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The Importance of Endangered Anatolian (Oriental) Sweetgum Forests for the Bird Species

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Abstract

The research was undertaken to assess bird diversity and abundance in the endangered and fragmented Anatolian (oriental) sweetgum (*Liquidambar orientalis*) forests, a rare, relict endemic of the eastern Mediterranean Basin. Five visits organized in three different sweetgum forest patches were performed around lake Köyceğiz between March 2018 and January 2019. In total, 76 bird species were recorded in all study sites. Among these species, evidence showed 14 breeds in these forests, while 34 have possibility to breed, and the rest were recorded as passage or wintering species. Green Woodpecker (*Picus viridis*) had been selected as an indicator species for the health of Anatolian Sweetgum forest patches since it showed a high dependency on these forest patches although there were suitable feeding and breeding habitats in surrounding areas. The results also suggest that Turtle Dove (*Streptopelia turtur*) and Eurasian Blackcap (*Sylvia atricapilla*) are possible indicators because they both winter and breed in Anatolian Sweetgum forests. The results suggest that Anatolian Sweetgum forest patches are important habitats for many birds, and the conservation efforts of these forests are also important for many bird species of southwestern Anatolia.

Key words: Anatolian (oriental) sweetgum forests, bird community, bird diversity, conservation of birds and forests, habitat fragmentation, *Liquidambar orientalis*

1. Introduction

Anatolian (oriental) Sweetgum forests are of global importance as a rare tertiary endemic of eastern Mediterranean Basin and an endangered forest ecosystem (Ürker and Çobanoğlu, 2017). The Anatolian Sweetgum (*Liquidambar orientalis* Miller) is a relict endemic species that distributed in south-western Anatolia (Turkey) and partly on Rhodes Island (Greece). The most extensive stands of the species are found in Muğla province, Turkey (Alan and Kaya, 2003). The trees are seen in groups or individually, in shallow, creek water and swamp areas. The sweetgums can also be seen in groups in small groves, or on riverbanks. These tree communities are called shallow gallery forests (Özkil et al., 2017) and are often seen in places with less inclination and more water.

The sweetgum forests are rich in biodiversity (Ürker and Ilemin, 2019) but have already suffered extensive damage and fragmentation. According to the current The International Union for Conservation of Nature (IUCN) Red List assessments (Ver. 2018.2) since the end of 2017; the threatened level of Oriental sweetgum has been updated from VU (Vulnerable) to EN (Endangered) due to the heavy habitat fragmentation, land occupation, illegal sweetgum oil production, overgrazing, and tourism activities (Kavak and Wilson, 2018). Since the 1950s, state-sponsored farming initiatives led to a massive shrinkage of sweetgum forests, and today, this tree species is becoming extinct (Özkil et al., 2017).

Birds can be a good indicator on the habitat fragmentation and can be used during the creation of new forests in following the succession periods (Wilcove et al., 1986). Although the importance of birds, there are very limited systematic bird surveys directly related to those forest ecosystems in Turkey.

This paper seeks to provide a summary of the findings of these studies and identify potential conservation opportunities for the bird diversity in Anatolian Sweetgum forests in Köyceğiz.

2. Material and Methods

2.1. Study sites

The Köyceğiz- Dalyan Specially Protected Area-SPA (it also has IBA and KBA status) which is study region located in and around the lake Köyceğiz (Southwestern Anatolia, Köyceğiz District, Mugla Province, TURKEY). The project region constitutes the greatest unbroken expanse of the oriental sweetgum forests and the best chance to establish a healthy sweetgum forest area (Ürker and Lise, 2018) (Figure 1). Three different forest parts which were presented below were selected to understand the properties of bird diversity and abundance and to compare the primer community parameters (Figure 1).

