
Duration of the trip		–*	***	**	**
Pathway conditions			***		
Sex			*		***
Age		**		–*	–*

: very strong relationship (p=0.00), **: strong relationship (p≤0.01), *: positive relationship (p<0.05), –: very strong negative relationship (p=0.00), –**: extremely negative relationship (p≤0.01), –*: negative relationship (p<0.05)

there must be a couple of diner-restaurant and shop-buffet; human-made structures must be distinctly recognized; walking time to reach the destination in the forest must be 5–10 min; and one must half-hourly encounter other visitors (Table 10).

RESULTS AND DISCUSSION

In the present study, visit and visitor characteristics and spatial features, which are effective in the spatial distribution of the visitors, are presented. According to the findings obtained, the number of groups of an individual in the area is low, and one of its reasons is security concern. The security problem is one major constraint blocking the spatial distribution in the area. Talay et al. (2010) revealed that among the reasons that prevent the adequate use of recreational areas, the lack of security is perceived as an important problem by the visitors. Kurdoğlu and Düzgüneş (2011) also pointed out that the lack of security is the most important constraint. The duration of the visit and those who perform the trip-walk activity increase as the group sizes increase, whereas the duration of the trip of the visitors on the routes, the presence of children near them, and their ages decrease. The visitors with children come to the area earlier than the ones without children, and their visits last shorter and come in smaller groups. Those who come for socialness and recreation spend longer times in the area. Those who come to the area because it is close to their residence are both late and more

Table 10. Visitor preferences about road/environment/route

Data	Category	%	Data	Category	%
Pathway conditions	Should be visited wearing heeled shoes	5.6	Bench and table	Both the bench and the table	94.6
	Should be visited wearing sport shoes	84.7		Only the bank is enough	3.5
	Should be visited wearing walking boots	9.7		Not a bench and a table	1.9
Walking time to reach the destination	5–10 s	36.6	Encounter other visitors	Continuous	15.9
	15–20 s	34.1		Every 10 min	23.8
	30 s	23.2		Half an hour	33.8
	1 h	3.5		One an hour	14.2
	>1 h	2.6		I do not meet anyone	12.3
Diner-restaurant	It can be as much as possible	19.5	Shop-buffet	It can be as much as possible	31
	Perhaps there must be a couple	47.9		Perhaps there must be a couple	56.7
	Not at all	32.6		Not at all	12.3
Road signs	It can be as much as possible	77	Warning signs	It can be as much as possible	80.9
	Perhaps there must be a couple	17.5		Perhaps there must be a couple	14.7
	Not at all	5.5		Not at all	4.4
Access restrictions	Everywhere	20.2	Legend signs	It can be as much as possible	82.2
	Only in important places	67.2		Perhaps there must be a couple	13.8
	Not to be access restrictions	12.6		Not at all	4
Human-made structures	Apparently noticeable	46.9	Destruction of vegetation cover	Destruction noticed	71.7
	Be slightly noticeable	30.4		Be less noticeable	18.7
	Inconspicuous	22.7		Be noticeable	9.6

frequent. Those whose journey time to the area is longer stay longer in the area. Visitors who stay in the area longer spend more time along the routes. As the number of trips on the routes increases, the number of visited road segments also increases, and the spatial distribution within the area is not limited to the entrance point vicinity but spreads to the whole area. In one of his studies on Vienna Danube National Park, Taczanowska (2009) also observed that there is a meaningful relationship between the duration of the visit and the route length, and that the time spent is related to the length of the path.

Those who perform activities, such as outing-trekking, mountain hiking, mountain biking, taking photos, brisk walking, walking dogs, picnicking, picking up herbs and mushrooms, and sledging, respectively, stayed on the routes longer. The ones who stayed on the routes the longest are the ones who go for outing-hiking. Taczanowska (2009) stated that the stays of >4 h have higher variance than those of 2 h, which is why the majority of the visitors, especially the hikers, take long pauses while performing their activities.

There is no correlation seen between visitor density and slope and segment length on the routes, whereas the number of visitors on the routes increases as the route segment width and the stand closures increase. Taczanowska (2009) found a linear relationship between the breadth of the road and the number of visitors and preferability. Gül and Kurdoğlu (2002) ascertained that stand closure, living cover, and density and distribution of the trees increase the visual quality on Fırtına Valley. Ribe (1989) reported that the more the closure increases, the less the landscape is perceived. Of those whose stand density is medium according to low-to-high conditions, older trees are more appreciated than younger ones. There is no relationship between the road paving material and the number of visitors because 50 out of the 54 segments in the area are stabilized in the urban forest.

According to the findings obtained from the relationship of the visit and visitor characteristics to the zones in the urban forest, of the visitors who prefer the first zone, the duration of sightseeing trip and visit is shorter. Those who came for the purpose of picnicking and nature-landscape passion preferred that zone less. In that zone, children's playgrounds and sitting areas are nested, and the region is on the roadside. For that reason, visitors who are in search of picnic and nature-landscape do not prefer this region. Sightseeing duration of the visitors who opt for the second zone is longer. More men than women spent time here. In addition, visitors who go for a stroll-walk, who take photos, and who sledge are many. Especially in Winter, the most visited segments are in that zone. Visitors use the fire safety road in the urban forest for sledging on snowy days. Therefore, this region is visited

most during the Winter months. In addition, on snowy days, road segments in other regions not being suitable for transportation increase the intensity in the second region. The duration of sightseeing trip and visit of the visitors who prefer the third zone is longer. There are ponds and recreation areas in this area. Visitors who come for the purpose of sports-movement-health choose that zone. Despite the road segments in the region are narrow and sloping, one of the most important reasons for being one of the most favorite regions is the existence of the water feature. It has been shown in various studies that water feature enhances visual landscape quality (Kıroğlu, 2007; Bulut et al., 2010). Of the visitors who opt for the fourth zone, the duration of sightseeing trip and stay is longer. As the group sizes increase, so does the preference degree of the region. Visitors who mostly perform activities, such as sports-movement-health, mountain hiking, and jogging, more likely prefer that zone because in that zone, there are facilities, such as playfields, playgrounds, picnic sites, recreational areas, and fountains. Many studies put forward that recreational facilities, such as picnic tables, fountains, playgrounds, and bicycle tracks, increase the recreational potential at that place (Kurdoğlu and Düzgüneş, 2011; Ateşoğlu, 2008).

Erkkonen and Sievänen (2002) recommend that visitors be asked about road preparation and increasing or decreasing the amount of service. According to the findings of the questions about the road/environment/route conditions asked for this purpose, the majority of the visitors would like to have as many bench-table and shop-buffet but one or two restaurants in the city forest. Most desire pathway conditions to be suitable for sport shoes. The vast majority of the visitors would like to have road signs, warning signs, legend signs on the roads, and some restrictors, such as pontoons, ropes, and strips, as many as possible. Taczanowska (2009) mentioned that signposts and waymarks increase the motivation of the visitors. However, there is no relationship between the frequency of sightseeing and satisfaction in urban forests.

Knowing the visit–visitor characteristics in revealing the spatial distributions of visits becomes more of an issue, in determining the locations of such areas, in determining the functions to be brought into the area, in guiding the flow of visitors in the area, and in determining the facility characteristics of the routes in the area. Associating spatial features in recreation areas to visit–visitor characteristics will provide convenience in meeting the needs and demands of the visitors and being directed to spatially desired areas. By this means, when recreational areas are being planned, it will be possible to meet the visitors' wishes and demands better, on the one hand, and to keep the visitors away from the areas that need to be protected, on the other hand. Thus, both the maximum benefit from the area will be achieved, and a sustainable recreational area where other creatures can also survive will be created. In conclusion, knowing the spatial attitudes of the visitors in recreational areas and their interactions with the environment will shed light on the studies to be conducted in the future.

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ISTANBUL UNIVERSITY CERRAHPASA

Original Article

Effect of vegetation patch size on selected chemical properties of soils under semiarid climate conditions

Yarı kurak koşullarda bitki grubu büyüklüğünün bazı toprak kimyası parametrelerine etkisi

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ABSTRACT

This study aimed to investigate effects of vegetation patches of different sizes on selected chemical characteristics of soil. The study was carried out in a semiarid region of Central Anatolia. Based on average diameter of the canopy, vegetation patches in the site were divided into three groups: 0–4 meters (m) (small), 4–8 m (medium), and >8 m (large). Soil samples were collected from under the patch canopy and near the canopy at the topsoil. The soil samples were mixed, and one subsample was taken as a representative of each patch size. A total of 20 subsamples for the small, 14 for the medium-sized, and 14 for the large patches were collected. The soil samples were analyzed for electrical conductivity, pH, potassium, calcium, magnesium, phosphorus, total nitrogen, and total carbon. Results showed that patch size had a significant effect on the phosphorus and total nitrogen contents of the topsoil. Topsoil around the large patches had significantly greater phosphorus content 0.03 grams/liter (g/L) than small (0.01 g/L) and medium-sized (0.01 g/L) patches. Similar to phosphorus values, the topsoil around the large patches had significantly greater total nitrogen content (0.70%) than the topsoil around the small (0.62%) and medium-sized (0.60%) patches. Since both nitrogen and phosphorus nutrients are important elements for early plant growth and survival, large patches should not be cleared from the sites during the land rehabilitation works due to their positive impacts on the topsoil under fragile landscape conditions in the semiarid regions.

Keywords: Central Anatolia, fertility island, patch size, soil chemistry, soil nutrients

ÖZ

Bu çalışma, farklı büyüklükteki bitki örtüsü gruplarının toprak kimyası üzerindeki etkilerinin incelenmesi amacıyla İç Anadolu'nun yarıkurak özelliklerini temsil eden Çankırı bölgesinde gerçekleştirilmiştir. İncelenen toprak kimyası parametreleri, elektriksel iletkenlik, pH, potasyum, kalsiyum, magnezyum, fosfor, toplam azot ve toplam karbon'dur. Bitki örtüsü grupları, tepe tacı çapının büyüklüğüne göre 0-4 metre (m) (küçük), 4-8 m (orta) ve > 8 m (büyük) olmak üzere üç gruba ayrılmıştır. Toprak örnekleri tepe tacının hemen altından ve tepe tacının çapı kadar uzağından olmak üzere 10 cm derinliğinde üst topraktan üçer örnek olarak alınmış ve bu toprak örnekleri her bitki örtüsü büyüklüğünü temsil etmek üzere karıştırılarak tek bir genel örnek haline getirilmiştir. Toplamda, küçük bitki grupları için 20, orta ve büyük bitki grupları için 14'er adet genel toprak örneği oluşturulmuştur. Sonuçlar, bitki gruplarının büyüklüğünün üst topraktaki fosfor ve toplam azot üzerinde etkili olduğunu, diğer parametreler üzerinde ise istatistiki anlamda herhangi bir etkisinin olmadığını göstermiştir. Büyük bitki gruplarından alınan toprak örneklerindeki fosfor miktarı 0,03 gram/litre (g/L) ile orta (0,01 g/L) ve küçük (0,01 g/L) bitki gruplarından alınan örneklerden yüksek çıkmıştır. Toplam azot miktarı da büyük bitki gruplarından alınan örneklerde (%0,70), orta (%0,60) ve küçük (%0,62) bitki gruplarından alınan toprak örneklerindekinden önemli ölçüde yüksek çıkmıştır. Hem azot hem de fosfor bitki gelişiminde ve yaşamında önemli besin elementleri olduğundan, sonuçlar yarıkurak koşullarda yapılacak rehabilitasyon çalışmalarında büyük bitki gruplarının toprakların azot ve fostor içeriğine yaptıkları pozitif etkiden dolayı temizlenmeyerek sahada bırakılmalarının uygun olacağını göstermektedir.

Anahtar Kelimeler: Besin zengini alanlar, bitki grubu büyüklüğü, İç Anadolu, toprak besin maddeleri, toprak kimyası

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INTRODUCTION

Plant covers in the arid and semiarid ecosystems are sparsely distributed due to water deficit (Aguiar and Sala, 1999; Maestre and Cortina, 2002). As seen in many dryland environments, patchy vegetation covers are common in the semiarid areas of Mediterranean region and have different soil

characteristics beneath the patches such as infiltration rates, water storage capacities, soil moisture content, aggregate stability, and nutrient content from adjacent bare soils (Boer and Puigdefábregas, 2005). Maestre and Escudero (2009) indicated that dryland desertification adversely affects nearly 250 million people worldwide. They tried to find a power law to use vegetation patches as an "early warning" systems for desertification process in Mediterranean drylands.

Therefore, patches can play important role on the soil and water conservation in the watersheds with poor soil conditions under arid and semiarid climatic conditions. Accumulation of plant debris and their decomposition on the topsoil beneath the patches can increase biological activity and productivity in the soil. This phenomenon also affects the plant diversity around the patches by creating island of fertility, influencing soil hydrology and erodibility (Puigdefábregas, 2005; Schade and Hobbie, 2005). Additionally, patch canopies can serve as an efficient trap for interception of atmospheric dust and chemical compounds. For example, Lequy et al. (2014) reported a large interception of atmospheric particulate deposition by canopy of beech stands in Northeastern France. Muvengwi et al. (2015) also suggested that nutrient enrichment in patches can increase resource heterogeneity, and it can have a significant impact on determining ecosystem structure and function in semiarid savanna ecosystems. Vegetation patches can not only alter soil chemistry beneath the patch canopies through dry deposition and litter turnover but also influence runoff and sediment fluxes in drylands. Boer and Puigdefábregas (2005) compared runoff and sediment yield of an area having patchy vegetation distribution with another area having uniform vegetation cover. They found that the area with patchy vegetation structure had a greater soil loss and storm discharge than the area with evenly vegetation distribution. Furthermore, distribution and pattern of vegetation types can change because of global warming. This expected natural phenomenon can cause permanent soil and vegetation losses and alter soil chemistry. Therefore, clearance or protection of existing patches with respect to their influence on soil nutrient content is an important issue during the land rehabilitation works in semiarid regions.

Besides the distribution and coverage area of vegetation patches, vegetation composition of the patches has also great impacts on soil erosion and runoff. In fact, a study carried out in semiarid Central Mexico showed that vegetation patches with different dominant species had significantly different impacts on runoff and soil loss (Vásquez-Meéndez et al., 2010). Vegetation patches in dry environments also creates island of fertility due to organic matter accumulation from decomposition of plant litter, and hence positively influences nutrient availability in the soils beneath the patches (Cerdán et al., 2016; Ridolfi et al., 2008). Schade and Hobbie (2005) investigated effects of velvet mesquite trees (*Prosopis velutina*) on soil moisture and biochemistry of nitrogen in the soils of Sonoran Desert in Arizona. They reported that *Prosopis velutina* had a positive impact on the soil by creating islands of fertility compared to the outside of the patches. In another study carried out in the northern Chihuahuan Desert in USA, Cross and Schlesinger (1999) found that all elements were homogenously distributed in the grassland soils while the plant-essential elements including nitrogen, phosphorus, and potassium were concentrated in the soils under the shrub (*Larrea tridentata*) patches. Besides above-mentioned positive impacts of patches on the soil under their canopies, especially woody vegetation patches create negative effects on the diversity and composition of understory vegetation. Schade et al. (2003) found declines in the species diversity and changes in the vegetation composition for understory vegetation growing under *Prosopis* canopies in the Sonoran Desert. In addition, Aguiar and Sala (1994) showed that emergence and survival of grass seedlings increased as the distance from the shrub patches increased due to decreased root competition between shrubs and grasses. On the other hand, despite some positive influences of vegetation patches on the soil nutrient status especially under the patch canopies, vegetation patches are removed from entire area in the rehabilitation of degraded lands in Turkey. Even though numerous plant species within the patches can have little forage value for grazing animals, they may be useful for watershed protection (Roundy and Call, 1988). Additionally, clearance of vegetation patches from the sites can expose soil surface directly to atmospheric events and can make organic matter poor soils much more vulnerable to erosion in the arid and semiarid lands. Moreover, revegetation of arid and semiarid ecosystems may not be successful due to limitations in growing conditions. Although complete eradication of patchy vegetation from entire land in site preparation can be time- and cost-saving compared to partial soil preparation with conserving existing vegetation this type of treatment may not be a promising strategy in terms of watershed protection in a dry environment. Therefore, regardless of vegetation type and desirability for livestock grazing, existing patches should be maintained in the areas where clearance of patches can increase erosion risk and vegetation manipulation is not necessary to increase composition of desirable forage plants. Thus, these existing patches can serve as a nucleus for seed production and future of seed for surrounding areas. A number of studies have been conducted worldwide to investigate effects of vegetation patches on soil beneath them. In the majority of these studies, researchers compared the chemical content of the soils under patches with those in the open spaces (Cerdán et al., 2016; Puigdefábregas, 2005) and the effects of patches composed of only certain shrub species (Cerdán et al., 2016, Erickson et al., 2005; Vásquez-Meéndez et al., 2010). Contrary, we examined effect of patches composed of more than one plant species including tree, shrub, grass, and forb species on the soils in the surrounding area of the patch canopy. In Turkey, forest service generally removes all existing patches regardless of patch size and use mechanical methods for revegetation of disturbed lands to save time and cost for a better soil tillage. This approach can have a high potential for failure especially in semiarid areas. Removal of all patch sizes can increase erosion potential and even accelerate it. Moreover, it can take time for rehabilitated lands to recover due to moisture deficit and become costly because of intensive land preparation works. Soil chemical characteristics directly influence the growth performances of the plants, and

deficiencies of nutrients such as potassium, calcium, phosphorus, nitrogen, and magnesium stunt plant growth (Fenn et al., 2006; Uchida, 2000; Zhao et al., 2005). Therefore, the soil samples were analyzed for electrical conductivity (EC), pH, potassium (K^{+}), calcium (Ca^{+2}), magnesium (Mg^{+2}), phosphorus ($P\text{-}PO_4^{-3}$), total nitrogen (N), and total carbon (C). If patches with larger sizes have positive impacts on soil nutrients around the patches, then they can be kept in the site and function as a seed source for surrounding area. Hence, this study aimed to determine if some selected soil chemical properties around the patches change depending on patch size. If all patch sizes have similar effect on soil chemistry around the patches, then it can be concluded that all patches can be removed from the site to prepare the land for the revegetation.

