ISTANBUL TECHNICAL UNIVERSITY ★ EURASIA INSTITUTE OF EARTH SCIENCES

BIRD SPECIES DIVERSITY IN TURKEY AND REMOTE SENSING HABITAT PARAMETERS

M.Sc. THESIS

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<u>ISTANBUL TEKNİK ÜNİVERSİTESİ ★ AVRASYA YER BİLİMLERİ ENSTİTÜSÜ</u>

TÜRKİYE'DEKİ KUŞ TÜRLERİ ÇEŞİTLİLİĞİ VE HABİTATIN UZAKTAN ALGIMA PARAMETLERİ

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Sangji LEE, a M.Sc. student of İTU Eurasia Institute of Earth Sciences student ID 601171004, successfully defended the thesis entitled "Bird Species Diversity in Turkey and Remote Sensing Habitat Parameters", which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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Deo gratias. To my wonderful family.
And to Aziza who became a pretty angel, Miss you..

FOREWORD

I want to thank everyone who gave me huge supports.

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September 2019 Sangji LEE

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ABBREVIATIONS

Atlas Data	: Turkish Breeding bird atlas data
AVHRR	: Advanced Very High Resolution Radiometry
CHM	: Canopy Height Model
DBH	: Diameter at breast heigh
DEM	: Digital Elevation Model
DHI	: Dynamic Habitat Index
DSM	: Digital Surface Model
EVI	: Enhanced Vegetation Index
fPAR	: Fraction of Photosynthetically Active Radiation
GPP	: Gross Primary Production
HDF	: Hierarchical Data Format
LiDAR	: Light Detection and Ranging
MCTK	: MODIS conversion Toolkit
MODIS	: Moderate Resolution Imaging Spectroradiometer
NASA	: National Aeronautics and Space Administration
NDVI	: Normalized Difference Vegetation Index
NIR	: Near-Infrared
P-value	: Significance Probability Value
SDM	: Species Distribution Model
STDEV, SD	: Standard Deviation
TIF	: Tagged Image File Format
USGS	: United States Geological Survey
WWF	: World Wide Fund for Nature

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BIRD SPECIES DIVERSITY IN TURKEY AND REMOTE SENSING HABITAT PARAMETERS

SUMMARY

Ecosystems are large and difficult to access. Therefore, it is difficult to measure the biodiversity. However, The development of various remote sensing technologies makes ecosystem research easier and more accurate than ever before. In this thesis, MODIS was used in the main study of Turkey as a whole, and LiDAR was used in further studies in some parts of the Black Sea.

It is inevitable that biodiversity is decreasing worldwide. Various natural and physical influences are changing the living place. This study was geared towards birds living in Turkey. Bird populations and species are also decreasing in Turkey due to environmental and climate changes. (boyla et al, 2019). This study identified the relationship between bird species richness and vegetation, which is considered a major habitat for birds. Several studies have already shown that they are positively correlated.(Liang et al, 2018; Seto et al, 2004) There is a need to identify Turkey as a case. I wanted to see if the relationship could be confirmed with the vegetation index, a single parameter. Analysis of the relationship between all bird species and vegetation observed in Turkey, including species that do not have vegetation as their habitat.

Remote sensing data was used to obtain vegetation information. The study used NDVI and EVI via MODIS Terra. First, I mapped three years of changes in NDVI and EVI from 2015 to 2017 throughout Turkey. All of them decreased every year. The trend were similar, but EVI was generally lower than NDVI, as usual. The map shows that the vegetation of the central inland regions of Turkey is further reduced.

To check the relationship with the obtained vegetation index, bird species data was extracted from Turkish Breeding bird atlas data during the same 2015-2017 period was identified. Both NDVI and EVI showed a positive correlation with the bird species data. Especially, the maximum value of NDVI correlated strongly with Bir Species Richness. And, the mean values were most correlated in EVI. It is believed that EVI is sensitive to the terrain. (Matsushita et al, 2007) In addition, the correlation with 2017 was highist. Even 2015 EVI was analyzed to be independent of bird species richness. It was found that the Species richness at the same time has changed with the decrease of vegetation. The results of this study provide an overall review of the positive correlation between bird species richness and vegetation in Turkey. Furthermore, the usefulness of NDVI and EVI was confirmed again.

After the main research as above, to understand the forest area in some areas a more detailed study was attempted. Further research on forest structure and bird diversity in local areas has been conducted. I used light detection and ranging (LiDAR) to collect more accurate high-resolution data for forest structure analysis.

The two forests of each 0.4 km wide and 10 km long are selected from the forests with high bird species richness and relatively low bird species richness and their structural analysis using the LiDAR poind cloud data and the CHMs classification which one of forest metrics greatest influence on birds habitat. In addition, I used forest management plans data to analyze the differences in specific tree types and growth levels in each region. Under the assumption that species observed in the Atlas square (50km x 50km), can live in or stay in all the forests in that square.

