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FOREST REVIEW

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FOREST VEGETATION MAPS AND ITS DEVELOPMENT IN TURKEY: A CASE FROM ISTANBUL-BELGRADE FOREST

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ABSTRACT: Forests provide a wide range of direct or indirect benefits to urban life which vary over space and time. Increasing demands from forest resources made planned forest management indispensable for sustainability. At this point, mapping forest stand types has come into prominence from the early stages of planning efforts. Belgrade Forest, which is a cultural and natural heritage of the city, has been influenced by historical processes and also with the development in forest science. In this study, forest maps of Belgrade forest were evaluated since the establishment of the first forestry school in terms of forest stand classification. Also, changes in some forest types were determined from the digitized of historical maps. It was found that first forest map (1888) distinguished oak, hornbeam and chestnut stands in addition to openings and meadows around the forest. Second map (1938) was prepared in planned forest management period and distinguished stand as management type and dominance of oak and chestnut. In both of these maps, beech were not mentioned and more emphasize were given to oak, chestnut and hornbeam. The map prepared in the second forest management plan period (1949-1965) gives more information about stand types. From past to present forest management plans were based on stand classification considering dominant tree species. However, detailed floristic researches carried out in the forest (653 sample plots and 380 species) condense compositional and structural information and expresses all historical, sociological and habitat factors. But these detailed researches have not already been implemented in forest management plans. In fact, conversion of current forest structure to potential forest structure based on historical vegetation maps can provide a basis for close to nature silviculture and thus failings in ecological restoration efforts might be eliminated.
Keywords: oak forests, forest history, forest degradation.

1 INTRODUCTION

Historical events, which influenced forest structure during the history, are good predictor for future conservation approaches. According to Nowak (1993) understanding these events will prepare foresters for present and future events that will influence urban forests for years to come. Human influence on natural ecosystems cause multi-directional changes on vegetation and these may continue for centuries. Due to such continuing anthropogenic effects which cannot be seen easily, less changed or altered vegetation types are even accepted as natural (Erz, 1992, Bergstedt, 1997, Reif and Walentowski, 2008).

It is well known that deforestation and forest degradation are increasing as a result of rapid population growth. When deforestation involves a reduction of the forest area, forest degradation often implies a change in the health and vitality of a forest ecosystem but it can also relate to other factors such as changes in the composition of tree species, a loss of biodiversity, a permanent or long term reduction in the crown cover and changes in timber volumes (Achard, 2009). In general, there are many difficulties to estimate the degree of degradation due to lack of knowledge of initial state of the forests. At this point, forest vegetation maps can be accepted among the main references showing changes in forest structure. However, vegetation maps based on forest species composition provide much more information. Such a detailed knowledge are presented by phytosociological studies which condenses compositional and structural information within a hierarchical system, and expresses all historical, sociological and habitat factors that influence the actual and potential vegetation (Blasi and Burrascano, 2013). Therefore, vegetation maps are important in terms of monitoring changes in forest structure.

Forestry works in Turkey are dated back to forestry school established in 1857 and first comprehensive studies have been accepted to be started since that time. In this context, pioneering researches and applications have been implemented in Belgrade Forest in Istanbul. For this reason, the forest is a good example for comparing historical developments with forest structure due to historical documents and researches. The forest was protected with special regulations due to its water resources and aqueducts built in Byzantium and Ottoman periods supplying water to the city. There are 7 reservoirs within the present boundaries of the forest and joined to the city by a joint aqueduct (Çolak *et al*., 2013). Especially, it was reported that the forest was protected with Sultan's edicts which forbid cutting trees. For this reason, forest area had not changed for longer periods due to these strict edicts. On the other hand, the forests were exposed to damages in some periods of time during history (Çolak *et al*., 2013).

The aims of this study are to (1) evaluate historical developments in forest stand classification derived from historical forest maps, (2) compare forest maps which were drawn in different time periods, (3) assess vegetation maps based on phytosociological studies and current forest management maps and (4) evaluate the place of forest vegetation maps in forest management planning and nature conservation.

2 MATERIAL AND METHODS

2.1 Study area

Belgrade Forest is located in northern part of Istanbul, between 28°53'25'' 29°00'55'' eastern longitudes and 41°09'44'' 41°14'40'' northern latitudes (Fig. 1). Belgrade Forest corresponding to 0.03% of total forested areas in Turkey covers an area of 5.444 ha. The forest is located on a peneplain which reaches maximum an altitude of 200 m. The highest point of the region is Kartal Tepe (230 m) in the north and the lowest point is

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Kuru Dere (40 m) in the south (Çolak *et al*., 2013). The distance from the Sea varies between 2-10 km.

According to Saatçioğlu (1940), the forest was covering whole peninsula in the past and decreased considerably till current borders due to over exploitation during Byzantium term and thereafter ongoing exploitations and fires. During Ottoman period, the forest was used as a water resource for the city.