MATERIAL AND METHODS

Study site

This study was carried out in Tatlıçay watershed in Çankırı (40° 33′–40° 51′ N latitudes and 33° 17′–33° 46′E longitudes). Size of the area is 67000 hectare (ha), and its elevation ranges from 720 m to 1820 m. About 50% of the area has steep or very steep

Table 1. Dominant plant species and their composition in the patches

Dominant plant species in the patches	Life forms	Overall composition (%)
Quercus macranthera Fisch. & Mey. Ex Hohen subsp. *syspirensis* (C. Koch) Menitsky	Tree, 1–2 m in diameter, 3–6 m in canopy diameter	25
Quercus pubescens Willd.	Tree, 5–10 m in height, 4–10 m in canopy diameter	15
Astragalus gossypinus Fischer *Astragalus anthylloides* Lam. *Astragalus emarginatus* Lab.	Herbaceous, 15–30 cm in height, 20–30 cm in canopy diameter	15
Pinus nigra Arn. subsp. *pallasiana* (Lamb.) Holmboe	Tree, 20–25 m in height, 10–20 m in canopy diameter	10
Gypsophila simulatrix Bornm. & Woron.	Herbaceous, 20–50 cm in height, 30–60 cm in canopy diameter	7
Juniperus oxycedrus L. subsp. *oxycedrus* *Juniperus* nana *Willd.*	Tree, 1–4 m in height, 2–4 m in canopy diameter	5
Amygdalus orientalis Miller.	Shrub, 0.5–1.5 m in diameter, 1–3 m in canopy diameter	5
Rosa dumalis Bechst. *Rosa canina* L. *Rosa gallica* L.	0.5–1.5 m in diameter, 1–1.5 m in canopy diameter	5
Grasses	Herbaceous, 3–7 cm in height, 3–5 cm in vegetative cover diameter	5
Paliurus spina-christi Mill.	Shrub, 1–1.5 m in diameter, 1–2 m in canopy diameter	3
Genista sessilifolia DC.	Herbaceous, 10–30 cm in height, 20–40 cm in canopy diameter	2
Hedysarum nitidum Willd.	Herbaceous, 5–10 cm in height, 10–20 cm in canopy diameter	2
Crataegus orientalis Pallas ex Bieb. *Rumex crispus* L. *Berberis vulgaris* L. *Melilotus officinalis* (L.) Pall. *Glycyrrhiza glabra* var. *glandulifera*. *Pyrus amygdaliformis* Vill. var. *amygdaliformis* *Jasminum fruticans* L. *Verbascum* sp. *Tamarix smyrnensis* Bunge. *Rhus coriaria* L. *Eryngium billardieri* Delar.	Some shrub and herbaceous plants with very small portions	Less than 1%

cm: centimeters; m: meters

slope greater than 12%. Mean annual precipitation is around 402.1 milimeters (mm), and over 60% of it falls during the dormant season. Average annual temperature is about 11.1°C and varies between 23°C in July and -0.6°C in January. Prevailing wind direction is southeast and originates from hot and dry air masses coming from Persian Gulf. The site has a semiarid continental climate with water deficit during the summer months according to Thornthwaite classification method. Soil of the study site is mainly composed of limestone and sedimentary rocks such as conglomerate and marl with gypsum. Soil texture is sandy silt with high lime content. The study site located in Central Anatolia under semiarid climatic conditions experiences severe soil erosion for decades due to degradation of vegetation cover as a result of human intervention. Because of land disturbance, the area has an unevenly distributed patchy vegetation cover and nutrient poor bare soil conditions in inter patches. Vegetation is mainly composed of dwarfed woody species like oak trees due to grazing and browsing, and spiny and noxious shrub species like *Astragalus* spp., with a small portion of herbaceous species that left ungrazed under the spiny shrubs patches or have relatively little forage value. Dominant plant species in the patches were identified, and their average composition was determined as a percent of total number of plant species in the patches (Table 1) (Gökbulak, 2013).

Soil sampling and analyses

Four transect lines with a minimum distance of 200 m from each other were established parallel to slope gradient at the same altitude, aspect, and similar slope in the study site where distribution of patches were almost uniform, topography and soil conditions were homogenous. Forty-eight vegetation patches that intercepted the transect lines were selected within 100 ha area. Based on mean diameter of canopy cover, vegetation patches were divided into three groups: 0–4 m, 4–8 m, and >8 m. To avoid influences of neighboring patches, distances between patches were kept with minimum that soil sampling points of two neighboring patches did not overlap each other. One soil sample from the beneath the approximate center of patch canopy and two samples from the near the patch with a half distance of canopy longest diameter were collected in the opposite direction on straight line through the patch canopy center (Figure 1). Thus, the soil sampling locations around the patches varied for each patch size depending on the longest diameters of the canopies. A total of three soil samples from the top soil (0–10 cm soil depth) under, and surrounding area of the patch canopy were collected for each patch intercepted the transect line (Figure 1). To prevent sampling errors and to decrease the effect of heterogeneity, soil samples were mixed and a subsample was taken as a representative of each patch sampled. A total of 20 samples for the small (0–4 m in diameter), 14 for the medium-sized (4–8 m in diameter), and 14 for the large (>8 m in diameter) patches were collected. The soil samples were analyzed according to the methods briefly described in Gülçur (1974) as below. Firstly, samples were air-dried and sieved through a 2 mm mesh for chemical analysis. EC and pH (soil/water ratio of 1/5) were determined using a WTW Multiline P4 (WTW; Weilheim, Germany) universal meter. K^{+}, Ca^{+2}, and Mg^{+2} were extracted from the samples using 1 N ammonium acetate solution. P-PO_4^{-3} was determined according to the molibdophosphoric blue color method using a PerkinElmer 2100 DV (Perkin Elmer; Waltham, Massachusetts, USA) atomic absorption spectrophotometer equipment (APHA-AWWA-WPCF 1975). Total N and total C were measured using a Leco Truspec CN 2000 (Leco; Michigan, USA) device as explained in its instructions manual. Data were analyzed using one-way variance analyses (ANOVA) to determine a statistically significant difference between data values. Since data should have a normal distribution to apply one-way ANOVA, Kolmogorov–Smirnov test was

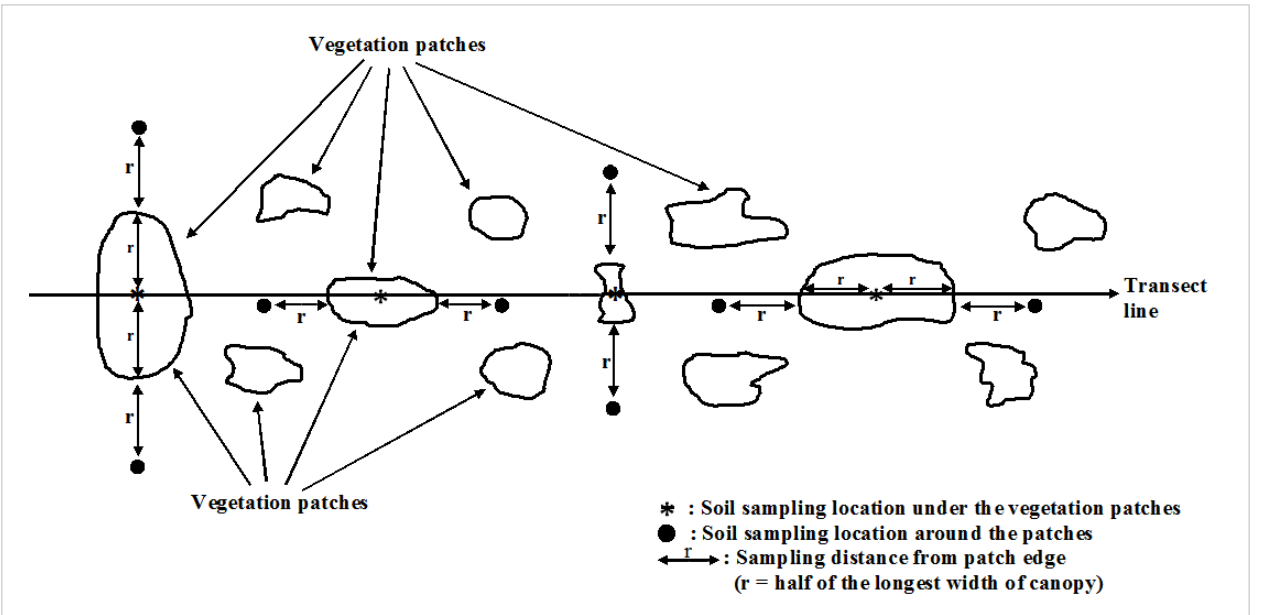

Figure 1. Schematic sketch of soil sampling location under and around the patch canopies

used. The variables that did not show normal distribution were approached to normal by logarithmic transformations. Means were separated with Tukey test ($p<0.05$) (Zar 1996). To all over statistical analyses, Statistical Package for the Social Sciences 21.0 was applied 2012 (SPSS IBM Corp.; Armonk, NY, USA).

RESULTS AND DISCUSSION

Results showed that patch size did not have significant effect on selected soil chemical characteristics except for nitrogen and phosphorus (Table 2). The soils around all patch sizes had similar pH values. Soil reaction was alkaline and varied between 7.10 and 7.55. EC values of the soils decreased from 0.55 µS/cm for the small patch to 0.35 µS/cm for the large patch, but these decreases were not statistically significant. Phosphorus was one of the two soil chemical characteristics that showed changes depending on patch size. Soils around the small and medium-sized patches had similar phosphorus values, whereas soils around the large patch had significantly almost two fold greater phosphorus content (0.03 g/L). Potassium content of the soils from surrounding of different patch size varied between 0.18 g/L and 0.34 g/L and did not show significant differences (Table 2). Calcium values decreased from 8.24 g/L to 4.06 g/L and magnesium values from 1.38 g/L to 0.43 g/L as patch size decreased, but the decreases were not great enough to be statistically significant among the patches ($p>0.05$). Total nitrogen was another soil chemical parameter that was significantly affected by patch size. Soils around the small and medium-sized patches had similar nitrogen content, whereas that around the large patches had significantly the greatest total nitrogen content ($p<0.05$) (Table 2). Similar to total nitrogen content, the large patches had the greatest total carbon content than soils around the small and medium-sized patches. However, the differences between the soil carbon contents were not statistically significant, and they varied between 3.11% and 4.83%.

Similar studies showed that it is very difficult to make generalization about effect of patch size on soil chemical properties. The differences between results of various studies can be attributed to the differences in the plant composition of the patches and the location of the soil sampling around the patches. For instance, Fraser and Carlyle (2011) investigated impacts of patches dominated only by spotted knapweed (*Centaurea stoebe* L.) with various sizes. They found that spotted knapweed patch size had significant influence on soil chemical properties. In contrast to results of our study, they stated that as patch size increased, soil carbon and nitrogen contents decreased and phosphate increased. In some studies, chemical contents of the soils under the patches were compared with those of the soils in the interspaces. There is no study available considering the soil characteristics under the patches and patch neighbors together. Cross and Schlesinger (1999) examined soil chemical characteristics under two shrubs, creosote bush and broom snakeweed dominated patches, and compared them with the soil properties in interspaces. In that study, researchers found that concentrations of phosphorus, nitrogen, and potassium were higher in the soils under the shrub canopy than those in the inter-patch spaces. Similarly, Cerdán et al. (2016) also investigated effects of woody patches dominated by some shrub species including *Pistacia lentiscus* L., *Quercus coccifera* L., *Ephedra fragilis* Desf., *Juniperus oxycedrus* L., and *Rhamnus lycioides* L. on the soils under the shrub canopies and compared these soil characteristics with those from interspaces in Southern Spain. They reported higher dissolved organic matter under the patches than inter-patch spaces. As seen from the literature, results can vary depending on differences in plant species, climate and soil conditions, and soil sampling location.

Even though most of the soil chemical characteristics were not significantly affected by patch size, phosphorus and nitrogen contents of the soils significantly increased with patch size. Since both nutrients are essential elements for plant growth (Firmansyah et al., 2017), and their deficiencies retard or stunt plant growth together with other nutrients (Fan et al., 2016; Li et al., 2016; Uchida 2000), impact of large patches on soil phos-

Table 2. Mean values (mean ± SEM) of selected chemical parameters in the soils around the vegetation patches with different diameters. Means with different superscript letters are significantly different between patch sizes at the same row ($p<0.05$)

	Patch diameter range (m)			
Soil chemical parameters	0–4 (n=20)	4–8 (n=14)	>8 (n=14)	Significance
pH	7.40±0.13	7.55±0.11	7.10±0.16	p>0.05
Electrical conductivity (µS/cm)	0.55±0.08	0.52±0.09	0.35±0.04	p>0.05
Phosphorus (g/L)	0.01^{a}±0.002	0.01^{a}±0.002	0.03^{b}±0.01	p<0.05
Potassium (g/L)	0.23±0.03	0.18±0.02	0.34±0.07	p>0.05
Calcium (g/L)	8.24±1.94	7.02±1.94	4.06±0.52	p>0.05
Magnesium (g/L)	1.38±1.02	0.51±0.13	0.43±0.05	p>0.05
Nitrogen (%)	0.62^{a}±0.02	0.60^{a}±0.01	0.70^{b}±0.04	p<0.05
Carbon (%)	3.55^{a}±0.43	3.11^{a}±0.37	4.83^{a}±0.76	p>0.05

g: grams; L: liter; m: meters; n: number of sub-samples; p: level of significance

phorus and nitrogen content should be considered before land preparation in the poor nutrient conditions such as the study sites in this study.

CONCLUSION

Results of this study showed that phosphorus and nitrogen content of the soil were influenced by patch size. Since both chemicals are macronutrients for plant growth, their deficiencies negatively affect plant growth in addition to other nutrients. Under poor nutrient conditions, large patches can be protected from vegetation clearance in the sites where the lands are rehabilitated. Based on results of this study, it can be said that small and medium-sized patches can be cleared from the land in the revegetation studies in this semiarid regions to manage a better soil preparation and to save time and cost. To have a clear picture, we need more studies to reach a conclusion about if patch sizes play important role on soil chemical content and if it is necessary to keep or remove all existing vegetation patches prior to revegetation of degraded lands during the soil preparation processes in the arid and semiarid regions.

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ISTANBUL UNIVERSITY CERRAHPASA

Original Article

A research on job satisfaction levels of employees in the furniture industry: A case of Istanbul, Turkey

Mobilya endüstrisinde çalışanların iş tatmin düzeylerine ilişkin bir araştırma: İstanbul ili örneği (Türkiye)

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ABSTRACT

The aim of the present study was to identify the level of job satisfaction among employees and the relationship between their intrinsic and extrinsic satisfaction levels that are of utmost importance for the furniture sector. For this purpose, the job satisfaction levels of employees working for furniture enterprises in Istanbul were measured by a survey method. The survey form consists of two sections. The first section includes questions regarding the demographic characteristics of the employees, whereas the second section includes a short version of the Minnesota Job Satisfaction Questionnaire. The obtained data were evaluated by using descriptive statistics, independent t-test, and one-way analysis of variance methods. As a result of the research, it was found that the participants were partially satisfied with intrinsic satisfaction factors, whereas they were not satisfied about whether extrinsic satisfaction factors have an impact on the level of job satisfaction. The outcomes of the analyses made between the job satisfaction levels of the employees working for the furniture industry in Istanbul and demographic variants revealed that job satisfaction did not vary meaningfully according to variants, such as gender, age, marital status, level of education, and professional experience of the employees. Furthermore, it was identified that the general satisfaction level of the white collar employees was lower than that of the other group of employees.

Keywords: Employee, furniture industry, job satisfaction

ÖZ

Mobilya sektörü için son derece önemli bir yere sahip olan çalışanların iş tatmin düzeylerinin tespit edilmesi, içsel ve dışsal iş doyum düzeyleri ile genel iş doyum düzeyleri arasındaki ilişkilerin belirlenmesi bu çalışmanın amacını oluşturmaktadır. Bu amaçla İstanbul ilinde mobilya sektöründe faaliyet gösteren işletme çalışanlarının iş tatmin düzeyleri anket tekniği kullanılarak ölçülmeye çalışılmıştır. Anket formu iki bölümü içermektedir. Birinci bölümünde çalışanların demografik özelliklerini belirlemeye yönelik sorular bulunmakta, ikinci bölümünde Minnesota iş tatmin ölçeğinin kısa formu yer almaktadır. Elde edilen veriler tanımlayıcı istatistikler, bağımsız t-testi, tek yönlü varyans testi yöntemleri kullanılarak değerlendirilmiştir. Araştırma sonucunda katılımcıların içsel tatmin faktörlerinden kısmen memnun oldukları belirlenirken, dışsal tatmin faktörlerinin iş tatmin düzeyini etkilediği konusunda memnun olmadıkları belirlenmiştir. İstanbul mobilya sektöründe çalışanların iş tatmin düzeyleri ile demografik değişkenler arasında yapılan istatistiki analizler sonucunda; çalışanların cinsiyeti, yaşı, medeni durum, eğitim düzeyi, mesleki deneyimi gibi değişkenlere göre iş tatmininin anlamlı bir farklılık göstermediği tespit edilmiştir. Ayrıca, genel tatmin düzeyinde beyaz yakalı çalışanların diğer kadro durumundakilerden daha düşük genel tatmin düzeyine sahip oldukları belirlenmiştir.

Anahtar Kelimeler: Çalışan, iş tatmini, mobilya endüstrisi

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INTRODUCTION

Satisfaction occurs when aspirations of individuals coincide with the impression gained from the working environment. On the other hand, job satisfaction occurs when the reward expectancy of an individual from a job is met (Üçüncü, 2016). Job satisfaction refers to the contentment or discontentment of the employees associated with their jobs. It occurs when the characteristic of a job meets the employee's individual needs and wants (Sat, 2011). According to a different definition, it is a comfort that a person longs for taking in the business cycle, job, organization, and colleagues (Yel-

boğa, 2012). It represents one of the most complex areas facing today's managers when it comes to managing their employees (Aziri, 2011). Once the desired level at job satisfaction is reached, job efficiency increases, and companies have the advantage of surpassing their opponents (Gedik et al., 2009).