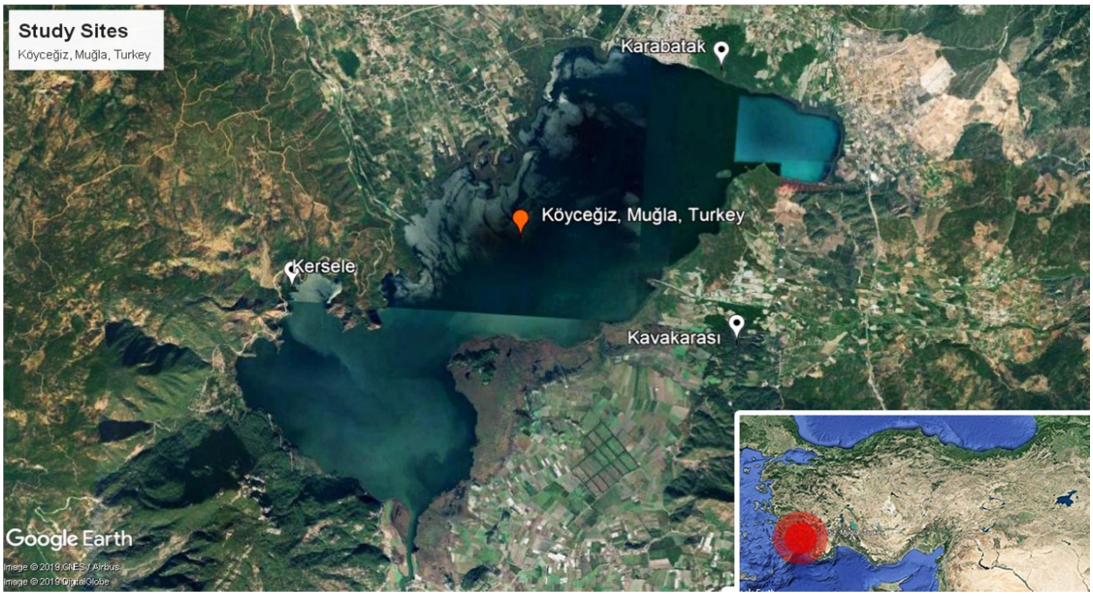

Figure 1. The Location Map of The Study Region and The Study Sites inside the Köyceğiz, Dalyan SPA.

2.1.1. Kavakarası

It is a highly fragmented forest patch due to its citrus gardens in and around it, located in the eastern part of the lake Köyceğiz. The forest patch covers an area of about 250 hectares with mature sweetgum trees. Human interference is high in the patch because of the roads which provide main transportation between Kavakarası village and citrus gardens. The sweetgum oil production mainly occurs in here and an inactive production facility still presents in the area.

2.1.2. Karabatak

Karabatak forest, which runs along the northern part of the lake and in the east of Köyceğiz city center, has an active interaction with the lake ecosystem. The area covers around 250 hectares and the fragmentation ratio is relatively low. Due to the winter and spring rains, the coastal part of forest stays under water. In the summer season, the small ponds and marshes keep remaining. The western part of the forest maintains its integrity, while the eastern part shows a fragmented status due to pasture and agricultural areas. The high interaction between the forest and the lake affects bird diversity positively. Reed warblers, grebes and kingfishers use both lake and forest for feeding. Due to its close proximity to the city center, the coastal part uses for night entertainment, picnics, hunting and gathering etc. by local people and causes high plastic pollution or wildlife disruptions.

2.1.3. Kersele

Kersele forest, located on the west coast of the lake Köyceğiz, covers the smallest area (about 30 hectares) with low fragmentation compared to other study sites. It is the most sheltered area from human impacts because of its distant location. However, cattle grazing is frequently observed during the summer season. The area is located in a bay covered with Turkish red pine (*Pinus brutia*) forests and limited with road and plantation

pine trees to the west and lake Köyceğiz to the east. Due to the spring water emerges in the heart of the forest, it has an active connection with lake and creates a suitable feeding ground for bird species like cormorants and herons. Just like in the Karabatak forest, most part of Kersele forest stays under water because of winter rains and an increasing water level of the lake.

2.2. Methods

Hourly transects, random and night surveys were applied as bird watching methodology which was explained briefly below (Grigory et al., 2004). The birdwatching methodology and data input were carried out compatible with the current breeding bird atlas of Turkey (Boyla et. al., 2019).

2.2.1. Hourly transects

For each forest patch, 2 walking routes which cover 1 km square area with roughly 1 km long paths were decided to sample according to Breeding Bird Atlas Methodology (Boyla et. al., 2019). An hour of walking in these routes had been completed from beginning to end and any bird heard and seen was recorded with possible breeding codes; the number of individuals were also recorded. The observations started with the earliest lights of the day. Immediately after the first route was completed within an hour, the second route has been passed. All hourly transects completed in averagely 2 hours after the sunrise.

2.2.2. Random survey

After the hourly transects and before the night surveys, 30 minutes drive had been completed in or around the forest patches to recorded possible or unnoticed species.

2.2.3. Night survey

To observe and record nocturnal species like owls and nightjars, 30-45 minutes observations had been held before sunrise and after sunset for each study site. Stationary observation by listening to calls of species resulted in the record of two expected species in the sites.