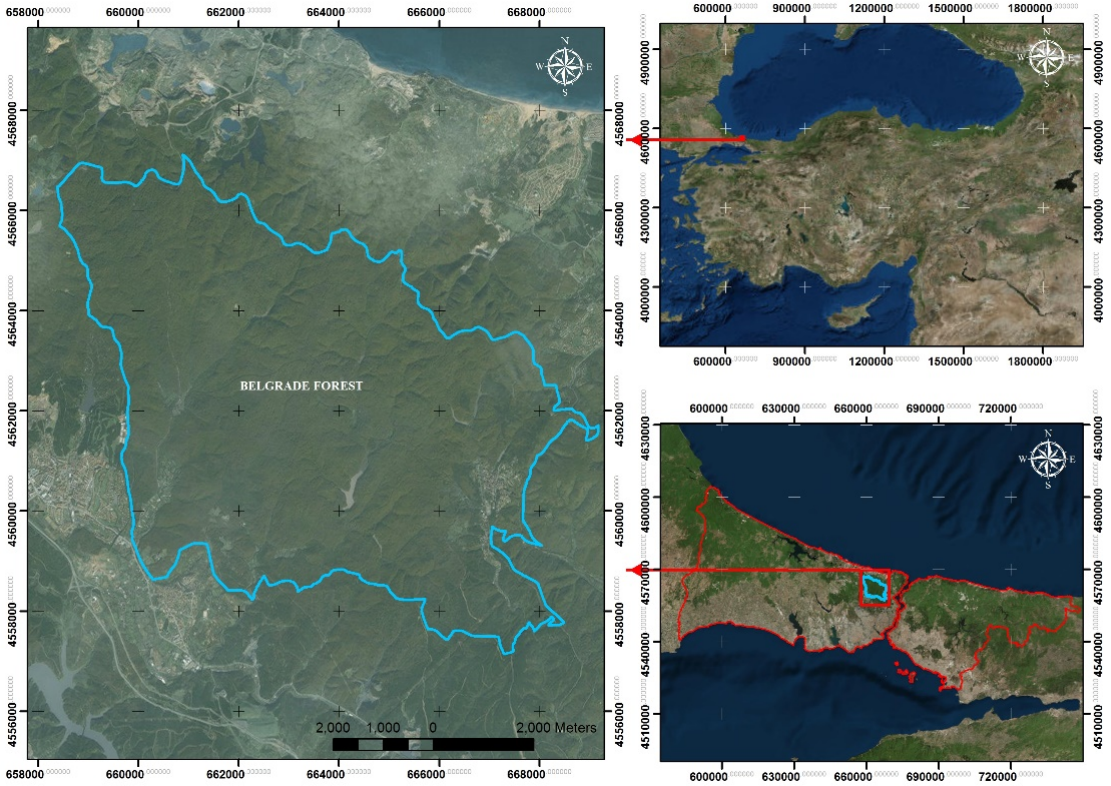

Figure 1: Location of Belgrade Forest

2.2 Climate and soil

According to Kantarcı (1980), Belgrade Forest has a climate type of humid, moderately warm with oceanic influences. Water deficiencies are only seen moderately in summer time and very humid in winter time. Vegetation period is about 7.5 months (230 days).

Large part the region is covered by limeless Neogene sediments (83.4%) which are stream materials. Under these deposits, carboniferous dust stones and greywacke schists occur. These schists cover 16.6% of the region. On carboniferous schists, brown forest soils develop which are shallow or moderately deep. On the other hand, quite deep podzolic brown soils, brown soils and pseudogleys develop on neogene sediments (Kantarcı 1980).

2.3 Vegetation

In terms of Mayr's climate zone classification, the study area falls in the *Castanetum-Fagetum* transition zone. Flora of Belgrade Forest contains Euxine-Colchic, Mediterranean and Central European elements (Yaltırık and Efe, 1989). According to Kayacık (1966), the ratio of Central European and Balkanic elements is 56,1 %, Mediterranean is 22 % and colchic is 18%.

Plant communities of Belgrade forest were firstly studied by Yaltırık (1963) according to Braun-Blanquet method. Yaltırık *et al.* (1983) classified plant communities as *Carpinus betulus-Acer campestre*, *Fagus orientalis-Ilex aquifolia*, *Quercus petraea* subsp. *iberica-Lathyrus niger*, *Erica arborea-Erica verticillata* communities. Second study was carried out by Yönelli (1986) who combined forest subcommunities to a higher unit called *Quercus petraea* subsp. *iberica-Carpinus betulus* which is composed of *Quercus frainetto*, *Fagus orientalis* and typical (*Castanea sativa*) subcommunities. As it was seen from these classifications, forest has an optimum conditions for Oak and Hornbeam trees. In addition, it was determined that 19 tree, 46 shrub and 316 species are found in Belgrade Forest from last flora research. Among herb species, 6 species are endemic and 9 species are rare (Çolak, 2013; Özalp, 2013; Özhatay and Yüzbaşıoğlu, 2013).

2.3 Method

In the context of the study, vegetation or forest maps and sample plot data which was used for forest stand type classification were evaluated. For this purpose, all available historical maps showing forest types of the region were found and classification methods were assessed considering development in forest science.

In the study, all maps were digitized using ArcGIS 10 geographic information system software and the areas of forest types were calculated.

The first map is dated back to 1888 which was prepared in the first years of the first Forestry School of Turkey (Fig. 2a). Second map was prepared after establishment of Turkish Republic in 1938 (Fig. 2b) in the context of first management plan. Third map was prepared in the second forest management period (1949) (Fig. 2c). Fourth map was prepared after a long time in 1986 by Yönelli (1986) who shows forest communities (Fig. 2d). The latest map was taken from Forest

Management Plan (2012) showing current condition of the forest (Fig. 2e).