The factors affecting job satisfaction are individual factors and organizational factors. Factors identified at the individual level are matching of personal interests and job, years of service and age, position in hierarchy, and overall life satisfaction. Organizational job satisfaction factors are organizational elements that shape the work environment and that facilitate or prevent employees getting what is important to them from their jobs (Janićijević et al., 2015).

There is a difference between the satisfaction that an individual feels during the job and after being rewarded. The satisfaction felt as a result of working is "extrinsic satisfaction," whereas the satisfaction felt during the work refers to "intrinsic satisfaction" (Üçüncü, 2016). Intrinsic satisfaction consists of the intrinsic qualities of the job, such as success, recognition or appreciation, the job itself, and job responsibility. Extrinsic satisfaction consists of job environment-related components, such as organizational policies and management, supervision methods, manager attitudes, relationships among co-workers and subordinates, working conditions, and salary (Arslan Yürümezoğlu and Kocaman, 2012).

If a worker has lower job satisfaction, she/he will be reluctant to go to work and willing to leave the organization and the job, as well as feeling incompetent, uncooperative, and prone to making mistakes and unreasonable decisions in addition to experiencing loss of performance (Sat, 2011). On the other hand, if a worker has higher job satisfaction, individual traits, such as performance gain and enhanced productivity, will be beneficial for individuals while increasing productivity with lower employee turnover rates and attracting skilled workers (Köroğlu, 2012).

The purpose of the present study was to investigate the levels of job satisfaction among workers in the furniture industry located in Istanbul.

MATERIAL AND METHODS

The Turkish furniture industry predominantly has an image consisting of traditional workshops and small-scale enterprises. Nevertheless, the number of medium- and large-scale enterprises has rapidly started to increase recently (Central Anatolia Exporters Association, 2016). As a rapidly developing and changing sector, the furniture industry has a growing potential in both domestic and foreign markets with emerging trademarks, increasing the number of small- and large-scale enterprises, favorable geographical location and growth-friendly policy of Turkey, as well as its young population, and improving gross domestic product per capita (The Union of Chambers and Commodity Exchanges of Turkey, 2013).

The furniture sector in Turkey is developed in certain regions where the market is busy, and/or forest products are ample. When we examine the regions where the furniture sector is more dominant, Istanbul, Kayseri, Bursa, Ankara, and Izmir emerge as the largest furniture producer provinces of Turkey. Other than this, Bolu, Eskişehir, Sakarya, Zonguldak, Trabzon, Balıkesir, Antalya, and Burdur are also among the furniture producers (Central Anatolia Exporters Association, 2016).

With respect to better workplace and employment opportunities in the furniture sector, the leading provinces of Turkey are İstanbul, Ankara, Bursa (İnegöl), Kayseri, İzmir, and Adana. The most important centers of the furniture sector in Istanbul are MASKO located in the İkitelli Organized Industrial Zone and MODOKO located in a small industrial estate (Central Anatolia Development Agency, 2016).

According to the 2014 Social Security Institution data, Turkey ranks fourth in the manufacturing industry with 20,867 enterprises and takes seventh place with an employment of 165,118 people (Central Anatolia Exporters Association, 2016). İstanbul remains under the general manufacturing sector employment rate with a rate of 5.7 employees per enterprise (Central Anatolia Development Agency, 2016).

A survey method was used to obtain data. Several previous studies were reviewed for the survey construction (Karataş and Güleş, 2010; Kahraman et al., 2011; Sat, 2011; Köroğlu, 2012). Data have been carefully examined and analyzed.

The survey consisted of two parts. The first part included the demographic characteristics of the participants, and the second part was based on the Minnesota Job Satisfaction Scale with 20 items that assess the overall job satisfaction.

The Minnesota Job Satisfaction Scale was first developed in 1967 by Weiss et al. and translated into Turkish in 1985 by Baycan (Arslan Yürümezoğlu and Kocaman, 2012). The Minnesota Job Satisfaction Questionnaire measures how an employee feels about working conditions, career progression, using her or his own judgments, and being appreciated and approved for doing good work (Kahraman et al., 2011; Köroğlu, 2012). The Minnesota Job Satisfaction Scale includes 20 items that are determinant of intrinsic, extrinsic, and general satisfaction (Weiss et al., 1967). Intrinsic satisfaction consisted of 12 items (1, 2, 3, 4, 7, 8, 9, 10, 11, 15, 16, and 20). Extrinsic satisfaction consisted of eight items (5, 6, 12, 13, 14, 17, 18, and 19). General satisfaction consisted of 20 items (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20). Intrinsic, extrinsic, and general satisfaction scores were calculated as the arithmetic mean of the scores of respective items (Akyüz and Yıldırım, 2015; Köroğlu, 2012; Sat, 2011). Response choices in the scale were as 1, very dissatisfied; 2, dissatisfied; 3, neither satisfied nor dissatisfied; 4, satisfied; and 5, very satisfied (Weiss et al., 1967).

To determine the numbers of the workers in the furniture industry, the records of the Union of Chambers and Commodity Exchanges of Turkey (Anonymous, 2016a) and Istanbul Chamber of Commerce (Anonymous, 2016b) were examined, and the

number was found to be 28,441 The sample size is determined as 380 with 95% confidence level and 5% margin of error (Yamane, 2001). To increase the reliability, 420 workers were surveyed, and 400 surveys were used for statistical analysis. Data were analyzed through statistical methods. We assumed that the participants responded in the survey objectively based on their own knowledge and experience.

RESULTS AND DISCUSSION

Reliability analysis

Reliability of the job satisfaction scale (Cronbach's alpha) was 0.942, indicating a high degree of reliability. If alpha is <0.40, it means that the scale is not reliable. If alpha is between 0.40 and 0.60, then it means that it has a low reliability. To be considered as reliable, the alpha should be between 0.60 and 0.80. If alpha is between 0.80 and 1.0, it means that the scale has a high degree of reliability (Kalaycı, 2016). While the value of reliability of intrinsic satisfaction was 0.911, the value of extrinsic satisfaction was 0.878.

Demographic features of the participants

The study comprised 86.8% of male and 13.3% of female participants. The age was grouped into the following four categories: (1) ≤24 years, (2) 25–35 years, (3) 36–45 years, and (4) ≥46 years. The distribution of respondents in these categories was 18.8%, 46%, 27%, and 8.2%, respectively (Table 1).

Of the participants, 64.2% were married, whereas 34% were single. Among them, 1.8% were engaged or divorced. There were six categories of education level: (1) primary school, (2) secondary school, (3) high school, (4) vocational school, (5) undergraduate, and (6) graduate. The distribution of the respondents into these categories was 15%, 30%, 29.3%, 15.2%, 9.5, and 1%, respectively. Of the respondents, 68% had a salary between 1301 and 2500 Turkish Liras. With respect to their positions at work, 19.5% of the participants were white collar, whereas 67% are blue collar, and 13.5% were office workers. It was identified that 66.2% of the participants worked in the production unit, 11.7% worked in the planning unit, 5.8% worked in the quality control unit, 3% worked in the maintenance unit, and 13.3% worked in the other units. With respect to experience (years of service), the respondents included 21.3% 1–3 years, 21% 4–6 years, and 36.3% ≥10 years. Of the participants, 30.5% were working at the same institution for <1 year, 33.5% 1–3 years, 19.8% 4–6 years, 5.3% 7–9 years, and 11% >10 years (Table 1).

Examination of job satisfaction degrees of the participants

Respondents, workers in the furniture industry operating in Istanbul, rated various aspects of the job satisfaction. Arithmetic mean and standard deviation values for the ratings are depicted in Table 2.

The mean of factors for intrinsic satisfaction was 3.7694, whereas the general satisfaction score was 3.7294. The results indicated that the participants are partially satisfied with intrinsic factors. However, the mean of extrinsic factors (3.6894) is lower than the general satisfaction score (3.7294). The participants have stated that they are not satisfied about whether extrinsic factors affect their job satisfaction or not. As analysis results reveal,

Table 1. Demographic features of the participants

Demographic features		Frequency	%
Gender	Male	347	86.8
	Female	53	13.3
Age group (year)	≤24	75	18.8
	25–35	184	46
	36–45	108	27
	≥46	33	8.2
Marital status	Married	257	64.2
	Single	136	34
	Other	7	1.8
Educational status	Primary school	60	15
	Secondary school	120	30
	High school	117	29.3
	Vocational school	61	15.2
	Undergraduate	38	9.5
	Graduate	4	1
Average monthly income (Turkish Liras)	1300 Liras	47	11.8
	1301–2500	272	68
	2501–4000	73	18.2
	≥4001	8	2
Work position	White collar	78	19.5
	Blue collar	268	67
	Office workers	54	13.5
Working section	Production	265	66.2
	Planning	47	11.7
	Quality control	23	5.8
	Maintenance	12	3
	Other	53	13.3
Work experience (year)	<1	28	7
	1–3	85	21.3
	4–6	84	21
	7–9	58	14.5
	≥10	145	36.3
Time span of their working in the same institution (year)	<1	122	30.5
	1–3	134	33.5
	4–6	79	19.8
	7–9	21	5.3
	≥10	44	11

Table 2. Examination of job satisfaction degrees of the participants

Level of satisfaction	Item no.	Items	Average*	Standard deviation
Intrinsic satisfaction	1	Being able to keep busy all the time.	3.7625	0.89895
	2	The chance to work alone on the job.	3.7125	0.89266
	3	The chance to do different things from time to time.	3.7650	0.88981
	4	The chance to be "somebody" in the community.	3.7550	0.88992
	7	Being able to do things that do not go against my conscience.	3.8350	0.84532
	8	The way my job provides for steady employment.	3.7900	0.82923
	9	The chance to do things for other people.	3.7350	0.84056
	10	The chance to tell other people what to do.	3.7475	0.81265
	11	The chance to do something that makes use of my abilities.	3.7425	0.83543
	15	The freedom to use my own judgment.	3.7475	0.83095
	16	The chance to try my own methods of doing the job.	3.7725	0.81079
	20	The feeling of accomplishment I get from the job.	3.8675	0.80720
Intrinsic satisfaction score			3.7694	0.84862
Extrinsic satisfaction	5	The way my boss handles his/her workers.	3.6500	0.93792
	6	The competence of my supervisor in making decisions.	3.7100	0.87625
	12	The way company policies are put into practice.	3.7250	0.80061
	13	My pay and the amount of work I do.	3.4975	1.03812
	14	The chances for advancement on this job.	3.6500	0.90805
	17	The working conditions.	3.7400	0.91350
	18	The way my co-workers get along with each other.	3.8075	0.83498
	19	The praise I get for doing a good job.	3.7350	0.88132
Extrinsic satisfaction score			3.6894	0.89884
General satisfaction score			3.7294	0.87373

*1: very dissatisfied; 2: dissatisfied; 3: neither satisfied nor dissatisfied; 4: satisfied; 5: very satisfied

the highest level of intrinsic satisfaction given as an answer to the 20th question is "The feeling of accomplishment I get from the job," whereas the answer to the 7th question is "Being able to do things that do not go against my conscience." The highest extrinsic satisfaction level as an answer to the 18th question is "The way my co-workers get along with each other" (Table 2). As a result of the evaluation of all the questions, the job satisfaction levels of the participants in the furniture sector were determined to be partially satisfied.

Demographic features and job satisfaction

We analyzed the relationship between demographic features and job satisfaction.

The relationship between the gender of the participants and their job satisfaction

Table 3 shows the relationship between gender and job satisfaction. There was no significant difference in job satisfaction across employee's gender ($p>0.05$).

The relationship between the age of the participants and their job satisfaction

Statistical analysis of the relationship between the age of the participants and their job satisfaction is shown in Table 4. The results of the statistical evaluations showed that there was no any significant difference between the age of the workers in the furniture industry in İstanbul and their job satisfaction degrees ($p>0.05$).

The relationship between the marital status of the participants and their job satisfaction

Comparison of job satisfaction degrees of the workers with respect to their marital status is shown in Table 5. The results of the statistical evaluations showed that there was no any significant difference between the marital status of the workers in the furniture industry in Istanbul and their job satisfaction degrees ($p>0.05$).

The relationship between the educational background of the participants and their job satisfaction

Statistical evaluation of the relationship between the educational background of the participants and their job satis-

Table 3. The relationship between the gender of the participants and their job satisfaction

	Gender	n	$\bar{X}$	σ	t	p
Intrinsic satisfaction	Female	53	3.86	0.732	1.195	0.233
	Male	347	3.76	0.582		
Extrinsic satisfaction	Female	53	3.78	0.779	0.936	0.353
	Male	347	3.66	0.643		
General satisfaction	Female	53	3.83	0.729	1.196	0.232
	Male	347	3.72	0.579		

n: number of sample; $\bar{X}$: arithmetic mean; σ: standard deviation; t: t-statistic; p: significance level

Table 4. The relationship between the age of the participants and their job satisfaction

	Age	n	$\bar{X}$	σ	F	p
Intrinsic satisfaction (year)	≤24	75	3.76	0.763	0.429	0.732
	25–35	184	3.74	0.512		
	36–45	108	3.79	0.568		
	≥46	33	3.86	0.604		
Extrinsic satisfaction (year)	≤24	75	3.68	0.815	0.031	0.993
	25–35	184	3.68	0.569		
	36–45	108	3.70	0.640		
	≥46	33	3.71	0.844		
General satisfaction (year)	≤24	75	3.73	0.763	0.212	0.888
	25–35	184	3.72	0.505		
	36–45	108	3.75	0.568		
	≥46	33	3.80	0.780		

n: number of sample; $\bar{X}$: arithmetic mean; σ: standard deviation; F: F-statistic; p: significance level

Table 5. Comparison of job satisfaction degrees with respect to the marital status of the participants.

	Marital status	n	$\bar{X}$	σ	F	p
Intrinsic satisfaction	Married	257	3.75	0.577	0.877	0.417
	Single	136	3.82	0.647		
	Other	7	3.58	0.726		
Extrinsic satisfaction	Married	257	3.67	0.636	1.611	0.201
	Single	136	3.74	0.689		
	Other	7	3.30	0.989		
General satisfaction	Married	257	3.72	0.572	1.219	0.297
	Single	136	3.78	0.641		
	Other	7	3.47	0.785		

n: number of sample; $\bar{X}$: arithmetic mean; σ: standard deviation; F: F-statistic; p: significance level

faction is shown in Table 6. There were no significant differences between the educational background of the workers in the furniture industry in Istanbul and their job satisfaction ($p>0.05$).

The relationship between the work experience of the participants and their job satisfaction

Statistical evaluation of the relationship between the work experience of the participants and their job satisfaction is

Table 6. The relationship between the educational background of the participants and their job satisfaction

	Educational background	n	$\bar{X}$	σ	F	p
Intrinsic satisfaction	Primary school	60	3.80	0.628	0.665	0.651
	Secondary school	120	3.81	0.516		
	High school	117	3.77	0.636		
	Vocational school	61	3.65	0.728		
	Undergraduate	38	3.79	0.521		
	Graduate	4	3.90	0.422		
Extrinsic satisfaction	Primary school	60	3.63	0.751	0.327	0.897
	Secondary school	120	3.70	0.570		
	High school	117	3.73	0.691		
	Vocational school	61	3.64	0.744		
	Undergraduate	38	3.69	0.593		
	Graduate	4	3.84	0.449		
General satisfaction	Primary school	60	3.73	0.649	0.414	0.839
	Secondary school	120	3.76	0.515		
	High school	117	3.75	0.630		
	Vocational school	61	3.64	0.717		
	Undergraduate	38	3.75	0.507		
	Graduate	4	3.88	0.419		

n: number of sample; $\bar{X}$: arithmetic mean; σ: standard deviation; F: F-statistic; p: significance level

Table 7. The relationship between the work experience of the participants and their job satisfaction

	Work experience	n	$\bar{X}$	σ	F	p
Intrinsic satisfaction (year)	<1	28	3.65	0.745	1.179	0.319
	1–3	85	3.85	0.591		
	4–6	84	3.78	0.556		
	7–9	58	3.66	0.677		
	≥10	145	3.78	0.575		
Extrinsic satisfaction (year)	<1	28	3.53	0.751	0.853	0.492
	1–3	85	3.75	0.654		
	4–6	84	3.72	0.592		
	7–9	58	3.61	0.784		
	≥10	145	3.70	0.636		
General satisfaction (year)	<1	28	3.60	0.730	1.100	0.356
	1–3	85	3.81	0.596		
	4–6	84	3.76	0.544		
	7–9	58	3.64	0.691		
	≥10	145	3.75	0.567		

n: number of sample; $\bar{X}$: arithmetic mean; σ: standard deviation; F: F-statistic; p: significance level

shown in Table 7. According to the results of the statistical analyses, there was no significant difference between the work experience of the participants and their job satisfaction ($p>0.05$).