3. Result

All 3 study sites had been counted with 5 visits between March 2018 and January 2019. Field surveys were conducted in 31 March - 1 April, 30 April - 3 May, 21-22 May, 9-11 September 2018 and 22-25 January 2019.

As a result of the surveys, 38 species in Kersele, 49 species in Kavakarası and 56 species in Karabatak and 76 bird species in total were recorded in all study sites (Table 1).

Table 1. Bird species observed in the Anatolian Sweetgum forests of Köyceğiz in the present study (March 2018-January 2019).

Species Name	Apr 2018	May 2018	June 2018	Sept 2018	Jan 2019	Status and Presence	IUCN Red List*
Little Grebe *(Tachybaptus ruficollis)*	✓	✓	✓	✓	✓	Rb / Ke, Kb	LC
Great Crested Grebe *(Podiceps cristatus)*		✓				b / Ke, Kb	LC
Common Woodpigeon *(Columba palumbus)*	✓		✓			b / Kv, Kb	LC
European Turtle Dove *(Streptopelia turtur)*			✓	✓		b / Ke, Kv	VU
Collared Dove *(Streptopelia decaocto)*		✓	✓	✓	✓	Rb / Kv, Kb	LC
Common Swift *(Apus apus)*	✓		✓			P / Kv, Kb	LC
Little Ringed Plover *(Charadrius dubius)*			✓			P / Ke	LC
Yellow-legged Gull *(Larus michahellis)*			✓			P / Kv	LC
White Stork *(Ciconia ciconia)*			✓			P / Ke	LC
Pygmy Cormorant *(Microcarbo pygmaeus)*				✓	✓	W / Ke	LC
Great Cormorant *(Phalacrocorax carbo)*			✓	✓	✓	Rb / Ke, Kb	LC
Grey Heron *(Ardea cinerea)*			✓	✓		Rb / Ke, Kb	LC
Black-crowned Night-Heron *(Nycticorax nycticorax)*		✓				P / Ke	LC
Common Buzzard *(Buteo buteo)*	✓				✓	Rb / Ke, Kb	LC
Eurasian Scops Owl *(Otus scops)*		✓				b / Ke	LC
Tawny Owl *(Strix aluco)*			✓	✓		b / Ke, Kv, Kb	LC
Eurasian Hoopoe *(Upupa epops)*	✓					b / Kb	LC
Common Kingfisher *(Alcedo atthis)*				✓	✓	b / Ke, Kb	VU
European Bee-eater *(Merops apiaster)*			✓	✓		b / Ke, Kv, Kb	LC
European Roller		✓				b / Kb	LC

(Coracias garrulus)							
Middle Spotted Woodpecker *(Dendrocoptes medius)*			✓	✓	✓	Rb / Kv, Kb	LC
Great Spotted Woodpecker *(Dendrocopos major)*				✓		Rb / Ke, Kv, Kb	LC
Syrian Woodpecker *(Dendrocopos syriacus)*			✓		✓	Rb / Ke, Kv	LC
Lesser Spotted Woodpecker *(Dryobates minor)*	✓			✓	✓	Rb / Kv, Kb	LC
Eurasian Green Woodpecker *(Picus viridis)*	✓	✓	✓	✓	✓	RB / Ke, Kv, Kb	LC
Red-backed Shrike *(Lanius collurio)*				✓		b / Kv, Kb	LC
Masked Shrike *(Lanius nubicus)*	✓		✓	✓		B / Kv, Kb	LC
Eurasian Golden Oriole *(Oriolus oriolus)*			✓			b / Kv	LC
Eurasian Jay *(Garrulus glandarius)*	✓	✓	✓	✓	✓	RB / Ke, Kv, Kb	LC
Common Magpie *(Pica pica)*					✓	P / Kv	LC
Hooded Crow *(Corvus cornix)*	✓	✓	✓	✓	✓	RB / Ke, Kv, Kb	LC
Common Raven *(Corvus corax)*			✓			P / Ke	LC
Sand Martin *(Riparia riparia)*	✓		✓			P / Kb	LC
Eurasian Crag Martin *(Ptyonoprogne rupestris)*					✓	P / Kb	LC
Barn Swallow *(Hirundo rustica)*	✓	✓	✓	✓		P / Ke, Kv, Kb	LC
Red-rumped Swallow *(Cecropis daurica)*	✓			✓		P / Kv, Kb	LC
Common House Martin *(Delichon urbicum)*	✓	✓	✓	✓		P / Ke, Kv, Kb	LC
Eurasian Blue Tit *(Cyanistes caeruleus)*	✓	✓	✓	✓	✓	RB / Ke, Kv, Kb	LC
Great Tit *(Parus major)*	✓	✓	✓	✓	✓	RB / Ke, Kv, Kb	LC
Long-tailed Tit *(Aegithalos caudatus)*	✓	✓	✓			RB / Ke, Kv, Kb	LC
Eurasian Nuthatch *(Sitta europaea)*			✓			b / Kb	LC