Phytosociological studies which were carried out in the forest were compiled and a database was constructed by Çoban and Bayraktar (2016) using TURBOVEG (Hennekens and Schaminée, 2001) software. Structural characteristics of this vegetation database and its potential usage for forest management were also assessed.

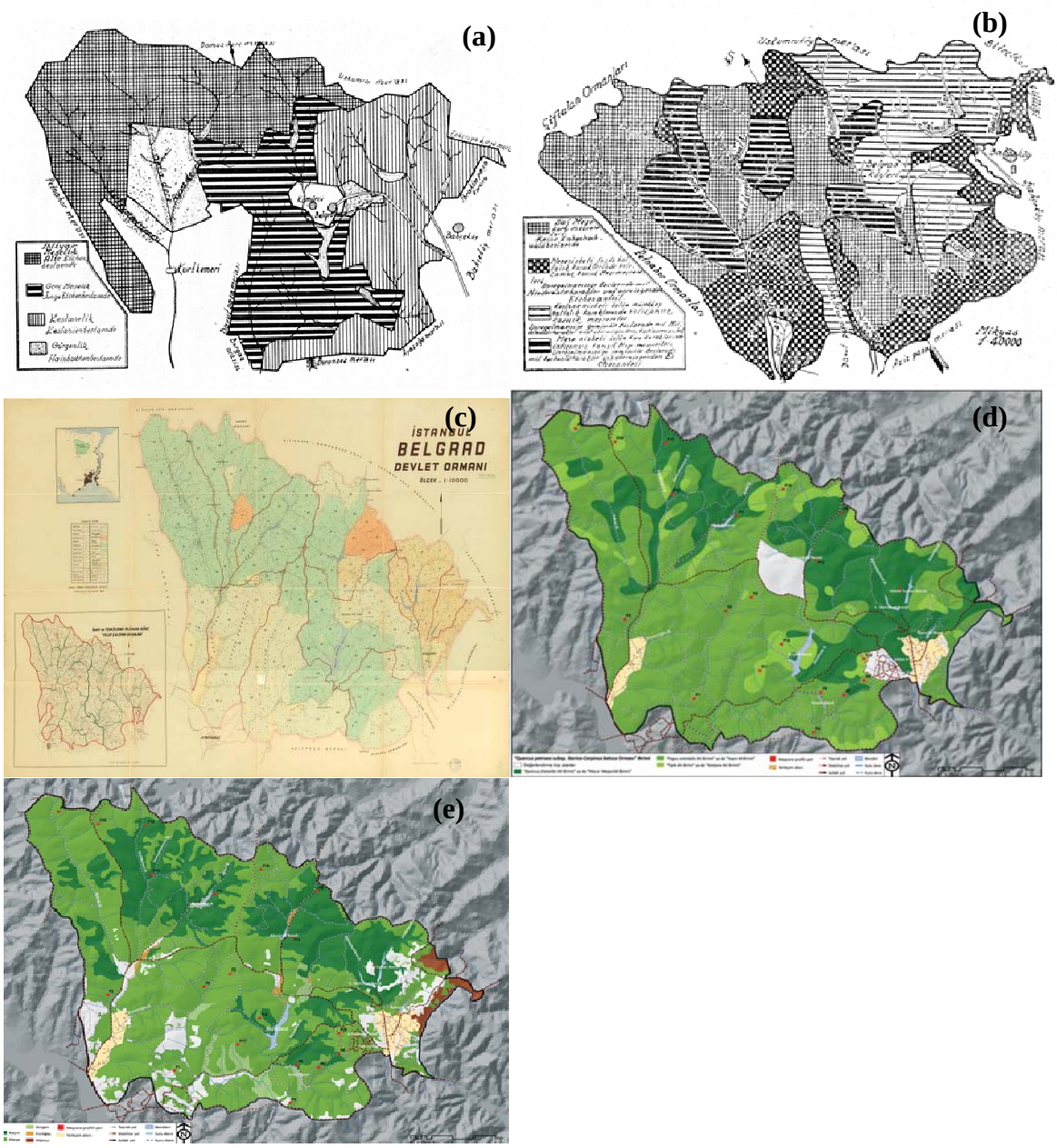

Figure 2: Maps showing forest types of Belgrade Forest from 1888 to 2012 (a: first forest map of 1888, b: first forest management map of 1938, c: forest stand map of 1949, d: forest vegetation map of 1986, e: forest management map of 2012) (Saatçioğlu, 1940, Çolak et al., 2013)

3 RESULTS

3.1 Historical forest vegetation maps

First known forest map dated back to 1888 was prepared by a student of the first forestry school of Turkey (Vural, 1940). In this map, forest types were classified broadly and gives information about general appearance of the forest and surrounding. It distinguishes four types of stands which include old oak, young oak, chestnut and hornbeam forests. In addition, land use types around the forests (i.e. meadows and settlements) were showed. However, beech forests were not mentioned. At that period, oak stands were covering large part of the forest as young or old stand (43%). Although coppice types was not used in the map, classification of

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oak forests as old and young forest might indicate irregular exploitation and undamaged forest types. For this reason, young oak forest may refer to irregular coppice forest which is found around settlement areas. Also, hornbeam forest around the settlements was probably in coppice character used for firewood. The map clearly shows that chestnut stands covered large areas (21%) at that period (Fig. 3).