Table 8. The relationship between the average monthly income of the participants and their job satisfaction

	Average monthly income	n	$\bar{X}$	σ	F	p
Intrinsic satisfaction (Turkish Liras)	1300	47	3.76	0.602	6.761	0.000
	1301–2500	272	3.83	0.611		
	2501–4000	73	3.68	0.493		
	≥4001	8	4.66	0.640		
Extrinsic satisfaction (Turkish Liras)	1300	47	3.74	0.642	6.736	0.000
	1301–2500	272	3.65	0.677		
	2501–4000	73	3.69	0.539		
	≥4001	8	4.69	0.637		
General satisfaction (Turkish Liras)	1300	47	3.80	0.600	7.197	0.000
	1301–2500	272	3.71	0.609		
	2501–4000	73	3.69	0.484		

n: number of sample; $\bar{X}$: arithmetic mean; σ: standard deviation; F: F-statistic; p: significance level

Table 9. The relationship between the work positions of the participants and their job satisfaction

	Work position	n	$\bar{X}$	σ	F	p
Intrinsic satisfaction	White collar	78	3.57	0.605	6.490	0.002
	Blue collar	268	3.80	0.586		
	Office workers	54	3.91	0.626		
Extrinsic satisfaction	White collar	78	3.55	0.669	3.471	0.032
	Blue collar	268	3.70	0.650		
	Office workers	54	3.86	0.684		
General satisfaction	White collar	78	3.56	0.600	5.437	0.005
	Blue collar	268	3.76	0.586		
	Office workers	54	3.89	0.623		

n: number of sample; $\bar{X}$: arithmetic mean; σ: standard deviation; F: F-statistic; p: significance level

The relationship between the average monthly income of the participants and their job satisfaction

The results of the statistical analyses about the effects of the average monthly income of the participants on their job satisfaction are shown in Table 8. There were significant differences between the participants' monthly income and their intrinsic satisfaction, as well as their general satisfaction degrees ($p<0.05$). The post hoc test that was done to determine at which subgroup levels this meaningful difference among intrinsic, extrinsic, and general satisfaction occurred revealed that the employees earning ≥4001 Turkish Liras (4.66±0.64, 4.69±0.64, and 4.67±0.63) had higher intrinsic, extrinsic, and general satisfaction than the other income groups by constituting a separate group.

The relationship between the work positions of the participants and their job satisfaction

The results of the statistical analyses done to determine the differences between their work positions and their job satisfaction are shown in Table 9. There were significant differences between the participants' work positions and their intrinsic satisfaction, as well as their general satisfaction degrees ($p<0.05$). The post hoc test determines the groups where the meaningful differences revealed by statistical analysis of the link between the ranks of the participants and their job satisfaction occur. As a result, it was identified that white collar employees (3.57±0.61) had lower intrinsic satisfaction than the employees from other ranks. Regarding extrinsic satisfaction, it was seen that office workers (3.86±0.68) differentiate from other workers as blue collars and have higher level of extrinsic satisfaction. When it comes to the general satisfaction level, we can say that white collar employees (3.56±0.60) have lower level of general satisfaction than the other rank of employees.

CONCLUSION

In conclusion, the present study revealed that male employees are dominant in the furniture sector in Istanbul. This can be explained by the higher number of male employees than fe-

male employees due to the intrinsic properties of the sector. Of the participants, 36.3% had at least 10 years of experience. The participants and the employees in the Istanbul furniture sector were predominantly high school graduates and undereducated. Upon reviewing the literature, we see that the forest product enterprises have challenges in finding employees specialized in forest products and process improvement. Some studies from the literature prove this conclusion (Sevim Korkut et al., 2017). When the work statuses of the participants were analyzed, 67% of them were found to be blue collars.

It was also seen that participants were partially satisfied with intrinsic factors but not satisfied about whether extrinsic factors affect their job satisfaction levels. As a result of the cross-examination of job satisfaction factors, the average job satisfaction level in the furniture sector in general is 3.7294, which is considered as a partial satisfaction level. Akyüz and Yıldırım (2015) calculated the average job satisfaction level in the forest product sector as 3.42, which is evident that the level of job satisfaction is generally high.

The statistical analysis made between job satisfaction and demographic variants suggests that female and male employees have similar job satisfaction levels. Some studies from the literature yielded the same result (Akyüz et al., 2011; Akyüz and Yıldırım, 2015; Sevim Korkut et al., 2017). This result is evident that female and male employees give similar value to their jobs. As a result of the study, there was no meaningful difference between the job satisfaction and ages of the participants. The researches in the literature support the same result (Sevim Korkut et al., 2017). In consequence of the study, it was found that job satisfaction did not show any meaningful difference as per marital status. The research in the literature also supports this conclusion (Akyüz et al., 2011; Akyüz and Yıldırım, 2015). The findings of the study reveal no meaningful difference between the job satisfaction and education level of the participants. On the other hand, Gedik et al. (2009) reported a meaningful difference between the job satisfaction and education levels of employees in the Düzce forest products industry. In this study, a meaningful discrepancy was found between the position of the employees in the enterprise and their job satisfaction. It was found that white collar employees had lower internal satisfaction than other ranks of employees, whereas office girls or boys had higher external satisfaction than blue collars, and white collars had lower general satisfaction level than others. Akyüz et al. (2011) stated that the difference in the positions of employees working for an institution does not change job satisfaction levels.

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ISTANBUL UNIVERSITY CERRAHPASA

Original Article

A new subspecies of *Phoenix theophrasti* Greuter (*Phoenix theophrasti* Greuter subsp. *golkoyana* Boydak) from Turkey

Phoenix theophrasti Greuter türünün Türkiye'de tanımlanan yeni bir alttürü (*Phoenix theophrasti* Greuter subsp. *golkoyana* Boydak)

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ABSTRACT

In the present study, a new subspecies (*Phoenix theophrasti* Greuter subsp. *golkoyana* Boydak) is described in Turkey. The unidentified *Phoenix* taxon native to Bodrum–Gölköy, Aegean Turkey and named as the "Gölköy *Phoenix* population" has been known to Gölköy's inhabitants for centuries. The Gölköy *Phoenix* population was considered to be representative of *P. theophrasti*. Boydak made the first of a number of trips to Gölköy and immediately noticed some distinct differences between the Gölköy *Phoenix* population, *P. theophrasti* Greuter, and *Phoenix dactylifera* L in the early summer of 1990. He continued his investigations on this taxon for many years to shed light on the subject. He made two new trips to the three native stands of *P. theophrasti* and the Gölköy *Phoenix* populations in 2015 and 2018. Measurements and observations were made on the morphological characteristics that showed distinct differences among the Gölköy *Phoenix* population, *P. theophrasti*, and *P. dactylifera*. These were related to the length of male stalks and female inflorescences and some fruit and seed characteristics. The results indicate that some distinctive morphological characteristics of the "Gölköy *Phoenix* population" merit its being described as a new subspecies. "*Phoenix theophrasti* Greuter subsp. *golkoyana* Boydak" differs from *P. theophrasti* Greuter with respect to its longer fruiting-female stalk length and longer male stalk length, its fruiting stalks hold fruits marginally higher, and its having seeds with slightly visible striate surface crust structures and deeper-wider grooves.

Keywords: A new subspecies, Bodrum–Gölköy, *Phoenix theophrasti*

ÖZ

Bu makale kapsamında Türkiye'de yeni bir alttür tanımlanmıştır (*Phoenix theophrasti* Greuter subsp. *golkoyana* Boydak). Ege Bölgesi, Bodrum-Gölköy'de doğal olarak bulunan ve "Gölköy *Phoenix* populasyonu" olarak adlandırılan tanımlanmamış bu takson, Gölköy halkı tarafından yüzlerce yıldan beri bilinmekteydi. Gölköy *Phoenix* populasyonu *Phoenix theophrasti* türünün bir temsilcisi olarak kabul ediliyordu. Bu makalenin yazarı, Gölköy'e yaptığı çok sayıdaki bilimsel gezinin, 1990 yılının erken yazında yaptığı ilkinde, Gölköy *Phoenix* populasyonu, *P. theophrasti* Greuter and *P. dactylifera* L. arasında önemli farklılıklar olduğunu gözlemledi. Yazar konuyu aydınlatmak için uzun yıllar bu takson ile ilgili çalışmalara devam etti. 2015 ve 2018 yıllarında, ülkemizde doğal olarak bulunan üç *P. theophrsti* populasyonu ile Gölköy *Phoenix* populayonuna iki bilimsel gezi daha yaptı. Gölköy *Phoenix* populasyonu, *P. theophrasti,* ve *P. dactylifera* arasında belirgin farklılıklar gösteren morfolojik özellikler üzerinde ölçmeler ve gözlemler yapıldı. Bunlar erkek çiçek sapları ve meyva saplarının uzunlukları ile bazı meyva ve tohum özelliklerini kapsamaktadır. Sonuçlar, "Gölköy *Phoenix* populayonu"nun bazı özgün ve farklı morfolojik özellikleri nedeniyle, onun yeni bir alttür olarak tanımlanmaya layık olduğunu ortaya koydu. *"Phoenix theophrasti* Greuter subsp. *golkoyana* Boydak", *P. theophrasti* Greuter türünden daha uzun meyva sapları ve daha uzun erkek çiçek sapları, meyva saplarının marjinal olarak daha fazla meyva tutmaları, tohumlarının çok az belirli olan tohum kabuğu dokusu, daha derin ve daha geniş tohum oluğu ile ayrılmaktadır.

Anahtar Kelimeler: Bodrum-Gölköy, *Phoenix theophrasti,* yeni bir alttür

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INTRODUCTION

Turkey is one of the most important floral regions in the world, with >11,707 taxa of herbaceous and woody species, of which 3035 are endemic (Güner et al., 2012). The rich vegetation in Turkey is because of its geographic location and topography, leading to different climate and subclimate types (Boydak and Çalışkan, 2014; Çalışkan and Boydak, 2017). Many new taxa were described in recent years.

Phoenix theophrasti Greuter and *Phoenix dactylifera* L. are in the genus *Phoenix* L. (Barrow, 1998). The genus *Phoenix* L. (Phoeniceae: Coryphoideae) belongs to the order Principes (Aracales) and the family Palmea (Arecaceae) (Uhl and Dransfield, 1987).

P. theophrasti was first described by Greuter in 1967 from the famous grove at Vai in Crete (Greuter, 1967). The species is now known from nine coastal localities on the same island (Barclay, 1974; Turland et al., 1993), where it is possible to find it growing along damp valley floors, streamsides, springs, and coastal rocks and cliffs, in all cases by the seashore and from 0 to 230 m altitude (Figure 1). Greuter (1967) remarked that the "Cretan Date Palm" had been known since Classical antiquity, when it was recorded in the Theophratus' writings. Many of them thought that it was an escaped cultivar of the Date Palm, *P. dactylifera* (e.g., Zohary, 1973). On the other hand, Greuter considered the Cretan palm to be a different species. He named it *P. theophrasti* on behalf of the Greek botanist-philosopher (Greuter, 1967).

The family Palmea was not known to occur naturally in Turkey until the first occurrence of *P. theophrasti* was recorded in the Datça Peninsula in 1982 (Boydak and Yaka, 1983; Boydak, 1985). The second occurrence was found in Kumluca–Karaöz in Finike Bay (Boydak, 1987). Another unidentified *Phoenix* taxon native to Bodrum–Gölköy–Aegean Turkey and named as the "Gölköy *Phoenix* population" was found later (Boydak and Barrow, 1995) (Figure 1).

Several species of the genus *Phoenix*, some other members of *Palmae* (*P. dactylifera*, *Phoenix canariensis*, *Phoenix roebelenii*, *Trachycarpus fortunei*, *Chamaerops humilis*, *Washingtonia robusta*, *W. filifera*, and *Syagrus romanzoffiana*), and some other palms are being cultivated in the Mediterranean and Aegean areas of Turkey (Esener, 1999; Hazir and Buyukozturk, 2013). *P. dactylifera* is cultivated for fruits and ornamental purposes, whereas others are generally cultivated for ornamental purposes.

Greuter (1967), quoting from Evreinoff (1956), wrote that fossil research revealed that some members of the genus *Phoenix* were identified in central Europe Miocene formations, around the Aegean coastal regions, and also found in Pleistocene formations. The characteristics of the fossil form *P. dactylifera* fossils

Figure 1. Natural distribution of *Phoenix theophrasti* Greuter and *P. theophrasti* Greuter subspecies *golkoyana* Boydak

Drude were found to be very similar to the characteristics of the date palm *P. dactylifera* L.

Recent investigations in new early Miocene fossil forest sites (18–20 million years ago) in northwest Turkey–Bolu–Seben (900 m) revealed the first record of silicified palm wood in Turkey (Akkemik et al., 2016). Later, this palm wood and three more unpublished Neogene palm fossil woods (two from Çanakkale–Gökçeada and one from Edirne–Keşan–Erikli) were studied by Iamandei et al. (2018). The palm woods were identified as *Palmoxylon coryphoides* Ambwani & Mehrotra from Gökçeada, *Palmoxylon* cf. *Trachycarpus* from Seben, and *Palmoxylon* cf. *Borasus* from Erikli (Iamandei et al., 2018).

Greuter (1967) and Zohary (1973) accepted that *P. dactylifera* had its origin in the mid-eastern hot deserts. According to Zohary (1973), these assumptions are consistent with Fischer and Beccari (1890). He also stated that this supposition of the date palms' Irano-Arabian origin is very consistent with the fact that the Sumerians are the source of the earliest evidence on date cultivation. However, he admits that this does not eliminate the possibility of an ancestral relationship between the cultivated date palm and *P. theophrasti*.

Nevertheless, the *Phoenix* taxon indigenous to the coastal plains in southern Iran and Iraq at the locations of Sharqa, Bander Abbas, and Basra was described as a wild form of *P. dactylifera* by Fischer (1881; in Greuter, 1967). It was stated that more research was necessary to determine if this taxon is actually *P. theophrasti* (Zohary, 1973). Barrow (1998) explained that *P. dactylifera* and *P. theophrasti* are difficult to differentiate on the basis of morphological and anatomical data. The author also added that molecular data supported the two species as close sisters; however, the author also accepted *P. theophrasti* as a different species when considering certain morphological features. Comprehensive research based on multiloci fingerprints supported the existing taxonomy, since all individuals from the same species clustered together. Specifically, *P. dactylifera*, *P. theophrasti*, and *Pinus sylvestris* were accepted as comprising the "*P. dactylifera* clade." The related species *P. atlanta* and *P. canariensis* appeared highly distinct from each other, with few or no alleles being mutual. These results showed that the date palm was preliminarily domesticated from wild populations of *P. dactylifera*, with only secondary and localized genetic contributions from other species (Pintaud et al., 2010).

P. theophrasti is distinguished from *P. dactylifera* by its erect fruit clusters and small, inedible fruits (Anon., 1983; Greuter, 1967). Both *P. theophrasti* and the Gölköy *Phoenix* population have sweet but in general thinner mesocarps. Turland et al. (1993) noted that *P. theophrasti* has smaller, shorter, and sharper leaves

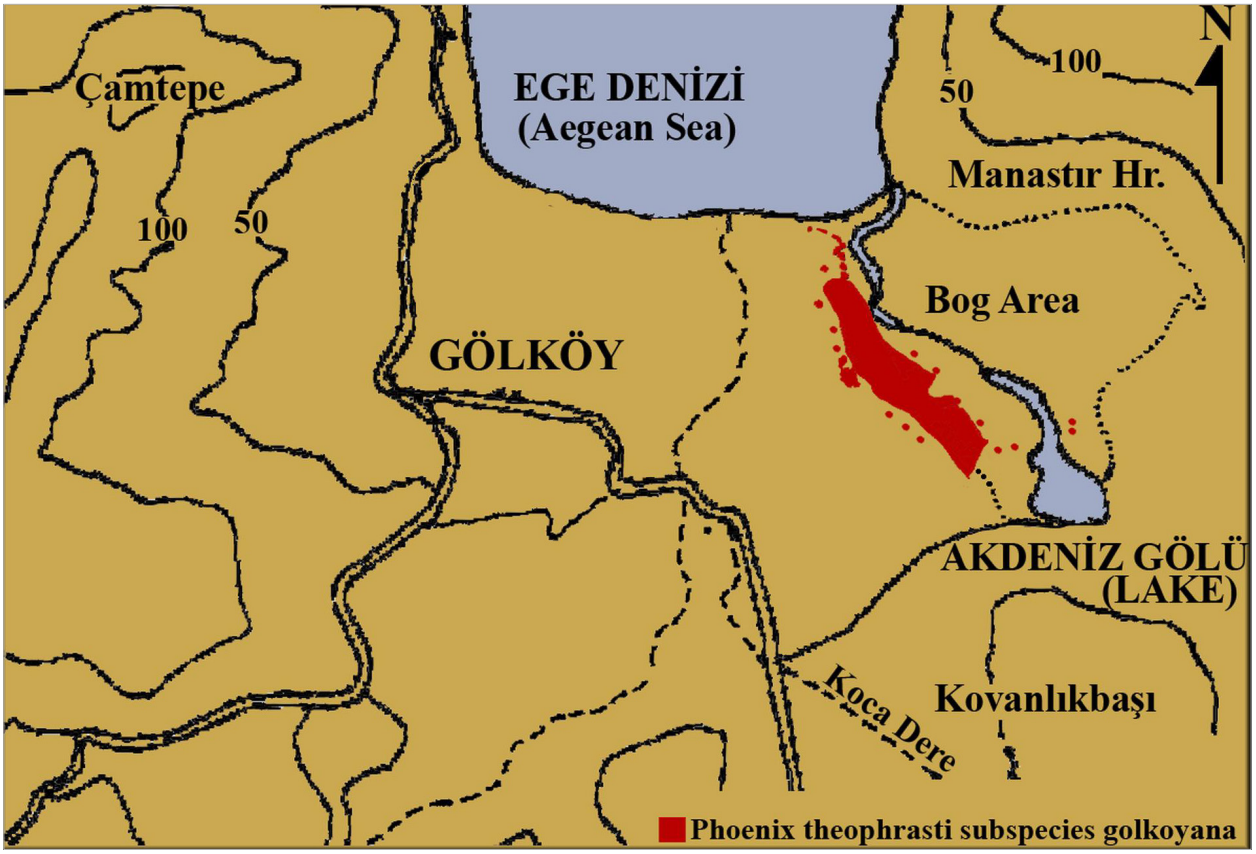

Figure 2. Location map of the *Phoenix theophrasti* Greuter subspecies *golkoyana* Boydak populations at Gölköy (Göltürkbükü), near Bodrum (adapted from Anon., 2013)

than *P. dactylifera*. The observations of the author of the present manuscript also suggest that the leaves of *P. theophrasti* are sharper than those of the Gölköy *Phoenix* population.