Eurasian Wren *(Troglodytes troglodytes)*	✓		✓		✓	RB / Kv, Kb	LC
Goldcrest *(Regulus regulus)*	✓					b / Kb	LC
Cetti's Warbler *(Cettia cetti)*	✓	✓	✓	✓	✓	RB / Ke, Kv, Kb	LC
Willow Warbler *(Phylloscopus trochilus)*				✓		P / Kv	LC
Common Chiffchaff *(Phylloscopus collybita)*					✓	W / Ke, Kv, Kb	LC
Eastern Olivaceous Warbler *(Iduna pallida)*		✓	✓			b / Kb	LC
Eurasian Reed Warbler *(Acrocephalus scirpaceus)*			✓	✓		P / Ke, Kb	LC
Great Reed Warbler *(Acrocephalus arundinaceus)*			✓			P / Ke, Kb	LC
Eurasian Blackcap *(Sylvia atricapilla)*	✓		✓	✓	✓	RWb / Kv, Kb	LC
Lesser Whitethroat *(Sylvia curruca)*	✓		✓	✓		b / Ke, Kv, Kb	LC
Sardinian Warbler *(Sylvia melanocephala)*			✓			b / Kb	LC
Common Whitethroat *(Sylvia communis)*			✓	✓		b / Ke, Kv, Kb	LC
Spotted Flycatcher *(Muscicapa striata)*				✓		b / Kv	LC
European Robin *(Erithacus rubecula)*	✓	✓	✓	✓	✓	RWB / Ke, Kv, Kb	LC
Thrush Nightingale *(Luscinia luscinia)*			✓			P / Kv	LC
Common Nightingale *(Luscinia megarhynchos)*	✓	✓	✓			b / Kv, Kb	LC
Collared Flycatcher *(Ficedula albicollis)*	✓					P / Kb	LC
Black Redstart *(Phoenicurus ochruros)*					✓	W / Kv, Kb	LC
Whinchat *(Saxicola rubetra)*				✓		P / Kb	LC
Mistle Thrush *(Turdus viscivorus)*			✓			P / Kv	LC
Song Thrush *(Turdus philomelos)*	✓		✓		✓	Rb / Kv, Kb	LC
Eurasian Blackbird *(Turdus merula)*	✓	✓	✓	✓	✓	RB / Ke, Kv, Kb	LC

Common Starling *(Sturnus vulgaris)*			✓			P / Kb	LC
Western Yellow Wagtail *(Motacilla flava)*		✓		✓		P / Ke, Kv	LC
Pied Wagtail/White Wagtail *(Motacilla alba)*			✓			P / Kv, Kb	LC
Tree Pipit *(Anthus trivialis)*				✓		P / Kv	LC
Common Chaffinch *(Fringilla coelebs)*	✓	✓	✓	✓	✓	RB / Ke, Kv, Kb	LC
Hawfinch *(Coccothraustes coccothraustes)*				✓		b / Kv	LC
European Greenfinch *(Chloris chloris)*	✓	✓	✓	✓		RB / Ke, Kv, Kb	LC
Common Linnet *(Linaria cannabina)*	✓		✓			b / Kv, Kb	LC
European Goldfinch *(Carduelis carduelis)*	✓	✓	✓	✓	✓	RB / Kv, Kb	LC
Eurasian Siskin *(Spinus spinus)*				✓	✓	b / Kv	LC
House Sparrow *(Passer domesticus)*			✓	✓	✓	Rb / Kb	LC

Status: P=Passage, R=resident, W=winter visitor, B=Breeding, b=may breed
Presence: Ke=Kersele, Kv=Kavakarası, Kb=Karabatak
IUCN Red List: LC=Least Concern, VU=Vulnerable (*Scope of Assessment: Europe)

Common Chaffinch, Barn Swallow, Eurasian Blackbird, Eurasian Green Woodpecker and Eurasian Jay were the most abundant and/or frequently encountered species for the Anatolian Sweetgum forests of Köyceğiz during the study (Table 2).