First forest management plan of the forest was implemented in 1937 and the map of 1938 shows the situation in the beginning of first management period and also in the first decades of Turkish Republic. Furthermore, it is possible to see the terminology for forest stand classification. In this map, management type of the forest (coppice or high forest) were indicated in addition to dominant tree species. Also, pure and mixed stand discrimination were used for stand classification. In the description of the forest type, dominance of main tree species was emphasized (i.e. coppice forest of oak dominated mixed forest). The map distinguishes pure oak high forests, oak-dominated mixed forest with irregular coppice characteristics, chestnut-dominated mixed forest with irregular coppice characteristics and oak dominated mixed high forests. In this classification, hornbeam and beech were not indicated and all included within mixed stand structure. The sized of distinguished stand types were calculated that pure (30% of the area) and mixed oak forest (38 %) were covered most part of the forest. On the other hand, other main tree species like beech and hornbeam stands were not determined as a separate stand and more emphasis were put on oak. From this classification, only pure and mixed stands of oak and chestnut stands were distinguished with their management type (Fig. 3).

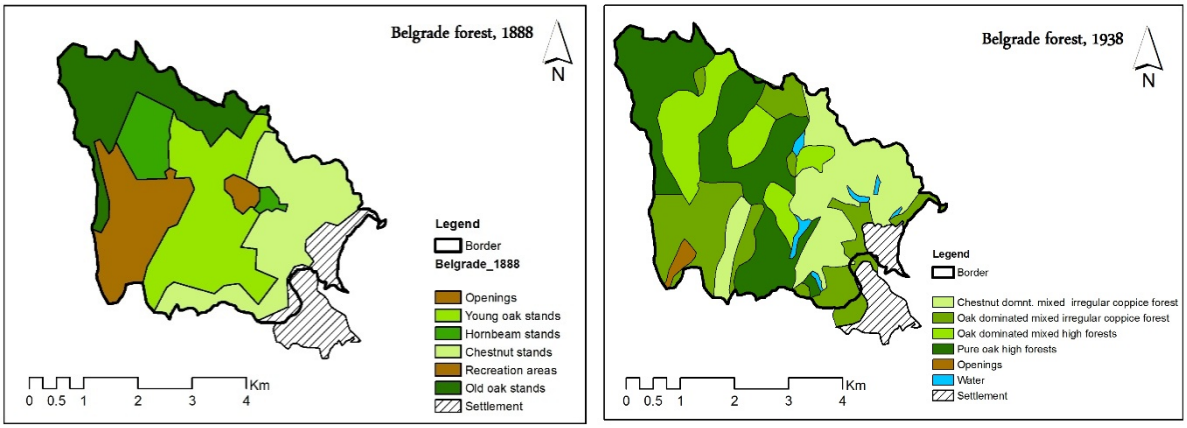

Figure 3: The first forest map prepared in 1888 (on the left) and forest management map of Belgrade Forest in 1938 (on the right) (modified from Çolak *et al*, 2013 and Saatçioğlu, 1940).

The map of 1888 shows that settlements inside and around the forest caused a decrease in the forest area due to farmlands and meadows in addition to irregular coppice stands. On the other hand, old oak forests further from settlements and main roads were not damaged much and the forest was mostly surrounded by meadows which are Ayazağa, Burunsuz and Davupaşa meadows in the south; Bahçeköy and Zekeriyaköy Meadows in the east; Uskumruköy and Domuzdere meadows in the north, Petnahor meadow in the west. From 1888 to 1938 forest openings were decreased and coppice stands were developed. However, chestnut stand were covered same areas and sizes of the stands were not change much (Fig. 3 and Table I).

Table I: Sizes of forest types in the map of 1888 and 1938

1888		**1938**	
Stand type	Area (ha)	Stand type	Area (ha)
Old oak stands	1131.40	Pure oak high forest stands	1771.32
Young Oak stands	1381.14	Oak-dominated mixed coppice stands	1343.21
Chestnut stands	1263.26	Oak-dominated mixed high forests	899.27
Hornbeam stands	413.67	Chestnut-dominated mixed coppice stands	1329.41
Openings	975.21	Openings	58.69
Settlements	676.41	Settlements	424.26
Total	5841.10	Total	5826.16

3.2 Developments in forest management periods

Forest management plans of the Belgrade forest was firstly prepared in 1937 and renewed in 1949, 1970, 1990, and 2012. Figure 3 shows the status of the forest at the second forest management period which based on 758 survey plots. In this map, forest types in this map were given as Beech, Oak coppice, Oak high forest and irregular Chestnut stands. The map differs from previous maps with the beech stand unit which was firstly described.

With the changing management purposes, timber production function of forest were replaced with soil protection, hydrological functions, health and aesthetical functions (Şad and Kızıl, 1996). In the recent forest management plans, wood production function were not considered and coppice forest were subjected to conversion to high forest. Similarly, these plans considered dominance of tree species and also stand structural characteristics in terms of aforementioned functions of the forest (Fig. 4). Currently, stand discrimination is based on tree species, stand development stage, horizontal cover and layers in even-aged forests. In addition, stand consisting of one species with a 90% ≥ volume are accepted as pure stands and any tree species incorporating stand mixture with a value of 10 % ≥ are accepted as mixed stands. Tree species which occur in the stand lower than 10% threshold value are not included in stand type which is a lack of these maps.