The unidentified *Phoenix* taxon native to Bodrum–Gölköy–Aegean Turkey and named as the "Gölköy *Phoenix* population" has been known to Gölköy's inhabitants for centuries (Boydak and Barrow, 1995). Bayraktar and Aslanboga (Professors of Landscape Architecture, Ege University) made a visit to the Gölköy *Phoenix* population in 1989 and thought it was a member of *P. theophrasti*. Boydak, the author of the current paper, made the first of a number of trips to Gölköy in the early summer of 1990. He instantly recognized certain obvious differences between the Gölköy *Phoenix* population, *P. theophrasti*, and *P. dactylifera*. Samples were given to the Herbarium of İstanbul University, Faculty of Forestry (October 1990) and sent to the Royal Botanic Garden, Edinburgh (December 1990) and Royal Botanic Gardens, Kew (July 1993). Boydak and Barrow visited the Gölköy population and the two indigenous stands of *P. theophrasti* in Datça–Eksera Deresi and Kumluca–Karaöz in Finike Bay in April 1994, and they collected more herbarium materials (Boydak and Barrow, 1995). Boydak continued his investigations on this taxon for many years. He made two more trips to the three native stands of *P. theophrasti* and the Gölköy *Phoenix* population in 2015 and 2018, collected further herbarium materials, and delivered them to the Herbarium of the Faculty of Forestry, İstanbul University-Cerrahpaşa (ISTO).

This new *Phoenix* population is found growing on swampy ground surrounded by the Gölköy Lake, the boundaries of the rapidly growing village of Gölköy, patches of *Pinus brutia* together with maquis, and the sea. A number of palms are currently included in the gardens of houses built recently (Boydak and Barrow, 1995). The Gölköy *Phoenix* population primarily covers an area of 3.9 ha according to the management plans of the Turkish Forest Service completed in 2013 (Anon., 2013). There are mainly four *Phoenix* groves covering 1.2 ha, 1.2 ha, 1.0 ha, and 0.5 ha inside or alongside the bog and/or bordering the village (Figures 2, 3).

Research based on anatomical data indicated a close relationship between *P. dactylifera*, *P. theophrasti*, and the Gölköy *Phoenix* population (Barrow, 1998). Boydak and Barrow (1995) stated that more sampling is necessary for understanding the precise nature of their relationships; however, they noted that morphological characteristics show several differences between the Gölköy palm and *P. theophrasti* and *P. dactylifera*. They discussed whether the Gölköy palm represents a new species or a subspecies or variety of *P. theophrasti* and *P. dactylifera*. As is explained above, Boydak continued his investigations on this taxon for many years to shed light on the subject.

When one sees the population so close to the village, one cannot help but ask if it is natural and native, rather than being the remnants of cultivated date palm grove. Reasons exist to think that it is natural and native. First, the palm yields small fruits that are slightly sweet but seldom fleshy; thus, it does not appear likely that they were planted as a fruit crop. No local record supports its usage as leaf or leaf-based fiber. Second, the population is robust and regenerating successfully by both seedlings

Figure 3. A view from the *Phoenix theophrasti* Greuter subspecies *golkoyana* Boydak populations

and suckers (Boydak and Barrow, 1995). Moreover, four Miocene and Neogene palm fossil wood sites representing different taxa were recently recorded in Anatolia, indicating that natural palm groves existed in the past in Anatolia (Akkemik et al. 2016; Iamandei et al., 2018). In addition, the "Gölköy *Phoenix* population" has been known to Gölköy's inhabitants for centuries.

The aim of the present study was to investigate the relationship and differences between *P. dactylifera*, *P. theophrasti*, and the Gölköy *Phoenix* populations by comparing some morphological properties, especially those that exhibit distinct differences.

MATERIAL AND METHODS

Measurements and observations were made on the morphological characteristics that showed distinct differences among the Gölköy *Phoenix* population, *P. theophrasti*, and *P. dactylifera*.

Table 1. Male and female inflorescence lengths of the Gölköy *Phoenix* population

Male inflorescence				Female inflorescence			
Tree no.	Length (cm)	Tree no.	Length (cm)	Tree no.	Length (cm)	Tree no.	Length (cm)
1	85	11	94	1	200	11	146
2	73	12	107	2	210	12	166
3	94	13	91	3	187	13	168
4	120	14	74	4	160	14	210
5	114	15	94	5	196	15	176
6	92			6	147		
7	68			7	132		
8	70			8	195		
9	120			9	149		
10	83			10	175		

Table 2. Results of the measurements of the *Phoenix theophrasti* populations and the Gölköy *Phoenix* population in Turkey and other measurements cited in the related literature

	Morphological characteristics			
Species and locality	Male stalk length		Female-fruiting stalk length	
P. theophrasti: Datça–Eksera Deresi	Up to 45 cm		Up to 65 cm	
P. theophrasti: Datça–Hurmalıbük	Up to 50 cm		Up to 70 cm	
P. theophrasti: Kumluca–Karaöz	Up to 55 cm		Up to 70 cm*	
Gölköy *Phoenix* population	Up to 120 cm		Up to 210 cm	
P. theophrasti (Barrow, 1998)	Up to 40 cm		Up to 70 cm	
P. dactylifera (Flora of China, 2019)	Up to 100 cm		Up to 200 cm	
	Fruit		Seed	
Fruit and seed dimensions	Thickness (mm)	Length (mm)	Thickness (mm)	Length (mm)
P. theophrasti: Datça–Eksera Deresi	11.0 (10–12)	17.5 (16–20)	8.9 (8–10)	15.3 (14–17)
p. theophrasti: Datça–Hurmalıbük	11.6 (10–13)	18.2 (16–20)	9.0 (7–10)	16.0 (14–18)
P. theophrasti: Kumluca–Karaöz	10.3 (8–12)	15.1 (13–17)	8.5 (8–10)	13.1 (11–15)
Gölköy *Phoenix* population	11.5 (9–15)	20.8 (16–27)	8.0 (4–10)	16.6 (12–21)
P. theophrasti: Crete (Greuter 1967)	(8–10)	(14–16)	(6–7)	(8–13)
P. theophrasti (Barrow, 1998)	Oblong	10×15 mm	(6–7)	(11–13)
P. dactylifera (Flora of China, 2019)	Oblong 3 cm	7 cm		
P. dactylifera (Barrow, 1998)	2–3 cm	4–7 cm	5–8 mm	20–30 mm

*110 cm on one tree at the edge of the population in a camping area

Figure 4. Male inflorescences of *Phoenix theophrasti* Greuter subspecies *golkoyana* Boydak (a, up to 120 cm, erect) and *P. theophrasti* Greuter (b, up to 55 cm, erect)

Figure 5. Comparison of male inflorescence lengths of *Phoenix theophrasti* Greuter (a) and *P. theophrasti* Greuter subspecies *golkoyana* Boydak (b)

These were related to the length of male stalks and female inflorescences and some fruit and seed characteristics.

The length of female inflorescences and male stalks of the *P. theophrasti* populations at Datça–Eksera Deresi, Datça–Hurmalıbük, and Antalya–Kumluca–Karaöz and the *Phoenix* population at Bodrum–Gölköy was measured on 15–20 female and 15–20 male trees using a tape measure. The longest female inflorescences and male stalks on each tree were selected for measurement. Observations were also made of the perpendicularity of the male and

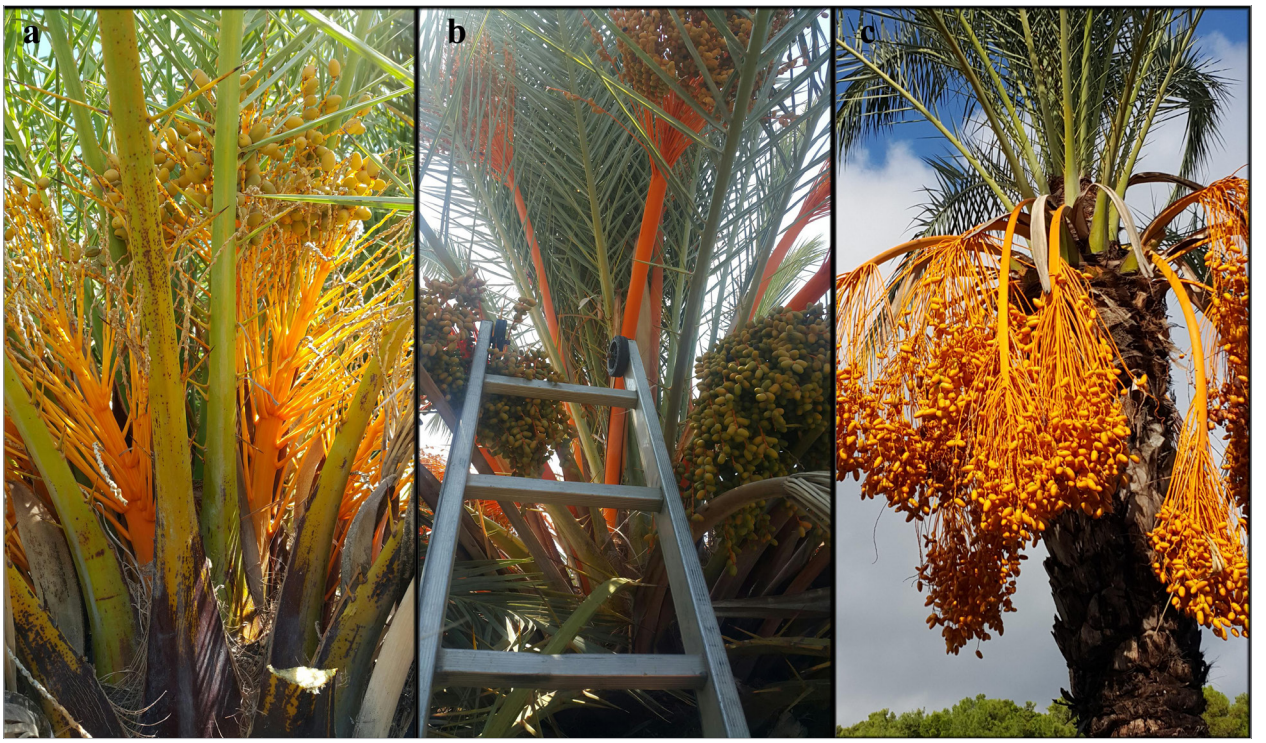

Figure 6. Female inflorescences of *Phoenix theophrasti* Greuter (a, up to 70 cm, erect), *P. theophrasti* Greuter subspecies *golkoyana* Boydak (b, up to 210 cm, erect or arching slightly), and *Phoenix dactylifera* L. (c, up to 200 cm, erect, becoming pendulous with fruit maturity)

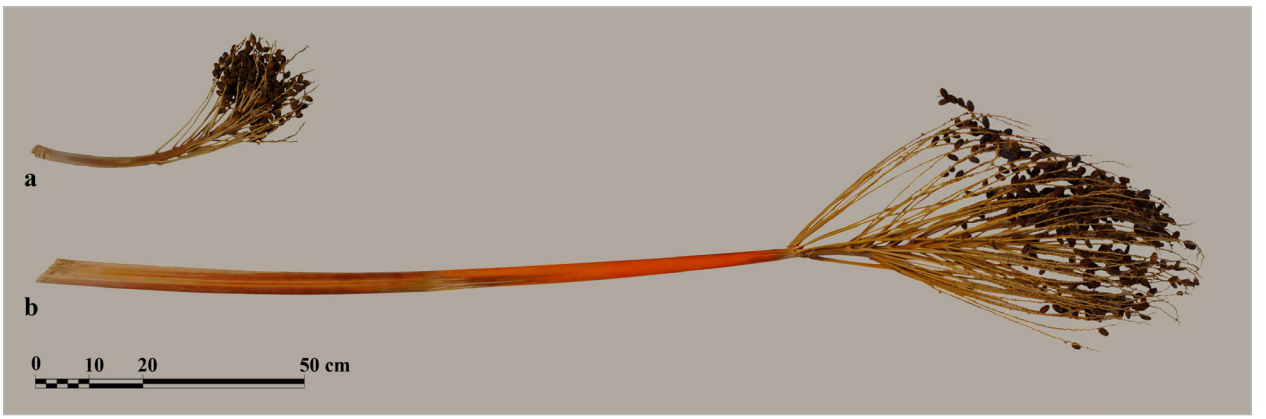

Figure 7. Comparison of female inflorescence lengths of *Phoenix theophrasti* (a) and *P. theophrasti* Greuter subspecies *golkoyana* Boydak (b)

female flower stalks. The Bodrum–Gölköy *Phoenix* population was on a topographic plane, and so a water tender-sprinkler and ladder were used to reach the samples. Since the topographies were steeply sloped at the Datça–Eksera Deresi, Datça–Hurmalıbük, and Antalya–Kumluca–Karaöz *P. theophrasti* populations, a portable ladder and long lever shears were used. Owing to the topography and the tree conditions in these populations, the length of some samples could only be estimated by close observations. However, only the direct measurements were considered.

The dimensions of fruits and seeds were measured in the laboratory by micrometer calipers at samples of hundred seeds for each *Phoenix* population. Equal numbers of fruits from each sampled tree were separated and compiled as one hundred seeds for each population. In addition, the seed surface structures and the shapes of the grooves of seeds were observed.

RESULTS AND DISCUSSION

The results of male and female stalk length measurements at the Gölköy *Phoenix* population were tabulated (Table 1).

As it is shown in Table 1, the maximum male and female stalk lengths are 120 cm and 210 cm at the Gölköy *Phoenix* population, respectively.

Figure 8. Fruiting stalks of *Phoenix theophrasti* Greuter subspecies *golkoyana* Boydak (b^1 and b^2), hold fruits marginally higher than *P. theophrasti* Greuter (a). The Gölköy *Phoenix* population's fruiting stalks hold fruits marginally higher than *P. theophrasti*. Specifically, the length of the fruiting area of the Gölköy *Phoenix* population is in general longer than that of female inflorescences together with the fruiting stalk of P. theophrasti

The maximum male and female stalk lengths and the other measurements of morphological features of the *P. theophrasti* population and the Gölköy *Phoenix* population, together with the measurements cited from the related literature, are compared in Table 2.

Similarities and differences of morphological properties among the Gölköy *Phoenix* population, *P. theophrasti*, and *P. dactylifera*

As is shown in Table 2, the Gölköy *Phoenix* population is different or similar to *P. theophrasti* and *P. dactylifera* in various morphological properties and fruit and seed characteristics:

The length of male inflorescences of the Gölköy *Phoenix* population is up to 120 cm (erect) and are over twice the male inflorescence lengths of *P. theophrasti* (up to 55 cm, erect), but the Gölköy *Phoenix* population has nearly the same male inflorescence lengths as *P. dactylifera* (up to 100 cm, erect) (Figures 4, 5) (Barrow, 1998; Flora of China, 2019).

The length of female inflorescences of the Gölköy *Phoenix* population is up to 210 cm (female inflorescences erect or arching slightly), which is approximately three times the female inflorescence lengths of *P. theophrasti* (up to 70 cm, erect), but has about the same female inflorescence lengths with *P. dactylifera* (up to 200 cm, erect, becoming pendulous with fruit maturity) (Figures 6, 7). Although the lengths of female inflorescences of the Gölköy *Phoenix* population and *P. dactylifera* are similar, female inflorescences of the Gölköy *Phoenix* populations are erect or arching slightly, whereas those of *P. dactylifera* become pendulous with fruit maturity (Barrow, 1998; Flora of China, 2019).

The Gölköy *Phoenix* population's fruiting stalks hold fruits marginally higher than *P. theophrasti*. Specifically, the length of the fruiting area of the Gölköy *Phoenix* population is in general longer than that of female inflorescences together with the fruiting stalk of *P. theophrasti* (Figure 8).

The fruit size of the Gölköy *Phoenix* population is substantially smaller than that of *P. dactylifera*, but is slightly larger than the fruit sizes of the *P. theophrasti* populations. Moreover, the ranges of both fruit thickness and lengths of the Gölköy *Phoenix* populations are greater than the fruits of all the *P. theophrasti* populations (Table 2, Figure 9). The fruit size of the Kumluca–Karaöz population is clearly smaller than that of the other *P. theophrasti* populations. However, fruit characteristics were not used as a criteria for the description of new subspecies (Greuter, 1967; Barrow, 1998; Flora of China, 2019).

The seed thickness of the Gölköy *Phoenix* population is nearly equal to that of *P. dactylifera*. The seed thickness of the Gölköy *Phoenix* is slightly thinner than that of *P. theophrasti* with the exception that the seed thickness of the Kumluca–Karaöz population is nearly equal to it. In contrast, the seed length of the Gölköy *Phoenix* population is slightly longer than that of *P. theophrasti* but shorter than that of *P. dactylifera*. Ranges of both seed thickness and length of the Gölköy *Phoenix* population are greater than the seeds of all the *P. theophrasti* populations (Table 2, Figure 10) (Barrow, 1998; Flora of China, 2019; Greuter, 1967).

The other distinctive characteristics of the seeds of the Gölköy *Phoenix* population compared with the *P. theophrasti* and *P. dactylifera* populations are explained below.

The seeds of the Gölköy *Phoenix* population have slightly visible striate or smooth surfaces and deep-wider grooves, whereas those of *P. theophrasti* have clearly visible striate surfaces and shallow grooves. On the other hand, the seeds of *P. dactylifera* have smooth seed surfaces and deeper and wider grooves than those of both the *P. theophrasti* and Gölköy *Phoenix* populations. One can easily distinguish the seeds of the Gölköy *Phoenix* population from those of all the *P. theophrasti* populations and *P. dactylifera* trees (Figure 10). Differences in seed characteristics

Figure 9. Fruits of Phoenix theophrasti Greuter subspecies golkoyana Boydak (a), groves of *P. theophrasti* Greuter (b, Hurmalıbük; c, Eksera Deresi; d, Kumluca–Karaöz) and *Phoenix dactylifera* L. (e). Although there are differences among the fruit sizes that are explained in the study, fruit characteristics were not used as criteria for the description of the new subspecies

are accepted as important criteria in taxonomy. These are the most distinctive seed characteristics of the Gölköy *Phoenix* populations when compared with the seeds of the *P. theophrasti* Greuter and *P. dactylifera* L. populations; therefore, they are used among the criteria for the description of the new subspecies.