Table 2. The frequency and abundance of the mostly observed species in all study sites.

Species	Frequency	Abundance
Common Chaffinch *(Fringilla coelebs)*	86%	2,036
Great Tit *(Parus major)*	78,6%	0,392
Eurasian Green Woodpecker *(Picus viridis)*	76,6%	1,336
Eurasian Blackbird *(Turdus merula)*	74%	1,926
Eurasian Jay *(Garrulus glandarius)*	72%	1,336
Eurasian Blue Tit *(Cyanistes caeruleus)*	63,4%	0,560
Barn Swallow *(Hirundo rustica)*	58%	2,548
Cetti's Warbler *(Cettia cetti)*	50,6%	0,746
European Greenfinch *(Chloris chloris)*	50%	1,016
European Robin *(Erithacus rubecula)*	50%	0,678

(Frequency: Percentage of Checklists Reporting Species /Abundance: Average Number of Birds per Checklist)

3.1. Community parameters

Following indices of community properties were used in this study; Sorensen's Similarity Index, Dominance Index, Shannon Diversity Index, Margalef Richness Index and Richness (Krebs, 1989) were estimated to assess the ecological status of the three forest patches studied.

The three forest parts were also compared with each other by taking into account the Dominancy, Diversity, Richness and Similarity Indices (Table 3).

Table 3. Summary of the community parameter results for the three forest patches included in the study.

Community Parameters	Kersele (Low fragmentation – smaller forest patch)	Kavakarası (High fragmentation – larger forest patch)	Karabatak (Low fragmentation – larger forest patch)
Dominancy	40,60	25,08	25,92
Diversity Index	2,56	2,95	3,03
Richness Index	6,29	6,78	7,76
Richness	38	49	56
Similarity	Kersele	Kavakarası	Karabatak
Kersele	-	0.51	0.57
Kavakarası	0.51	-	0.68
Karabatak	0.57	0.68	-

3.2. Indicator species

According to the results of the survey, Green Woodpecker (*Picus viridis*) was selected as an indicator species of Anatolian Sweetgum forest in Köyceğiz.

Green Woodpecker (*Picus viridis*) is a resident species of the Anatolian Sweetgum forest in Köyceğiz. During the study, it was recorded in all study sites but its breeding confirmed only in two mature forest patches, Kavakarası and Karabatak. It is a difficult species to observe visually however its call is an iconic sound for the Anatolian Sweetgum forest. Because of the surrounding area consists of agricultural lands and human settlements and have distance to nearest pine forests in Kavakarası and Karabatak, the sweetgum forest patches are the only breeding ground for it in the study area. So, the presence of the sweetgum forest and its health have key role in the existence of Green Woodpecker in the region.

In addition to the Green Woodpecker (*Picus viridis*), there are some important species for the Anatolian Sweetgum forest. They are Turtle Dove (Streptopelia turtur) and Eurasian Blackcap (Sylvia atricapilla). Because of its dense vegetation, humid and temperate climate, Anatolian Sweetgum forest gives opportunity to these species as breeding and wintering ground. Turtle Dove is one of them. It is a vulnerable species according to IUCN Red List (BirdLife International, 2017). Most of the individuals had been recorded in the top canopy part of high sweetgum trees and many individuals observed while feeding under the citrus trees. Although any physical evidence could not be found, the territorial defense and courtship had been observed.

Similarly, Eurasian Blackcap (*Sylvia atricapilla*) prefers the sweetgum forest as breeding and wintering ground. During the breeding season, it uses the bushes vegetation under the sweetgum trees. Additionally,

because of the suitable climate conditions, some populations winter in the Mediterranean coast. For the sweetgum forest, the Eurasian Blackcap was mostly observed in higher branches and in creeper kind vegetation which remain green in winter around the sweetgum tree. When the pine forest vegetation around the sweetgum forest is limited, the Anatolian Sweetgum forest patches give a great opportunity for wintering of the Eurasian Blackcap.

4. Discussion

This study has two important results. First, the sweetgum forest is an important breeding, feeding and wintering ground for local bird fauna including some threatened species. Secondly, it demonstrates the impact of forest fragmentation on the diversity, abundance and frequency of the species in the endangered Anatolian (Oriental) sweetgum (*Liquidambar orientalis*) forests which are a rare, relict endemic for Levant Region (Eastern Mediterranean Basin).