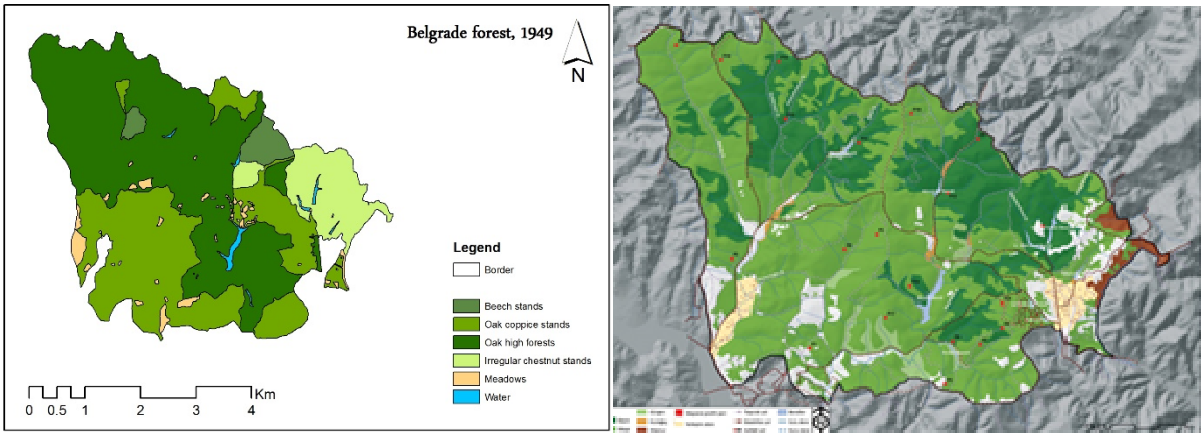

Figure 4: Forest stand maps prepared in 1949 and 2012 (Forest management plans of 1949 and 2012)

When the changes in forest stand types were compared, a gradual decrease in chestnut stands can be clearly seen and also openings were closed and classified as coppice stands of oaks in the map. On the other hand, comparison between other stand types is not possible due to dominance of tree species were considered in forest management plan of 1949. For example, only pure stands of beech were given in the map and their mixture with oak species were not mentioned and accepted as oak stands (Table II).

Table II: Sizes of forest types in the map of 1949 and 1986

1949		1986	
Stand type	Area (ha)	Forest communities	Area (ha)
Chestnut stands	539.26	Castanea sativa sub-community	426.59
Oak high stands	2713.62	Quercus frainetto sub-community	1484.41
Oak coppice stands	1763.57	Fagus orientalis sub-community	3250.67
Beech stands	172.75	Settlement	247.21
Meadows	137.01	Openings	432.22
Total	5326.21	Total	5841.10

3.3 Phytosociological studies and vegetation maps

In parallel with forest management plans, phytosociological studies were also carried out in the forest since 1963. Plant communities of the forest were firstly studied by Yaltırık (1963) who took releves from pre-defined stand types and identified plant communities were described with the characteristic species. The dataset includes 104 relevés and 129 species. Average number of species and Shannon diversity per relevés was calculated as 20.31 and 2.12 respectively. The second study was carried out by Yönelli (1986) who took 549 releves (352 taxa) from natural and plantation areas (*Pinus brutia, Pinus nigra* ssp. *pallasiana, Pinus pinaster, Pinus strobus*) which cover most of the forest. Average species numbers and shannon diversity per relevés were found to be 36.92 and 2.47 respectively. In addition, forest stand profiles, which shows stand structural diversity, were prepared by Yönelli (1986) (Fig. 5 and Table III).

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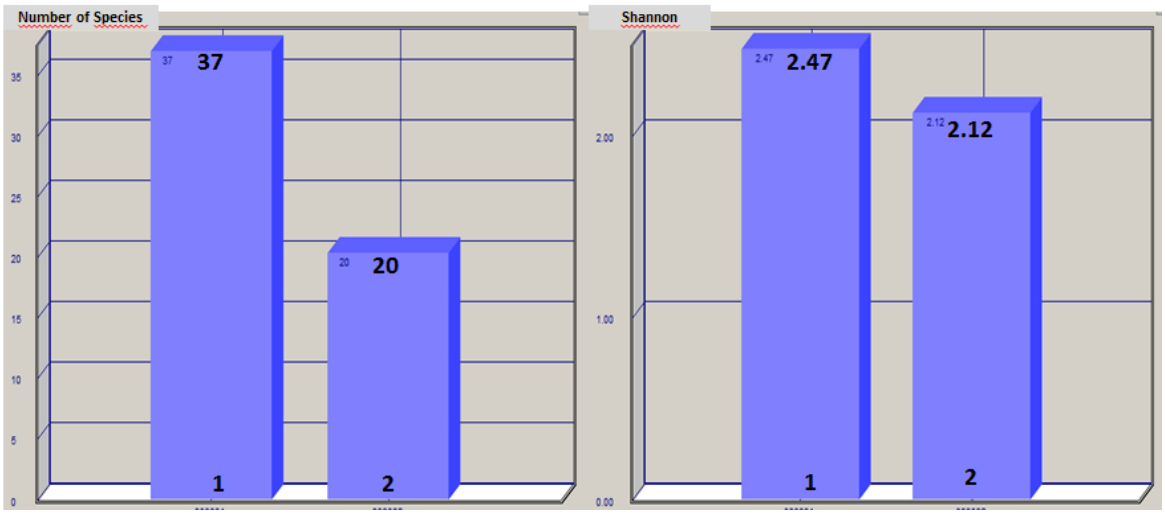