The Gölköy *Phoenix* population and *P. theophrasti* fruits are slightly sweet, but scarcely fleshy. They are not cultivated for fruit productions; however, *P. dactylifera* has fruits that are sweet and fleshy and has been cultivated for many thousands of years for its fruit.

Evaluations and description of a new subspecies

As was described above, *P. theophrasti* was distinguished from *P. dactylifera* by its erect fruit clusters and small inedible fruits (Anon., 1983; Barrow, 1998; Greuter, 1967).

The results of this morphological study strongly indicate that various morphological features of the Gölköy *Phoenix* population appear similar to and/or different from either *P. theophrasti* or *P. dactylifera*. Therefore, the Gölköy *Phoenix* population merits being described as a new subspecies.

Since the Gölköy *Phoenix* population has a 50 km distance from the nearest *P. theophrasti* population (Datça–Eksera Deresi *P. theophrasti* population), a natural buffer zone has existed as barrier to interbreeding with other *Phoenix* populations. Therefore, the Gölköy *Phoenix* population can be described as a subspecies of *P. theophrasti* as follows:

P. theophrasti Greuter subsp. *golkoyana* Boydak subsp. nov.

Type:

TURKEY C1 Muğla: Bodrum, Gölköy (Göltürkbükü), female, latitude 37.1147° N, longitude 27.3981° E, Plain, 3 m., 27 August 2018, M. Boydak (holotype: ISTO 38308); ibid, (paratypes: (male) ISTO 38309, (female) ISTO 38310); ibid, 01 October 1990, M. Boydak (paratype: ISTO 27384).

"*Phoenix theophrasti* Greuter subsp. *golkoyana* Boydak" differs from *P. theophrasti* Greuter with respect to its longer fruiting-female stalk length and longer male stalk length, its fruiting stalks hold fruits marginally higher, and its having seeds with slightly visible striate surface crust structures and deeper-wider grooves.

An identification key is given for these two species:

1. Fruit clusters erect or slightly arching; fruits small and inedible; male inflorescences length up to 120 cm; female inflorescences length up to 210 cm; seed surfaces smooth and striate; seed grooves deep or shallow.

    2. Male inflorescences length up to 55 cm; female inflorescences length up to 70 cm, erect; seed surfaces deeply striate; seed grooves very narrow and shallow.
    P. theophrasti* Greuter subsp. *theophrasti

    2. Male inflorescences length up to 120 cm; female inflorescences length up to 210 cm, erect, arching slightly; seed surfaces slightly striate or smooth; seed grooves wide and deep.
    ***P. theophrasti* Greuter subsp. *golkoyana* Boydak subsp. nov.**

1. Fruit clusters erect, becoming pendulous with fruit maturity; fruits larger and edible; female inflorescences length up to 200 cm; male inflorescences length up to 100 cm, erect; seed surfaces smooth; seed grooves wider and deeper.
P. dactylifera

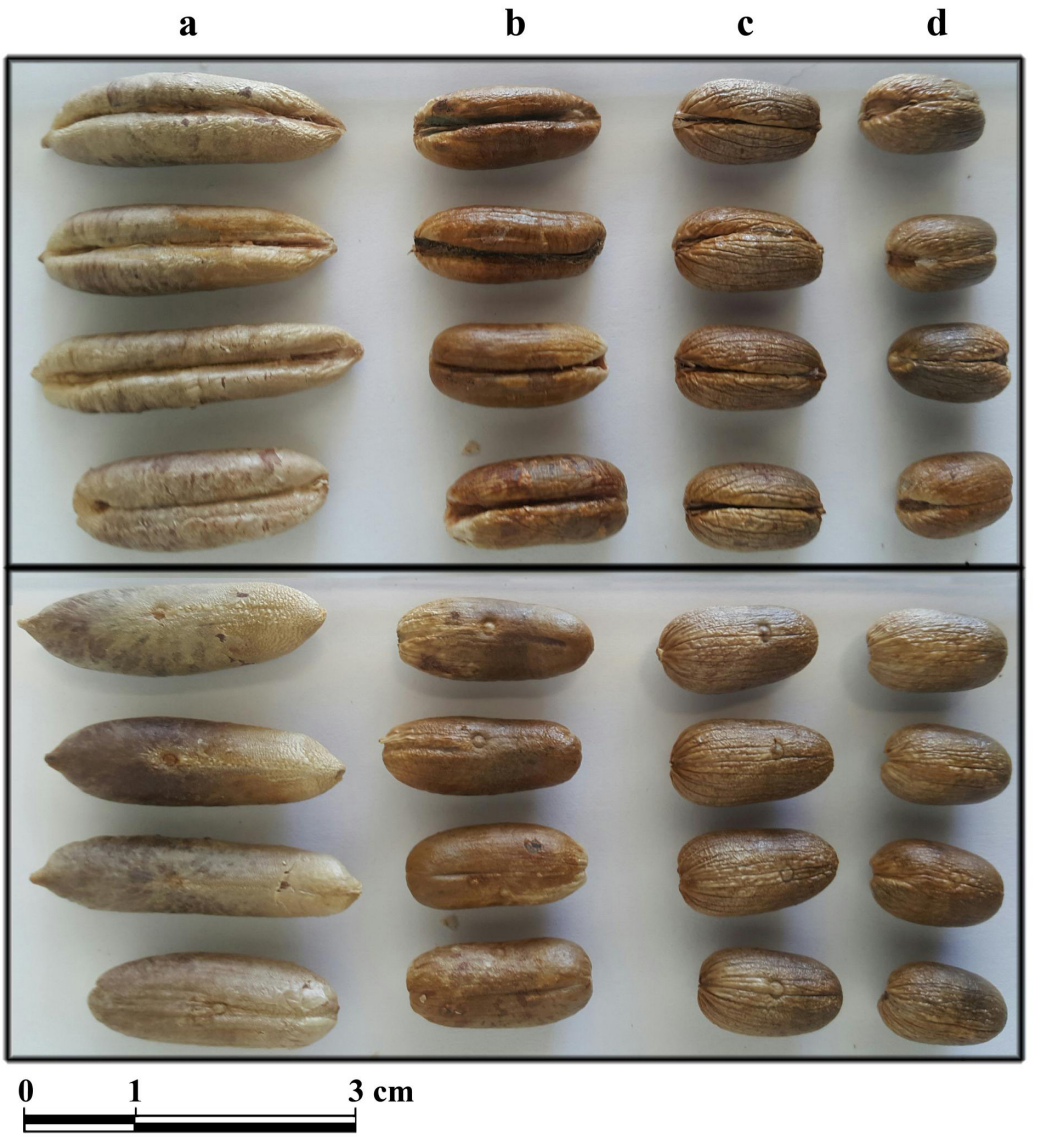

Figure 10. The seeds of the Gölköy *Phoenix* population have slightly visible striate or smooth surfaces and deep-wider grooves (b), whereas the seeds of *Phoenix theophrasti* have clearly visible striate surfaces and shallow grooves (c, d). On the other hand, *P. dactylifera* has smooth seed surfaces and deeper and wider grooves than the seeds of both the *P. theophrasti* and Gölköy *Phoenix* populations (a). One can easily distinguish the seeds of the Gölköy *Phoenix* population from the seeds of all the *P. theophrasti* populations and *P. dactylifera* trees. These are the most distinctive seed characteristics of the Gölköy *Phoenix* populations when compared with the seeds of the *P. theophrasti* Greuter and *P. dactylifera* L. populations; therefore, they are used among the criteria for the description of the new subspecies

Conservation of *P. theophrasti* Greuter ssp. *golkoyana* Boydak

The *P. theophrasti* Greuter ssp. *golkoyana* Boydak population primarily covers an area of 3.9 ha according to the management plans of the Turkish Forest Service completed in 2013 (Anon., 2013). There are mainly four *Phoenix* groves covering 1.2 ha, 1.2 ha, 1.0 ha, and 0.5 ha inside or alongside the bog and/or bordering the village (Figures 2, 3). In addition, a number of palms are currently included in the gardens of houses built recently. This population is unique and of great importance as a natural palm grove in Turkey; therefore, it is imperative that positive action is taken to ensure its conservation and development.

The name Gölköy, which means "Lake Village," originates in the lake that surrounds the palm grove and the village. A drainage trench surrounding the whole area was constructed to establish a golf area in the early 1990s. The lake is fed by a number of copious springs; thus, the drainage ditch is unlikely to dry out the swamp completely. However, the sinking water-table did have adverse impacts on the local ecosystem which then could affect the conditions of the palm grove (Boydak and Barrow, 1994, 1995).

Therefore, in 1993, Boydak applied to the local and city governors to demand effective protective measures for the Gölköy grove, including bans on both the water drainage scheme and the village's expansion into the palm population. In addition, based on the authors' report, and other evidence, in 1994, Birgin, prepared another report and suggested breaking the agreement between the local authority and the private company developing the golf area. Later, the golf area and drainage activities were banned. By applying conservation status to the area, the grove is legally in a more protected condition now.

Fire also affected the grove in June 1993, but the grove recovered by a healthy abundance of suckers sprouting at the base and trunk together with healthy seedlings. Many palms flowered in the following years. Currently, they are very healthy and obviously living up to the meaning of the word *Phoenix*, "rising from the fire" (Boydak and Barrow, 1995).

Currently, tourism has become an important source of income for the locals; pressure grows to develop the village with new summer housing and tourist facilities (Boydak and Barrow, 1995).

The combined effect of the fire and expansion and development of the village necessitated that a conservation status be placed upon the grove, which the grove now has. In addition, non-governmental organizations are paying great attention to the grove.

P. theophrasti Greuter subsp. *golkoyana* Boydak is among the endangered species; however, Göltürkbükü–Gölköy consisting of the *P. theophrasti* Greuter ssp. *golkoyana* Boydak groves and other patches or individuals including those in private estate gardens are under conservation statutes as a natural protected area (Byfield and Özhatay, 2005). In addition, the *P. theophrasti* Greuter populations are under conservation regimes. The population and the palm trees that are currently included in the gardens of houses are also under protection according to the management plans of the Turkish Forest Service completed in 2013 (Anon., 2013).

CONCLUSION

"*Phoenix theophrasti* Greuter subsp. *golkoyana* Boydak" differs from *P. theophrasti* Greuter with respect to its longer fruiting-female stalk length and longer male stalk length, its fruiting stalks hold fruits marginally higher, and its having seeds with slightly visible striate surface crust structures and deeper-wider grooves. This population is unique and of great importance as a natural palm grove in Turkey; therefore, it is imperative that positive action is taken to ensure its conservation and development, together with the three native *P. theophrasti* stands in Turkey. In addition, its range could be expanded by planting in parks, streetsides, and gardens in the Mediterranean and Aegean regions both to expand its population and for ornamental purposes. This population has also great importance as a natural palm grove that contributes to the world's flora.

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Original Article

Biomass factors used to calculate carbon storage of Turkish forests

Türkiye'de ormanlardaki karbon birikiminin hesaplamasında kullanılabilecek bitkisel kütle katsayıları

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ABSTRACT

The countries that are parties to the Kyoto Protocol submit annual inventories of greenhouse gases to the United Nations Framework Convention on Climate Change Secretariat. The reports comprise values of emission and removal of greenhouse gases from different sectors (energy, industrial processes and product use, agriculture, land use, land use change, and forestry, and waste). These reports are prepared by using the methodologies indicated in guides that are prepared by the Intergovernmental Panel on Climate Change. Among the guides, those that are forestry related include: guidelines for the land use, land use change, and forestry (LULUCF) sector reported in 2003 and for the agriculture forestry and other land uses (AFOLU) sector reported in 2006. According to these guidelines, carbon, which is stored in the biomass as stock or annually sequestered amounts, can be calculated by using various factors derived from growing stock or annual increment in forests. Similarly, the amount of carbon removed from the forest by fire, production, or illegal cuttings can also be estimated using such factors. In this study, the biomass expansion factor (BEF_1) is determined as 1.212 for the conifers and 1.310 for the broadleaved species. Also the BEF_2 was updated and determined as 1.326 for the conifers, and 1.262 for the broadleaved species. In this study, the biomass conversion and expansion factors (BCEF's) that are used in the AFOLU guide were also calculated.

Keywords: Agriculture forestry and other land use, biomass conversion and expansion factors, biomass expansion factors, carbon inventory in forests, land use, land use change and forestry

ÖZ

Kyoto Protokolüne taraf olan ülkeler her yıl düzenli olarak sera gazı ulusal envanterlerini hazırlayarak Birleşmiş Milletler İklim Değişikliği Çerçeve Sözleşmesi (BMİDÇS) sekretaryasına sunmaktadırlar. Bu raporlar değişik sektörlerdeki (enerji, endüstriyel süreçler ve ürün kullanımı, tarım, arazi kullanımı, arazi kullanım değişikliği ve ormancılık (LULUCF), atıklar) sera gazları salım ve bağlanma miktarlarını içermektedirler. Raporların hazırlanmasında Hükümetler Arası İklim Değişikliği Paneli (IPCC) tarafından hazırlanan rehberlerde belirtilen yöntemler kullanılmaktadır. Bu rehberlerden ormancılıkla ilgili olanları 2003 yılında yayınlanan arazi kullanımı, arazi kullanım değişikliği ve ormancılık (LULUCF) ile 2006 yılında yayınlanan tarım, ormancılık ve diğer arazi kullanımı (AFOLU) olarak adlandırılan rehberlerdir. Bu rehberlere göre ormanlar tarafından bağlanan karbon miktarının hesaplanmasında ormanlardaki ağaç serveti ya da artım değerlerinden çeşitli katsayılar kullanılarak bitkisel kütlede stok halinde depolanan ya da yıllık olarak biriktirilen karbon miktarları hesaplanabilmektedir. Benzer şekilde yangın, üretim, kaçak kesimler ile ormandan uzaklaştırılan karbon miktarları da yine katsayılar yardımı ile tahmin edilebilmektedir. Çalışmada AFOLU rehberine göre kullanılması gereken bitkisel kütle genişletme faktörlerinden (BEFs) BEF_1 katsayıları ibreliler için 1,212 ve yapraklılar için 1,310 olarak belirlenmiştir. Çalışmada ek olarak kullanılabilir odun hacmini topraküstü bitkisel kütleye dönüştürmede kullanılabilecek BEF_2 katsayıları güncellenerek yapraklılar için 1,326 ve ibreliler için 1,262 olarak bulunmuştur. Ayrıca AFOLU rehberinde verilen yöntemlerde kullanılan bitkisel kütle dönüştürme ve genişletme faktörleri (BCEFs) de hesaplanmıştır.

Anahtar Kelimeler: Arazi kullanımı, arazi kullanım değişikliği ve ormancılık, bitkisel kütle dönüştürme ve genişletme faktörleri, ormancılık ve diğer arazi kullanımı, bitkisel kütle genişletme faktörleri, ormanlarda karbon envanteri, tarım

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INTRODUCTION

The countries that are parties to United Nations Framework Convention on Climate Change (UNFCCC) have to fulfill the requirements of the contract and send various national reports on the

implementation of (climate change national communications, national inventory reports of greenhouse gases, and biennial reports) to the UNFCCC Secretariat. Turkey has been included in both the Annex-1 and Annex-2 lists in the UNFCCC and has not signed the contract for many years as the countries in these lists have a greenhouse gas reduction obligation under the Kyoto Protocol. At the 7th Conference of the Parties in Marrakesh in 2001, Turkey was accepted to the Convention in 2004 with the adoption of the special situation of Turkey, its annulment from the Annex-2 list and the granting of a separate status from the countries in the Annex-1 list, and the elimination of the greenhouse gas reduction obligation. The Kyoto Protocol was signed in 2009.

The national reports prepared by the countries in Annex-1 and Annex-2 lists of the UNFCCC differ in terms of their content and time. The national inventory reports of greenhouse gases are prepared annually and include emission and storage amounts of greenhouse gases from energy, industrial processes and product use, agriculture, forestry, wastes, and other sectors. The national inventory reports include the greenhouse gas emission and removal amounts from 1990 to the year two years before the report was submitted. The national communications on climate change are prepared every four years. Unlike the national inventory reports, communications include policies and measures on climate change, expected impacts of climate change, greenhouse gas emission projections, and education, training, and achievements on raising public awareness. In the biennial reports, issues such as greenhouse gas emissions, greenhouse gas reduction targets, projections, and support to developing countries are reported.

In Turkey, the national inventory report of greenhouse gases is prepared every year since 2006 and sent to the UNFCCC Secretariat. The first national communication on climate change was prepared in 2007. However, because the preparation of the national communication started later than the other countries, national communications for climate change 2, 3, 4, and 5 were written as a single communication and were sent to the secretariat in 2013. The sixth National Communication Report was completed in 2016 and seventh in 2018. Until now, three biennial reports have been prepared.

The guidelines prepared by the IPCC are used in the preparation of national inventories for greenhouse gases. These guidelines include methods for calculating the amount of removal and emissions of greenhouse gases in each sector. According to this method, different land uses such as forestry and agriculture, energy use, industry, agriculture, and forestry and their contribution to the production or consumption of waste, and waste of greenhouse gas are calculated separately in national inventory reports. These national inventories cover emission and removal values from 1990 to the year two years before the inventory was prepared.

In the national reports submitted to the UNFCCC, forests have a special importance both in terms of forming an important pool by storing the atmospheric carbon and as a carbon source in cases like destructive incidents in forested areas. In the national inventory reports of greenhouse gases, the calculation of carbon emission and removal amounts from the forestry sector was carried out according to the methods specified in the Land Use, Land Use Change, and Forestry (LULUCF) section of the IPCC Guide dated 2003 until 2015 (IPCC, 2003). As of 2015, the guidelines for Agriculture, Forestry, and Other Land Use (AFOLU) have been used in the calculations in IPCC's 2006 guide (IPCC, 2006).