According to the results of survey, 76 bird species had been recorded in all study sites. 14 of them recorded as breeding species in the areas, while 34 of them may breed but no physical evidence found. The rest recorded as passage or wintering species. However, while the fragmentation level of each sweetgum forest patch is increasing, the number of species is decreasing.

In regard to the results of community parameters; it can be understood that the bird fauna starts to be more homogenous with the increasing forest area if the similarity indices are taken into account. The same situation should be estimated on richness and diversity; in such cases, the habitat fragmentation takes place and gets more important for the bird fauna (Laurance, 2008). When the diversity and richness indices are examined, it is easily noticeable that both of them are rising with the increasing forest area and decreasing habitat fragmentation.

Our results provide empirical evidence that fragmentations cause to increase the genetic bottleneck effects in the Anatolian (Oriental) Sweetgum forests (Kavak and Wilson, 2018). We, therefore, recommend that any kind of seedling strategies such as making corridors between the fragmented parts and/or creating plantations in the new areas should be preferred for those forests (Ürker and Yalçın, 2011; Özkil et al., 2017). Second, we suggest that necessary conservation actions (such as less pesticide usage, stopping the occupations of the forest lands and corruption of the water regimes, managing the hunting etc.) should be taken into account for the indicator birds live inside those forests. Moreover, the selected indicator species Green Woodpecker and important species Turtle Dove and Eurasian Blackcap should be regularly monitored to follow the changing of the ecological conditions for the Anatolian Sweetgum forests of Köyceğiz.

Conflicts of Interests

Authors declare that there is no conflict of interests

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References

Alan, M., Kaya, Z. (2003). *Oriental Sweet Gum* (*Liquidambar orientalis* Mill.). EUFORGEN Technical Guidelines.

BirdLife International, (2017). *Streptopelia turtur* (Amended version of 2017 assessment). The IUCN Red List of Threatened Species. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T22690419A154373407.en Downloaded on 13 February 2019.

Boyla, K. A., Sinav, L., Dizdaroğlu D. E. (2019). *Türkiye Üreyen Kuş Atlası* (Breeding Bird Atlas of Turkey). WWF-Türkiye, Doğal Hayatı Koruma Vakfı, İstanbul.

Grigory, D., Gibbons, D. W., Donald, P. F. (2004). *Bird Census and Survey Techniques.* William J. Sutherland, Ian Newton, and Rhys Green (Eds.), In: Bird Ecology and Conservation: A Handbook of Techniques. Oxford: Oxford University Press.

Kavak, S., Wilson, B. (2018). *Liquidambar orientalis*. The IUCN Red List of Threatened Species 2018. http://dx.doi.org/10.2305/IUCN.UK.20181.RLTS.T62556A42326468.en.Downloaded on 10 February 2019.

Krebs, C. J. (1989). *Ecological Methodology.* New York: Harper and Row Publishers Inc.

Laurance, W. F. (2008). Theory meets reality: how habitat fragmentation research has transcended island biogeographic theory. *Biological Conservation, 141* (7) 1731-1744.

Özkil, A., Ürker, O., Zeydanlı, U. (2017). *Art in Sweetgum Forest. Nature Conservation Centre.* Ankara: Dumat Ofset.

Ürker, O., Yalçın, S. (2011). Köyceğiz'de Biterse Dünya'da da Biter! Sığla Ormanı. TÜBİTAK Bilim ve Teknik Dergisi, Ankara, Turkey.

Ürker, O., Çobanoğlu, N. (2017). *Çevre Etiği Bağlamında Anadolu Sığla Ormanları.* LAP - Lambert Academic Publishing, Germany.

Ürker, O., İlemin, Y. (2019). A pioneer study on the wildlife properties of anatolian sweetgum forests, a case assesment on mammalian diversity in terms of ecosystem integrity. *Fresenius Environmental Bulletin*, *28* (7), 5474-5480.

Ürker, O., Lise, Y. (2018). Anadolu sığla ormanları örneği üzerinden doğa korumada yeni bir kavram olan hassas orman ekosistemlerinin incelenmesi. *Anatolian Journal of Forest Research*, *4* (1), 1-10.

Wilcove, D. S., McClellan, C. H., Dobson, A. P. (1986). *Habitat Fragmentation in the Temperate Zone.* In; M. E. Soule (Ed.), Conservation biology: the science of scarcity and diversity. Sinauer Associates, Sunderland, MA.