Figure 5: Average species number in phytosociological datasets (1: Yönelli /1986/; 2: Yaltırık /1963/)

Table III: Summary of vegetation datasets (Çoban and Bayraktar, 2016)

Author/s	Nr of releves	Minimum	Maximum	Average	Std_deviation
Yönelli (1986)	549	10	67	36.92	9.14
Yaltırık (1963)	104	6	40	20.31	7.66

Forest vegetation map based on 549 releves distinguished 3 forest sub-communities under *Quercus petraea* subsp. *iberica-Carpinus betulus* community. Each forest community was described with their differential species and stand structural characteristics. *Castanea sativa* forest type which were determined as a typical sub-community covers 426.59 ha. On the other hand, *Fagus orientalis* sub-community cover large part of the forest (3250.67 ha). However, *Quercus petraea* occur in all forest communities. In addition, *Quercus frainetto* sub-community was firstly determined as a seperate unit for the first time with this vegetation map which was not distinguished in forest management maps (Fig. 6).

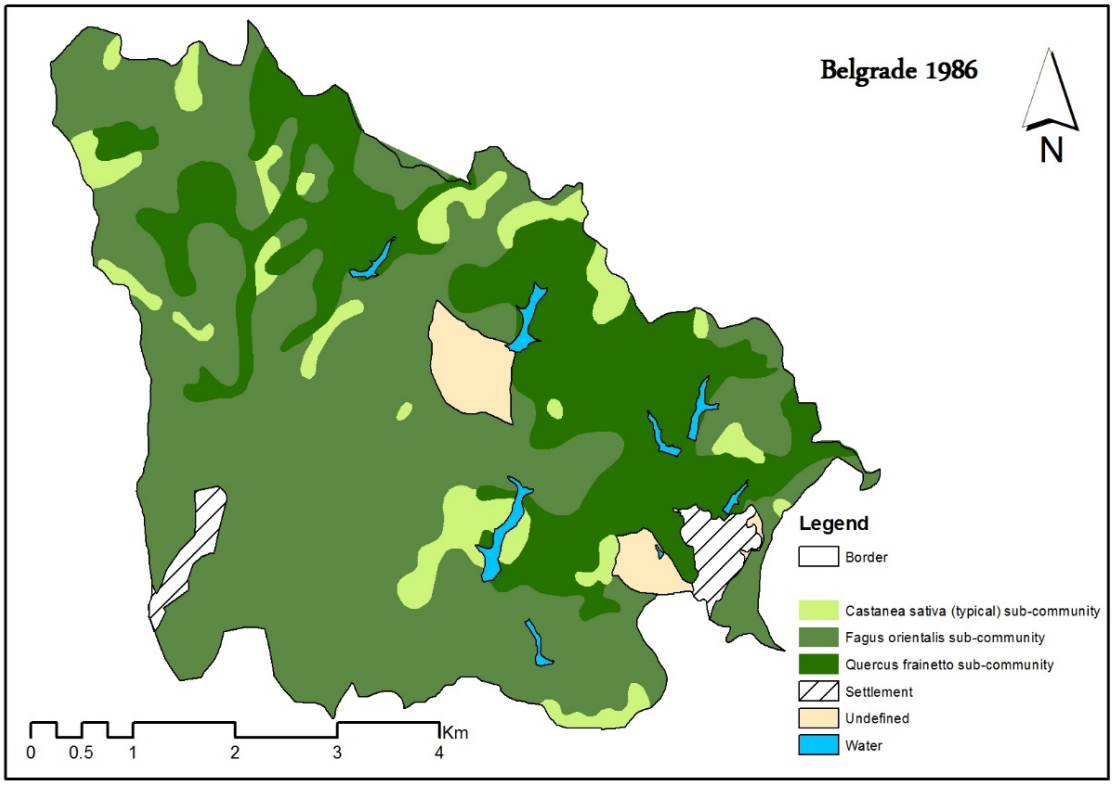

Figure 6: Vegetation map of Belgrade forest (modified from Yönelli 1986)

Vegetation database of the forest consists of environmental data which describes site conditions. However, it is possible to increase environmental variables (soil type, site quality, bedrock type) of each syntaxa from a variety of studies carried out in the forest. Both phytosociological studies complete deficiencies of each other. For instance, Yönelli (1986) have high number of sample plots including plantation areas. However, this study does not include maquis (pseudomaquis) vegetation which occur within the forest openings and surrounding of the forest. On the other hand, Yaltırık (1963), covers all vegetation types including maquis and low-lying damp alder stand which occur in limited areas along streams. The vegetation database includes slope, aspect, altitude and top stand height in addition to species composition data (Table IV).