The basic approach in both the LULUCF and AFOLU guidelines is to convert the growing stock and annual increment values, which are determined as biomass in the forest inventories, using various factors first to the biomass and then to the content of carbon in this biomass. In the forest inventory, stem wood sections include growing stock and annual increment values of forests in many countries, including Turkey. However, apart from the stem wood, carbon accumulation also happens in branches, leaves, and roots. Although the stem wood is cut out from the ecosystem along with the cutting in forest areas, a significant amount of production waste left on the field is added to the litter and dead wood carbon pools with waste leaves, barks, and roots (Yıldız, 2000; Yıldız and Esen, 2002; Yıldız, 2004). The calculation of the total carbon stock in forest areas or the annual total carbon accumulation should include these parts. In order to achieve this, LULUCF and AFOLU are used to convert and increase the stem wood biomass or annual increment values into the total biomass (Table 1). This conversion and expansion are done with various biomass factors. In LULUCF, these processes are performed by converting the stem wood volume to the stem wood biomass by first multiplying it with the stem weight of the wood and then expanding the biomass to the above-ground biomass by multiplying it with a biomass expansion factor (BEF) as a coefficient. Similar operations in AFOLU are done by using biomass conversion and expansion factors (BCEFs). BCEF is practically equal to the stem wood biomass multiplied by the BEF. Various factors are also used in the calculation of the amount of biomass lost from forests due to reasons such as production, fire, insect-fungus damage, illegal cuttings, and collection of the waste parts from the silvicultural treatments. Then the calculated amount of biomass is multiplied by the carbon content and the amount of carbon accumulated in or removed from the forests is calculated.

Developed by Prof. Dr. Ünal Asan for BEF_1, the coefficient used to extend the stem wood biomass to the above-ground biomass for the calculations relating to forestry in the inventory, Turkey's national GHG conversion factors were calculated as 1.24 and 1.22 for broadleaved and coniferous species, respectively (MEF, 2006). The BEF_2 values, for using merchantable stem wood to calculate the above-ground biomass, were calculated as 1.24 for broadleaved and 1.26 for coniferous species and these biomass factors were used in national inventory reports prepared between 2006 and 2014. However, in these inventories, it was stated that the wood density values used in the calculation of carbon accumulation in living biomass were inaccurate (Tolu-

Table 1. The factors used to calculate the amount of the carbon stock in the living biomass, the annual carbon storage, and the amount of carbon derived from the forest according to the LULUCF and AFOLU guidelines

Factors in LULUCF		Factors in AFOLU	
Symbol	Definition	Symbol	Definition
WD	Wood density (t/m^3)	$BCEF_I$	The biomass conversion and expansion factor for conversion of net annual increment in volume (including bark) to above-ground biomass (t/m^3)
BEF_1	The biomass expansion factor for conversion of annual net increment (including bark) to above-ground biomass increment (dimensionless)	$BCEF_S$	The biomass conversion and expansion factor for expansion of merchantable growing stock volume to above-ground biomass (t/m^3)
BEF_2	Biomass expansion factor for conversion of merchantable volume to above-ground tree biomass (dimensionless)	$BCEF_R$	The biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass removals (including bark) (t/m^3)
R	Root/shoot ratio (dimensionless)	R	Root/shoot ratio (dimensionless)
f_{BL}	Fraction of biomass left to decay in forest (dimensionless)	CF	Carbon factor (in temperate climate zones, 0.51 for coniferous, 0.48 for broadleaved tree species)

LULUCF: land use, land use change, and forestry; AFOLU: agriculture forestry and other land use

Table 2. References used in this study

Species	Tree count	Diameter (cm)	Reference	Species	Tree count	Diameter (cm)	Reference
Pinus sylvestris	10	19.5–31.0	Uğurlu et al., 1976	*Quercus* sp.	32	10.0–31.0	Durkaya, 1998
Pinus sylvestris	33	17.0–66.0	Atmaca, 2008	*Quercus* sp.	310	7.0–38.5	Makineci et al., 2011
Pinus sylvestris	46	10–50	Aydın, 2010	*Fagus orientalis*	32	11.0–46.0	Saraçoğlu, 2000
Pinus sylvestris	50	10–46	Ülker, 2010	*Fagus orientalis*	11	8.6–16.0	Makineci et al., 2011
Pinus sylvestris	55	7.1–63.2	Çömez, 2011	*Castanea sativa*	34	15.0–37.0	İkinci, 2000
Pinus sylvestris	13	6.1–10.9	Tolunay, 2012	*Alnus glutinosa*	86	7.0–30.0	Saraçoğlu, 1998
Pinus brutia	14	9.0–39.8	Sun et al., 1980	*Robinia pseudoacacia*	12	7–15	Tüfekçioğlu and Güner, 2008
Pinus brutia	33	8.0–52.0	Ünsal, 2007	*Carpinus* sp.	12	6.9–20.4	Makineci et al., 2011
Pinus nigra	44	12.0–60.0	Çakıl, 2008	*Sorbus* sp.	12	7.1–23.4	Makineci et al., 2011
Picea orientalis	30	20.0–52.0	Özkaya, 2004				
Abies sp.	34	7–56	Karabürk, 2011				
Cedrus libani	36	10-46	Ülküdür, 2010				

nay and Çömez, 2008; Tolunay, 2011). In addition, the increasing number of biomass studies in recent years for forest sector (Uğurlu et al., 1976; Sun et al., 1980; Durkaya, 1998; Saraçoğlu, 1998; İkinci, 2000; Saraçoğlu, 2000; Özkaya, 2004; Ünsal, 2007; Atmaca, 2008; Çakıl, 2008; Tüfekçioğlu and Güner, 2008; Aydın, 2010; Ülker, 2010; Ülküdür, 2010; Çömez, 2011; Karabürk, 2011; Makineci et al., 2011; Tolunay, 2012) revealed the necessity to renew the BEF_1 and BEF_2 coefficients used in the calculations. The biomass factors given in this study were used in The National Inventory reports of greenhouse gases after 2015.

MATERIAL AND METHODS

For the calculation of the factors used in the LULUCF and AFOLU guidelines, first of all, the studies on biomass and wood density in Turkey were compiled. In most of these studies, the tree biomass equations have been developed using diameter at breast height or diameter and tree height as independent variables. In some studies, tree biomass tables have been created by using developed tree biomass equations. Apart from the studies conducted by Çömez (2011) and Tolunay (2012), no studies were reported directly on generating BEF's. For this reason, biomass factors were calculated by using the values obtained from the measurements or equations derived from studies related to tree biomass. However, calculations can be inaccurate when the leaves, branches, and above-ground biomasses of the trees obtained from the equations or tables are outside the diameter range covered by the study. For this reason, the diameter ranges used in the studies in the generation of biomass factors were taken into consideration (Table 2).

According to the LULUCF guideline, the BEF_1 was calculated as follows:

$$BEF_1 = \frac{B}{SB} \quad (1)$$

Here, B is the above-ground biomass (t) and *SB* is the stem biomass (including bark) (t).

In addition to the BEF_1, even if it is not included in the guidelines, the coefficients that can be used to estimate the leaf and branch biomass have been produced by using leaf and branch weights instead of the above-ground biomass.
–
The BEF_2 coefficient was calculated as follows:

$$BEF_2 = \frac{B}{MSB} \quad (2)$$

In the equation, MSB is the merchantable stem biomass (including bark) (t). However, no studies were reported in Turkey to convert merchantable stem biomass to above-ground biomass. Difficulties in calculating this coefficient are due to the use of branches and trunk end pieces thicker than 3–4 cm in our country as firewood. For this reason, the approach developed by Asan and given in MEF (2006) was used in the calculation of BEF_2 coefficient. In this approach, pine, larch, Scotch pine, Taurus cedar (*Cedrus libani*), fir (*Abies* sp.), oriental spruce (*Picea orientalis*), oak (*Quercus* sp.), and oriental beech (*Fagus orientalis*) species are used from the tables of product varieties made by Sun et al. (1978). The following assumptions were made in the calculations.

- There is no information about branch biomass in the tables of types of wood products. Therefore, from previous studies, branch biomass was calculated according to diameter steps for tree species and it was accepted that 50% of this branch biomass was merchantable branch wood.
- It is assumed that half of the firewood rates given for diameter steps in the product range tables remain in the forest.
- Calculations are made for coniferous species (calabrian pine (*Pinus brutia*), Scotch pine (*Pinus sylvestris*), Taurus cedar, fir, oriental spruce) and broadlevaed species (oak and oriental beech). Because there is no table of types of wood products for Anatolian chestnut (*Castanea sativa*), the types of wood products for this species are considered to be the same as those of oriental beech.

As there is no study reported in our country, no investigation can be done to develop the fraction of biomass left to decay in forest (f_{BL}). This value was accepted as 0.15 in LULUCF (IPCC, 2003) and 0.19 in the national inventory reports of greenhouse gases of Turkey (MEF, 2006).

The biomass conversion and expansion factors (BCEF's) are practically equal to the multiplication of stem biomass (including bark) and BEF's. Therefore, the $BCEF_1$ and $BCEF_S$ coefficients were obtained by multiplying the wood densities by the BEF_1 and BEF_2 factors described previously. The $BCEF_R$ was calculated by dividing the $BCEF_S$ coefficient by 0.92 for coniferous and by 0.9 for broadleaved species as explained in the AFOLU guidelines (IPCC, 2006).

Species-specific BEF and BCEF factors were found with the approaches described above. However, in both LULUCF and AFOLU guidelines, it is stated that the calculations can be made not only on the basis of species but also on the total of coniferous and broadleaved species groups. However, the total tree growing stock and annual increment values of oak and oriental beech in broadleaved and calabrian pine and black pine (*Pinus nigra*) in coniferous species in our country are more than other ones. For this reason, for each of the coniferous and broadleaved species classes, growing stock values, total stem wood, and total above-ground biomass amounts were calculated for each species using coefficients on the basis of species. Then, at country level, total above-ground biomass values calculated separately for coniferous and broadleaved species were divided by total stem biomass and generalized factors were developed for coniferous and broadleaved species. Growing stock values in forests change every year. Because the calculations have been made since 1990 and with the developed coefficients, retroactive calculations will be made and the growing stock in 2004 was used in the calculation.

Although there are some studies on the carbon concentration of trees in Turkey (Tolunay, 2009; Çömez, 2011; Makineci et al., 2011; Durkaya, 2013), such studies remained at the local level and the carbon content specific to the tree species was not calculated as the given carbon ratios were used in national inventories made by other countries in LULUCF or AFOLU.

Table 3. Basic wood densities of the main tree species in Turkey (t/m³ in dry weight)

Coniferous	Wood density t/m³	Broadleaved	Stem wood Bulk density t/m³
Pinus brutia	0.478[a]	*Fagus orientalis*	0.530[a]
Pinus nigra	0.470[a]	*Quercus* sp.	0.570[a]
Pinus sylvestris	0.426[a]	*Carpinus* sp.	0.630[d]
Pinus pinea	0.470[b]	*Alnus* sp.	0.407[a]
Pinus halepensis	0.480[c]	*Populus* sp.	0.350[d]
Pinus pinaster	0.440[d]	*Castanea sativa*	0.480[d]
Pinus radiata	0.380[e]	*Fraxinus* sp.	0.562[g]
Abies sp.	0.350[a]	*Robinia pseudoacacia*	0.680
Picea orientalis	0.358[a]	*Liquidambar orientalis*	0.468
Cedrus libani	0.430[a]	Other Broadleaved	0.550
Juniperus sp.	0.460[a]		
Other Coniferous	0.431[f]		

[a] As et al. (2001); [b] Erten and Sözen (1997a); [c] Erten and Sözen (1997b); [d] IPCC (2003); [e] Topaloğlu (2005); [f] Coniferous mean; [g] Gürsu (1971); [h] Broadleaved mean

There are very few studies on the determination of root/shoot ratios in Turkey (Kantarcı, 1983; Tüfekçioğlu and Güner, 2008; Doğan, 2010; Çömez 2011; Sargıncı, 2014). Because the studies were carried out in limited number of species in limited number of trees, root/shoot ratio coefficients that could be used throughout the country were not calculated.

RESULTS AND DISCUSSION

The wood density values of various tree species distributed in Turkey have been compiled and shown in Table 3 (As et al., 2001, Erten and Sözen, 1997a, Erten and Sözen, 1997b, Gürsu, 1971, IPCC, 2003; Topaloğlu, 2005). Again, the BEF factors calculated on the basis of tree species by re-evaluation of the biomass studies are given in Table 4 and BCEF factors are given in Table 5. However, in the national inventory reports of greenhouse gases, carbon accumulations in forests can be calculated only for coniferous and broadleaved species groups without taking into account the tree species. Therefore, generalized factors are also produced for the groups of coniferous and broadleaved species. The wood density and BEF factors used in LULUCF are shown in Table 6 and BCEF factors used in AFOLU are shown in Table 7. As mentioned earlier, the number of studies on root biomass in Turkey is quite low. Therefore, by increasing the number of studies on root biomass, the coefficients given in the IPCC guidelines can be used until the root/shoot ratio coefficients can be used safely in the calculations. The coefficients in these guidelines are also given in Table 8.

Wood density values to be used to convert the stem volume (including bark) to stem biomass for Turkish forests were cal-

Table 4. The BEF_1, BEF_2, BEF_{leaf}, and BEF_{branch} factors that are generated from the biomass studies

Species	BEF_1	BEF_2	BEF_{leaf}	BEF_{branch}	Reference
Pinus sylvestris	1.242±0.092	1.254±0.088	0.063±0.025	0.179±0.073	Uğurlu et al., 1976
Pinus sylvestris[a]	1.198±0.032	1.239±0.113	0.071±0.023	0.127±0.021	Atmaca, 2008
Pinus sylvestris	1.324±0.224	1.318±0.164	0.126±0.112	0.198±0.137	Aydın, 2010
Pinus sylvestris	1.159±0.176	1.192±0.101	0.091±0.149	0.068±0.051	Ülker, 2010
Pinus sylvestris	1.279±0.106	1.266±0.082	0.062±0.029	0.207±0.087	Çömez, 2011
Pinus sylvestris	1.263±0.050	1.459±0.036	0.085±0.019	0.178±0.040	Tolunay, 2012
Weighted mean	1.247±0.154	1.265±0.128	0.085±0.091	0.162±0.098	
Pinus brutia	1.225±0.062	1.251±0.098	0.038±0.017	0.187±0.049	Sun et al., 1980
Pinus brutia[a]	1.349±0.022	1.384±0.112	0.112±0.044	0.237±0.023	Ünsal, 2007
Weighted mean	1.319±0.064	1.329±0.109	0.094±0.051	0.225±0.038	
Pinus nigra[a]	1.071±0.026	1.180±0.087	0.011±0.005	0.060±0.023	Çakıl, 2008
Picea orientalis[a]	1.132±0.009	1.203±0.026	0.052±0.003	0.080±0.005	Özkaya, 2004
Abies[a]	1.345±0.069	1.350±0.102	0.121±0.033	0.224±0.040	Karabürk, 2011
Cedrus libani[a]	1.300±0.055	1.337±0.052	0.080±0.042	0.220±0.049	Ülküdür, 2010
Quercus sp.	1.324±0.157	1.378±0.051	0.094±0.047	0.230±0.130	Durkaya, 1998
Quercus sp.	1.322±0.195	1.366±0.870	0.079±0.076	0.243±0.154	Makineci et al., 2011
Weighted mean	1.322±0.192	1.367±0.085	0.080±0.073	0.242±0.152	
Fagus orientalis[a]	1.228±0.080	1.257±0.071	0.021±0.007	0.177±0.058	Saraçoğlu, 2000
Fagus orientalis	1.556±0.166	1.576±0.060	0.234±0.115	0.321±0.084	Makineci et al., 2011
Weighted mean	1.305±0.174	1.303±0.119	0.071±0.106	0.234±0.089	
Castanea sativa[a]	1.320±0.068	1.334±0.087	0.020±0.005	0.300±0.066	İkinci, 2000
Alnus glutinosa[a]	1.103±0.051		0.030±0.018	0.073±0.037	Saraçoğlu, 1998
Robinia pseudoacaci[a]	1.315±0.085		0.091±0.025	0.224±0.071	Tüfekçioğlu and Güner, 2008
Carpinus sp.	1.482±0.193		0.145±0.082	0.337±0.160	Makineci et al., 2011
Sorbus sp.	1.338±0.185		0.089±0.041	0.249±0.182	Makineci et al., 2011

[a] Biomass table and equations developed by the authors were calculated for the diameter ranges measured in the field
BEF_1: the biomass expansion factor for conversion of annual net increment (including bark) to above-ground biomass increment; BEF_2: biomass expansion factor for conversion of merchantable volume to above-ground tree biomass; BEF_{leaf}: the biomass expansion factor for conversion of annual net increment (including bark) to leaf biomass increment; BEF_{branch}: the biomass expansion factor for conversion of annual net increment (including bark) to branch biomass increment

Table 5. The $BCEF_I$, $BCEF_S$, $BCEF_R$, $BCEF_{leaf}$, and $BCEF_{branch}$ factors that are generated from the biomass studies

Species	$BCEF_I$ (t/m³)	$BCEF_S$ (t/m³)	$BCEF_R$ (t/m³)	$BCEF_{leaf}$ (t/m³)	$BCEF_{branch}$ (t/m³)
Pinus sylvestris	0.531±0.066	0.539±0.055	0.586±0.059	0.036±0.039	0.065±0.042
Pinus brutia	0.630±0.031	0.635±0.052	0.691±0.057	0.045±0.024	0.108±0.018
Pinus nigra	0.503±0.012	0.555±0.041	0.603±0.044	0.005±0.002	0.028±0.011
Picea orientalis	0.405±0.003	0.431±0.009	0.468±0.010	0.019±0.001	0.029±0.002
Abies sp.	0.471±0.024	0.473±0.036	0.514±0.039	0.042±0.012	0.078±0.014
Cedrus libani	0.559±0.024	0.575±0.022	0.625±0.024	0.034±0.018	0.095±0.021
Quercus sp.	0.754±0.102	0.779±0.045	0.866±0.046	0.046±0.039	0.138±0.081
Fagus orientalis	0.692±0.099	0.691±0.060	0.767±0.061	0.038±0.060	0.112±0.051
Castanea sativa	0.528±0.033	0.534±0.042	0.593±0.042	0.008±0.002	0.120±0.032
Alnus glutinosa	0.449±0.021			0.012±0.007	0.030±0.015
Robinia pseudoacacia	0.894±0.058			0.062±0.017	0.152±0.048
Carpinus sp.	0.934±0.122			0.091±0.052	0.212±0.101
Sorbus sp.	0.736±0.102			0.049±0.023	0.137±0.100

$BCEF_I$: the biomass conversion and expansion factor for conversion of net annual increment in volume (including bark) to above-ground biomass; $BCEF_S$: the biomass conversion and expansion factor for expansion of merchantable growing stock volume to above-ground biomass; $BCEF_R$: the biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass removals; $BCEF_{leaf}$: the biomass conversion and expansion factor for conversion of net annual increment in volume (including bark) to leaf biomass; $BCEFb_{ranch}$: the biomass conversion and expansion factor for conversion of net annual increment in volume (including bark) to branch biomass

Table 6. The generalized factors of wood density, BEF_1, BEF_2, BEF_{leaf}, and BEF_{branch}

Vegetation Type	Stem wood Bulk Density (t/m³)	BEF_1	BEF_2	BEF_{leaf}	BEF_{branch}
Coniferous	0.446	1.212	1.262	0.062	0.150
Broadleaved	0.541	1.310	1.326	0.073	0.237

BEF_1: the biomass expansion factor for conversion of annual net increment (including bark) to above-ground biomass increment; BEF_2: biomass expansion factor for conversion of merchantable volume to above-ground tree biomass; BEF_{leaf}: the biomass expansion factor for conversion of annual net increment (including bark) to leaf biomass increment; BEF_{branch}: the biomass expansion factor for conversion of annual net increment (including bark) to branch biomass increment

Table 7. The generalized coefficients of $BCEF_I$, $BCEF_S$, $BCEF_R$, $BCEF_{leaf}$, and $BCEF_{branch}$

Vegetation Type	$BCEF_I$ (t/m³)	$BCEF_S$ (t/m³)	$BCEF_R$ (t/m³)	$BCEF_{leaf}$ (t/m³)	$BCEF_{branch}$ (t/m³)
Coniferous	0.541	0.563	0.612	0.028	0.067
Broadleaved	0.709	0.717	0.797	0.039	0.128

$BCEF_I$: the biomass conversion and expansion factor for conversion of net annual increment in volume (including bark) to above-ground biomass; $BCEF_S$: the biomass conversion and expansion factor for expansion of merchantable growing stock volume to above-ground biomass; $BCEF_R$: the biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass removals; $BCEF_{leaf}$: the biomass conversion and expansion factor for conversion of net annual increment in volume (including bark) to leaf biomass; $BCEF_{branch}$: the biomass conversion and expansion factor for conversion of net annual increment in volume (including bark) to branch biomass

Table 8. The root to shoot ratio given for the temperate zone forests in the LULUCF and AFOLU guidelines

	LULUCF (IPCC, 2003)		AFOLU (IPCC, 2006)	
Vegetatio Type	Above-ground Biomass (t/ha)	Root/Shoot Ratio	Above-ground Biomass (t/ha)	Root/Shoot Ratio
Coniferous	< 50	0.46	< 50	0.40
	50–150	0.32	50–150	0.29
	> 150	0.23	> 150	0.20
Oak sp.	> 70	0.35	> 70	0.30
Broadleaved	< 75	0.43	< 75	0.46
	75–150	0.26	75–150	0.23
	> 150	0.24	> 150	0.24

LULUCF: land use, land use change, and forestry; AFOLU: agriculture forestry and other land use; IPCC: intergovernmental panel on climate change

culated as 0.446 t/m³ for coniferous species and 0.541 t/m³ for broadleaved species (Table 6). In previous calculations, made up to 2015, the wood density values were used as 0.496 t/m³ and 0.638 t/m³ for coniferous and broadleaved species, respectively (NIR Turkey, 2014). The wood densities calculated in this study were lower. This is due to the use of oven dry wood densities (oven dry weight/oven dry volume), not the wood density values (oven dry weight/fresh volume), in the calculations up to 2015. Oven dry wood densities are higher than the basic wood densities, leading to overestimation of carbon accumulations or stocks. In coniferous species, fir has the lowest basic wood

density of 0.350 t/m^3 and Aleppo pine (*Pinus halepensis*) has the highest basic wood density of 0.480 t/m^3. In broadleaved species, basic wood densities vary between 0.350 t/m^3 and 0.680 t/m^3 (Table 3). The basic wood densities compiled for the main tree species of Turkey are similar to those used in other countries' greenhouse gas national inventories (Table 9).

In Turkey, the biomass expansion factor for conversion of stem biomass to above-ground biomass (BEF_1), which was used in national greenhouse gas inventories until 2015, was obtained from the studies carried out by cutting 24 coniferous and 184 broadleaved trees, and it was calculated as 1.22 for coniferous species and 1.24 for broadleaved species (NIR Turkey, 2014). However, over time, the number of plant biomass studies has increased considerably (Tables 2, 4). Therefore, the need to renew these factors has emerged. In this study, according to 18 different studies, BEF and BCEF factors were produced by using data of 398 coniferous and 541 broadleaved trees which were

Table 9. Biomass factors that are used in the national inventory reports of greenhouse gases in forestry sector of some countries on coniferous (C) and broadleaved (B) species

	Stemwood Bulk Density (t/m^3)		BEF_1		BEF_2		Carbon Factor (CF)		
Country	C	B	C	B	C	B	C	B	Reference
Austria	0.38	0.54					0.47	0.48	NIR Austria, 2015
Bulgaria	0.43	0.603			1.08	1.03	0.50	0.50	NIR Bulgaria, 2015
Croatia	0.39	0.56	1.15	1.20	1.30	1.40	0.50	0.50	NIR Croatia, 2015
Switzerland							0.50	0.50	NIR Switzerland, 2015
Germany			1.33–1.65	1.34-1.69			0.50	0.50	NIR Germany, 2015
Hungary	0.37-0.49	0.34-0.64					0.51	0.48	NIR Hungary, 2015
Italy	0.38-0.53	0.29-0.69	1.29-1.53	1.23-1.53			0.47	0.47	NIR Italy, 2015
Japan	0.287-0.464	0.294-0.668	1.15-1.67	1.18-1.41			0.51	0.48	NIR Japan, 2015
Lithuania	0.41	0.47	1.221	1.178			0.51	0.48	NIR Lithuania, 2015
Latvia	0.36-0.38	0.40-0.47	1.27-1.58	1.19-1.45			0.528-0.531	0.508-0.521	NIR Latvia, 2015
Belgium	0.40-0.55	0.35-0.60			1.23-1.40	1.29-1.42	0.50	0.50	NIR Belgium, 2015
Poland	0.4464	0.4464			1.30	1.40	0.47	0.47	NIR Poland,2015
Romania	0.40	0.644					0.47	0.47	NIR Romania, 2015
LULUCF	0.31-0.49	0.35-0.63	1.15	1.20	1.30	1.40	0.50	0.50	IPCC, 2003
Turkey	0.35-0.48	0.35-0.68	1.071-1.3455	1.103-1.482	1.18-1.35	1.303-1.367	0.51	0.48	This study
	0.446	0.541	1.212	1.310	1.262	1.326			
	$BCEF_I$ (t/m^3)		$BCEF_S$ (t/m^3)		$BCEF_R$ (t/m^3)		CF		
Country	C	–	–––	B	C	B	C	B	Reference
Czech Rep.	0.53–0.60	0.74–0.85			0.52–0.57	0.70–0.82	0.49	0.48	NIR Czech Rep., 2015
Finland	0.572–0.812	0.805–0.813			0.62–0.64	0.73–0.85	0.50	0.50	NIR Finland, 2015
Greece			0.44–0.74	0.62–1.28			0.50	0.50	NIR Greece, 2015
Spain			0.44–0.80	0.62–1.28			0.50	0.50	NIR Spain, 2015
Holland			0.764	0.764			0.51	0.48	NIR Holland, 2015
Portugal	0.528–1.166	0.630–1.230					0.51	0.48	NIR Portugal, 2015
Slovakia	0.45–0.81	0.45–0.95					0.50	0.49	NIR Slovakia Rep., 2015
AFOLU	0.53–1.50	0.48–1.50	0.70–3.00	0.80–3.00	0.77–3.33	0.89–3.33	0.51	0.48	IPCC, 2006
Turkey	0.405–0.63	0.449–0.934	0.431–0.635	0.534–0.779	0.468–0.691	0.593–0.866	0.51	0.48	This study
	0.541	0.709	0.563	0.717	0.612	0.797			

BEF_1: the biomass expansion factor for conversion of annual net increment (including bark) to above-ground biomass increment; BEF_2: biomass expansion factor for conversion of merchantable volume to above-ground tree biomass; $BCEF_I$: the biomass conversion and expansion factor for conversion of net annual increment in volume (including bark) to above-ground biomass; $BCEF_S$: the biomass conversion and expansion factor for expansion of merchantable growing stock volume to above-ground biomass; $BCEF_R$: the biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass removals

evaluated for biomass studies. In Turkey, biomass studies have been carried out in 13 different tree species. The most tree species which have been investigated are Scotch pine (*Pinus sylvestris*). Oak is the most sampled species by cutting 342 trees in 2 different studies. In the species of hornbeam (*Carpinus* sp.), wild service tree (*Sorbus* sp.), and pseudoacacia (*Robinia pseudoacacia*), there are only above-ground biomass values belonging to 12 trees (Table 2). With the reassessment of biomass studies, the BEF_1 factors were determined with the lowest as 1.071 in European black pine (*Pinus nigra*) species and the highest as 1.345 in fir genus (Table 4). The mean BEF_1 value for the coniferous species was calculated as 1.212 (Table 6). Broadleaved BEF_1 values are slightly higher and vary between 1.103 and 1.482 (Table 4). The generalized BEF_1 factor that can be used for broadleaved species was found to be 1.310 (Table 6). These values were compared with the national inventories of greenhouse gases submitted to the UNFCCC Secretariat by other countries (NIR Austria, 2015; NIR Belgium, 2015; NIR Bulgaria, 2015), NIR Croatia; NIR Czech Rep., 2015; NIR Finland, 2015; NIR Germany, NIR Greece, 2015; 2015; NIR Holland, 2015; NIR Hungary, 2015; NIR Italy, 2015; NIR Japan, 2015; NIR Latvia, 2015; NIR Lithuania, 2015; NIR Poland; 2015; NIR Portugal, 2015; NIR Romania, 2015; NIR Slovakia Rep., 2015; NIR Spain, 2015; NIR Switzerland, 2015) in 2015 and were found to be very close (Table 9). The species-specific BEF factors given in Table 4 can be used to calculate carbon by species. However, in Turkey, most of the species in relationship between the biomass of the stem over bark and the above-ground biomass (branch + leaf) has not been examined to show clearly on enough trees. As a matter of fact, it is known that these factors may vary according to some factors (species, age, silvicultural treatments, crown closure, and site conditions) (Lehtonen et al., 2004; Jalkanen et al., 2005; Teobaldelli et al., 2009; Çömez, 2011). In addition, BEF factors may vary according to climate zones (IPCC, 2003). The fact that biomass factors are highly variable and change from stand to stand increases the uncertainties in biomass samplings. It is very difficult to develop biomass factors for each stand. For this reason, it would be more appropriate to determine the ecological regions first and then develop the biomass factors separately for each tree species with sufficient sampling according to the variables affecting the ratios among the tree crown such as age, closure, and site index (Tolunay, 2012).

In the study, the BEF_2, which is used in the calculation of the amount of carbon removed from the forest with cuttings, has been calculated with various assumptions. Because, in Turkey, the number of biomass studies is quite inadequate for converting the merchantable biomass to above-ground biomass. In this study, the BEF_2 was found 1.262 for coniferous and 1.326 for broadleaved species by using the product types table made by Sun et al. (1978) (Table 6). BEF_2 was accepted as 1.24 for coniferous and 1.26 for broadleaved species in the calculations up to 2015 (NIR Turkey, 2014), which is lower than the values found in this study. This leads an underestimation of the amount of carbon removed from the forests. The recalculated BEF_2 factors are lower than the coefficients given in the IPCC (2003) guideline, but are quite similar to the BEF_2 factors calculated on the basis of species in Belgium (Table 9). However, there is still a need to increase the number of studies to calculate the BEF_2 coefficient.

Practically, the BCEF's in the AFOLU guideline are calculated by multiplying the basic wood density and the BEF factors. Within these biomass factors, $BCEF_I$ converts growing stock directly to above-ground biomass. The $BCEF_I$ for Turkey was determined as 0.541 t/m^3 for coniferous and 0.709 t/m^3 for broadleaved species (Table 7). $BCEF_S$ was found 0.563 t/m^3 and 0.717 for coniferous and broadleaved, respectively (Table 7). $BCEF_R$ was calculated as 0,613 t/m^3 in coniferous and 0,797 t/m^3 in broadleaved species. These calculated factors are in parallel with the BCEF factors used in other countries (Table 9).

In this study, the $BCEF_{leaf}$ and $BCEF_{branch}$ factors that can be used to calculate the biomass of leaves and branches were generated from growing stock for the first time in Turkey. These factors can also be used for many different purposes, such as determining the amount of carbon and nutrients that reach the litter by litterfall in forests. For instance, Koca et al. (2013) has calculated the amounts of biogenic volatile organic compounds derived from Turkish forests by using the $BCEF_{leaf}$ in this study.

As mentioned before, the number of studies on the root biomass of trees is quite low in Turkey. It will be more accurate to use the coefficients given in the guidelines until the number of root biomass studies increases (Table 8).

In this study, biomass carbon concentration that can be used throughout the country were not calculated enough due to the small number of studies. Among these studies, Tolunay (2009) and Çömez (2011) found that the weighted mean carbon contents of the Scots pine type above-ground biomass were 51.93% and 52.46%, respectively. In some other studies, the above-ground biomass carbon content was not predominantly calculated, and the carbon concentrations of each of the tree components were measured separately. In these studies, the average carbon concentrations of tree components in Taurus cedar (*Cedrus libani*) 49.5–52.8% (Durkaya et al., 2013a), *Abies nordmanniana* subsp. *bornmulleriana* 47.8–51.1% (Durkaya and et al., 2013b), 50.2–51.6% in calabrian pine, 50.3–52.6% in Scots pine, and 51.4–52.3% in European black pine (Durkaya et al., 2015). Among the broadleaved species, carbon contents of various components of the oaks found to be 47.4–49.8% (Makineci et al., 2015), 49.29–54.19% in oriental beech and 49.01% -55.76% in chestnut (Sargıncı, 2014). In the AFOLU guideline, it is stated that carbon content can be used as 0.51 for coniferous and 0.48 for broadleaved forests in temperate zone forests (IPCC, 2006). In the studies, all conducted in Turkey, there are generally conclusions that the carbon ratios of coniferous species are slightly higher than 50% and slightly lower in broadleaved species. For this reason, until the studies on the carbon ratios of the tree components increase, the carbon content values given in the AFOLU guidelines can be used.

Since 2006, Turkey has been preparing a national inventory report of greenhouse gases and submitting it to the UNFCCC

Secretariat every year. In the reporting period, including 2014, the calculation of carbon emissions and removals in the forestry sector was made by using the methods given in LULUCF and using the factors produced from a small number of biomass studies. Using the biomass factors presented in this study by Karabıyık (2014), carbon stocks and annual net carbon accumulations between 2002–2012 were calculated. As a result, while the average annual net carbon accumulation was 13.64 million t C/year according to the national greenhouse gas inventory report in the 10-year period examined, it was determined by Karabıyık (2014) that there was 8.04 million t C/year carbon accumulation. The difference is up to 5.6 million t C/year and is quite high. As a matter of fact, according to FAO data, annual net carbon accumulation in live trees is 7.9 million tons C/year between 2000 and 2010 (FAO, 2011). Therefore, Karabıyık (2014) explained that the biomass factors produced by this study can be used safely in the calculation of carbon accumulation in the forests of Turkey. Thereafter, since the reporting made to the UNFCCC Secretariat in 2015, the biomass factors produced in this study and the methods given in the AFOLU guide have been used in the calculations (NIR Turkey, 2015). In this report, the average annual carbon accumulation for the period 2002–2012 was determined as 9.02 million t C/year (NIR Turkey, 2015) and the difference from the value calculated by Karabıyık (2014) decreased to 1 million t C/year. This difference is due to the fact that the amount of wood collected from the forests and illegal cuttings are taken as official recordings.

CONCLUSION

According to the provisions of UNFCCC and Kyoto Protocol, countries listed in Annex 1 are obliged to prepare greenhouse gas inventories. These inventories and other reports (biennials and national communications) also undergo various evaluation processes. The communications prepared by Turkey and the national inventory reports of greenhouse gases are also subject to these evaluations. However, because Turkey does not commit to reduce greenhouse gases due to its special position, evaluations have mostly remained at the level of recommendations. In addition, the Kyoto Protocol expired in 2012 but was extended until the end of 2020. The long-standing negotiations for the preparation of a new agreement for the post-Kyoto period resulted in a new agreement at the end of 2015 at the 21st Climate Change Parties Conference (COP21) in Paris. All climate change negotiations are expected to be measurable, reportable and verifiable in terms of greenhouse gas emission and removal amounts, commitments and other activities of the Contracting Parties on climate change. In this study, new biomass factors which can be used to calculate carbon accumulation in forests were calculated. These factors were compared with the factors used in other countries and were found to be quite similar. In a study conducted by Karabıyık (2014), these carbon coefficients were recalculated in the forests of Turkey and it was stated that FAO could be used in the calculations since it is very close to the values given for annual carbon accumulation in Turkey's forests (FAO, 2011). As of 2015, these coefficients have been used in the national inventories of greenhouse gases and received positive responses in the assessment processes carried out by the UNFCCC. However, these developed biomass factors are still produced from a few biomass studies and need to be developed by considering factors such as forest type (degraded or productive; high forests or coppice), tree species, age, canopy closure, site index, silvicultural treatments throughout the country. In addition, it is necessary to carry out studies to determine the amount of carbon that is not given in this study in the future, but which is removed from the forest by fire, insect, and fungal damage.

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