Table IV: An example of header data of Belgrade Forest vegetation database (Çoban and Bayraktar, 2016)

Relevé number: 16		Relevé number: 655	
Author	: Yönelli (1986)	Author	: Yaltırık (1963)
Nr. relevé in table	:189	Nr. relevé in table	: 3
Cover abundance scale	: Braun/Blanquet (old)	Cover abundance scale	: Braun/Blanquet (old)
Date (year)	: 1963	Date (year)	: 1986
Relevé area (m^2)	: 400.00	Relevé area (m^2)	: 200.00
Altitude (m)	: 90	Altitude (m)	: 89
Aspect (degrees)	: NW	Aspect (degrees)	: NNE
Slope (degrees)	: 20	Slope (degrees)	: 30
Height (highest) trees (m)	: 18	Richness	: 15
Community	:*Quercus frainetto* subcom.	Shannon	: 1.72
Richness	: 29	Evenness	: 0.64
Shannon	: 2.49	Simpson	: 0.71
Evenness	: 0.74		
Simpson	: 0.87		

Phytosociological sample plots consist of all plant species in contrast with forest management survey plots which include only tree species exceeding %10 volume or stem numbers. Other species with an amount of less than 10% are not recorded in the survey plots. However, many tree species which are important in stand composition occur in Belgrade forest. For instance, the forest has optimum conditions for oak species and contain *Quercus petraea, Quercus frainetto, Quercus robur, Quercus cerris, Quercus infectoria and Quercus coccifera.* In addition to these, there occur many deciduous and shrub species co-occurring with main tree species (Table V). In the phytosociological data, it is possible to distinguish all tree species in each stand layer in addition to herb species. On the other hand, seedling or saplings of tree species stored within the herb layer show regeneration status of stands.

Table V: Tree and shrub species in vegetation database of Belgrade Forest

Tree layer	Shrub layer	
Acer campestre	*Arbutus unedo*	*Prunus divaricata*
Acer trautvetteri	*Calluna vulgaris*	*Prunus spinosa*
Alnus glutinosa	*Chamaecytisus pygmaeus*	*Prunus x domestica*
Carpinus betulus	*Cistus creticus*	*Pyracantha coccinea*
Castanea sativa	*Cistus salviifolius*	*Pyrus elaeagnifolia*
Fagus orientalis	*Clematis vitalba*	*Pyrus malus*
Fraxinus angustifolia	*Cornus mas*	*Quercus coccifera*
Pinus nigra s. pallasiana (plantation)	*Cornus sanguinea*	*Rosa canina*
Pinus pinaster (plantation)	*Corylus avellana*	*Salix cinerea*
Pinus sylvestris (plantation)	*Crataegus monogyna*	*Sambucus ebulus*
Pinus brutia (plantation)	*Daphne pontica*	*Smilax excelsa*
Pinus strobus (plantation)	*Erica arborea*	*Sorbus domestica*
Populus tremula	*Erica manipuliflora*	*Spartium junceum*
Quercus cerris	*Euonymus europeaus*	
Quercus frainetto	*Frangula alnus*	
Quercus infectoria	*Genista tinctoria*	
Quercus petraea	*Hedera helix*	
Quercus robur	*Ilex aqifolium*	

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Tilia argentea	*Ilex colchica*
Cerasus avium	*Laurocerasus officinalis*
Juniperus oxycedrus	*Laurus nobilis*
Populus tremula	*Ligustrum vulgare*
Populus alba	*Malus sylvestris*
Sorbus domestica	*Mespilus germanica*
Sorbus torminalis	*Osyris alba*
Abies bornmülleriana	*Phillyrea latifolia*

3.4 Historical developments and vegetation change

Belgrade forest is very important in terms of presenting historical development effecting improvement in forest science of Turkey due to pioneering studies carried out there. These studies, which were implemented in this forest, encouraged foresters for further application in all around Turkey. Following the history of Turkish forestry, scientific methods were increasingly continued but this development process was interrupted during WWI and Independence War of Turkey. Therefore, damages were occurred in forest structure due to authority gap. In the subsequent processes, establishment of Turkish Republic and enacted forest laws implemented planned method for managing forests. However, more informative floristic researches and vegetation maps prepared for forest communities were not adopted in forest management plans (Table VI).

Table VI: Development in forest science and vegetation mapping with historical processes in case of Belgrade forest (developed from Eraslan (1963), Şad and Kızıl (1996), Çolak et al. 2013) (intensity of red colour represent the degree of disturbance)

Year	1857	1870	1888	1894	1917	1918	1923	1924	1937	1938	1949	1953	1956	1957	1963	1986	2012...
	Forestry faculty	First forest directory	First forest map	Removal of villages	1st Management of Rep. of Turkey	WW I and Independence War	Establishment of Rep. of Turkey.	State Forest Enterprise	Forest law (Nr. 3116)	1st Belgade Forest Manag. Plan	1st Revision plan of the forest	Protection Forest	Forest Law (nr.6831)	First recreation areas	Pytosociological studies	Pytosociological studies	
Event	First attempts to manage forest				Planned management term of Turkey Forest damages during the wars				Conservation policies in the first decades of the Republic of Turkey			Status of forest changed Picnic areas were opened			Floristic and ecological characteristics of the forest were studied.		
Description	With the increasing inhabitants, illegal fire wood exploitation caused damages. Belgrade villages were removed due to pollution in water resourses of İstanbul. First forestry school were established and the forest subjected to many researches.				First forest management plan of Turkey were conducted which prometed further plans. Forests were decided to managed as high and coppice forest forms with forest management plans				Rehabilitation and improvement of the forest were given to the forestry faculty First forest management plan of the forest were completed.			Legal status of the forest was defined as 'Protection Forest'.			Forest communities were determined using Braun-Blanquet method.		
Stand classification	Forest stands were classified with a dominance type approach														Floristical classifications		
	There is not a standart for stand classification.				Coppice and high forest management forms were adopted in management plans.				Coppice and high forest, stand development stage, dominance of trees and canopy cover								
Disturbance type	With the increasing inhabitants, illegal fire wood exploitation caused damages.				Autority gap caused illegal and over exploitation during the war				After the establishment of Republic of Turkey, strict conservation precautions were taken.			Some recreational areas were allowed around dams which increased forest degradation.					
Disturbance intensity																	

4 DISCUSSION AND CONCLUSION

First records about the flora of Belgrade forest dated back to 16th century (Belon, 1517-1564). Since that time, many famous botanists had been visited the forest and published plant lists which contributed to phytosociological studies. Establishment of forestry school (1857) accelerated scientific researches which laid the foundations of sustainable forest management (Çolak *et al.*, 2013.). Until 1857, a forestry based on a planned and sustainability principle had not been implemented in Turkey. For this reason, it was accepted that forestry began with the establishment of the first forestry school of Turkey in 1857 (Eraslan, 1963). An important progress were started with the first forest management plan of Turkey which was carried out in Adapazarı-Hendek by a team of Turkish and Austrian foresters in 1917. Following the establishment of Turkish Republic, management of forests with methods concerning sustainability were increasingly adopted with the legal rules (i.e. Forest Law No: 3116) and forest management plan of Belgrade forest was firstly put into practice in 1937. During these developments, available historical forest stand maps show the progress in forest stand classification.

From historical perspective, forest maps were prepared based on main forest tree species and also management type (coppice or high forest). Implementation of aerial photographs and statistical methods enabled discrimination of forest stands up to 1 ha in currently applied forest management plans. In this method, forest stands are determined with tree species, mixture ratio, stand development stage and cover density and these are represented with standardized symbols (Eraslan, 1971). On the other hand, tree species with the lowest mixture ratio (less than 10% cover value) are not included in the stand type. Forest stand maps which use same classification methodology are more applicative in terms of monitoring the success of forest management on nature conservation. Forest maps of Belgrade Forest, which were prepared in different time periods, show the development in forest stand classification from past to present. Beside this progress in forest management, phytosociological studies which integrate information on forest's current and potential composition were completed in the forest. Developments in the digital storage and numerical analysis of vegetation data, which had started in the 1960s, provided many opportunities for further usage of phytosociological datasets (Mucina and van der Maarel 1989). In this context, Belgrade Forest, which has a longer history in terms of scientific researches and many ecosystem based studies, can be accepted as a sample forest for Turkey. For instance, detailed phytosociological studies and vegetation maps can be combined with forest stand maps. Thus, close-to-nature management approach can be achieved and a multifunctional base for sustainable forest management can be obtained. However, floristic composition of the stands were not considered although available phytosociological studies for a long time. According to Pott (2011) plant communities, which are classified with their floristic composition, express all historical, sociological and local influences. Also, the use of plants and of plant communities as indicator for land planning and nature conservation policy is in principle quite accepted in most countries (Loidi, 1994). The use of vegetation maps based on forest types with detailed information on composition instead of maps based on dominant tree species will also contribute to the assessment of the indicator tree species composition (Blasi and Burrascano, 2013). For this reason, plant community maps encompass much more information then forest maps prepared based on main tree species. Because each forest community consists of characteristic species which repeated in the same communities. Also, further analysis of species composition reveals information about site conditions and also disturbance regime with indicator plans. Plant community maps also provide basis for hemeroby and naturalness maps.

Assessment of forest degradation for longer periods are not sufficient from these maps although many existing historical documents. Because, historical forest maps does not present a detailed information due to different classification schemes which they adopted. In addition, some anthropogenic effects cannot be seen easily from stand types determined from dominance of tree species. On the other hand, remarkable changes can be observed in terms of coppice forests and chestnut forest areas. For instance, the effect of the conservation attempts after the establishment of Forestry school and removal of villages can be seen from the maps of 1888 and 1938. Removal of villages inside the forest had caused a decrease in irregular coppice stands and also openings (or meadows) from 1888 to 1938. Also, these protection precautions were interrupted with the World War I and following Independence War of Turkey which caused over exploitation of valuable oak forests due to authority gap (Çolak *et al.,* 2013; Çoban and Akgül, 2014). Due to these damages, strict protection measures were implemented and regular forest management plans were started. Because of the importance of the forest, forest functions were redefined and conservation approaches were adopted. Following these advances considerable changes have been occurred in the forest structure especially in the areas of coppice and high forests. But, stands of chestnut has dramatically decreased due to Ink disease (*Phytophthora cambivora* /Petri/ Buisman) and Chestnut blight (*Cryphonectria parasitica* /Murrill/ Barr) (Çolak *et al.*, 2013.).

Sustainability of forests can be ensured with the ecosystem management referencing reliable documents. For instance, forest biological diversity (tree species composition, naturalness and deadwood) is accepted one of the criteria and indicator for sustainable forest management (Blasi and Burrascano, 2013). Vegetation maps which reflect biological diversity of the forests more or less can be accepted among the main references for monitoring biological diversity. Although vegetation maps based on floristical composition are not widespread in Turkey, some important forest areas were intensively studied in terms of vegetation classification and vegetation mapping (i.e. Aksoy, 1978; Yönelli, 1986). On the other hand, forest stand types are also classified with the aim of forest management for all forests of Turkey for a long time. These two approaches which have a long-standing background must be evaluated as an integrated basic for a sustainable forest management.

The results also indicated that GIS can be used to effectively monitor and analysing of forest pattern changes in long term.

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