The results were that CHM was similar in overall trend, but the region with high species richness of bird had a higher proportion of '10 -20m ' than the low species richness region. Through the DEM, I could find many ridgelines, including steep slopes in the region with high specie richness. In addition, The region of high specie richness of bird had more varieties of trees than low specie richness region. DBH proportion was '8-19.9cm' of non-thick trees was high. At the top crown closure level, it was confirmed that both areas were dense forests with a high degree of closure.

It results show the effectiveness of LiDAR in assessing forest health and productivity, and assessing habitat quality. Continued research into forests and habitats using various techniques such as LiDAR can lead to the creation of appropriate wildlife habitat models to build ecological forest management.

Comprehensive correlation analyzes between habitat and other factors, climate change and forest structure etc, are required. Climate and physical changes at the time of the change in vegetation should also be identified. In order to maintain biodiversity, further research should be conducted to identify what changes are being made to the ecosystem and why these changes have occurred.

TÜRKİYE'DEKİ KUŞ TÜRLERİ ÇEŞİTLİLİĞİ VE HABİTATIN UZAKTAN ALGIMA PARAMETLERİ

ÖZET

Ekosistemleri geniş ve erişilmesi güçtür. Bu yüzden, biyoçeşitliliği ölçmek zordur. Ancak gelişen çeşitli uzaktan algılama sitemleri teknolojileri ile ekosistem araştırmaları hiç olmadığı kadar kolay ve doğru hale gelmiştir. Bu tezinin ana çalışmasında MODIS kullanılmıştır. Ek olarak Karadeniz'in bazı bölgelerinin detaylı bir çalışmasında LiDAR kullanılmıştır.

Biyoçeşitlilğin dünya çapında azalması kaçınılmaz. Çeşitli doğal ve fiziksel etkiler yaşam alanlarını değiştirmekte. Bu çalışma Türkiye'de yaşayan kuşlara yöneliktir.Türkiye'de kuş nüfusu ve türleri de çevresel ve iklim değişikliklerinden dolayı azalmaktadır. (boyla et al, 2019). Bu çalışma kuş türleri için başlıca habitat olarak kabul edilen bitki örtüsü ve kuş türü zenginliği arasındaki ilişkiyi tanımlamıştır.Bir çok çalışma aralarındaki pozitif korelasyonu ortaya çıkarmıştır. .(Liang et al, 2018; Seto et al, 2004) Ancak Türkiye'ye ayrı bir tanımlama gerekmektedir. Habitatında bitki örtüsü olmayan kuşlar dahil olmak üzere Türkiye'deki tüm tür sayıları tek bir parametre olan bitki örtüsü indeksi ile ilişkilendirip ilişkilendirilemeyeceğini görmek istedim.

Bitki örtüsü bilgisini elde etmek için uzaktan algılama verileri kullanılmıştır. Çalışmada MODIS Terra aracılığı ile NDVI ve EVI kullanılmıştır.Öncelikle 2015'ten 2017'ye Türkiye genelinde NDVI ve EVI deki değişiklikleri haritaladım. Hepsi her yıl düşüş gösterdi. Eğilim benzerdi ancak, EVI genellikle her zamanki gibi NDVI'dan düşüktü. Harita Türkiye'nin iç bölgelerinin bitki örtüsünün azaldığını göstermektedir.

2015-2017 yıllarında yapılan Türkiye Kuş yetiştirme atlas verilerinde kuş türleri arasındaki ilişki tespit edilmiştir. Hem NDVI hem de EVI kuş türleri verileri pozitif bir korelasyon göstermiştir.Özellikle NDVI'ın maksimum değeri kuş türü zenginliği ile büyük bir ilişki göstermiştir ve ortalama değerler en çok EVI ile ilişki göstermiştir. EVI'nin araziye duyarlı oluduğuna inanılır. (Matsushita et al, 2007) Ek olarak, 2017 ile en çok ilişki göstermektedir. 2015 EVI bile kuş türü zenginliğinden bağımsız olarak analiz edildi. Bu sayade, tür zenginliğinin bitki örtüsünün azamasıyla değiştiğini tespit ettik. Bu çalışmanın sonuçları Türkiye'deki kuş türü zenginliği ile bitki örtüsü arasındaki pozitif ilişkinin genel bir incelemesini sunmaktadır.Dahası, NDVI ve EVI'nin kullanılışlığı tekrar doğrulandı.

Yukarıdaki ana araştırmadan sonra, bazı ormanlık alanları anlamak için daha ayrıntılı çalışmalar denendi. Karadeniz alanlarda orman yapısı ve kuş çeşitliliği hakkında daha fazla araştırma yapılmıştır. Buna örnek olarak orman yapısını doğru yüksek çözünürlüklü verilerle analiz etmek için "Light Detection and Ranging(LiDAR)" kullanıldı.

Türkiye’de Üreyen Kuş Atlası kullanılarak kuşların bol olduğu ve nispeten düşük olduğu alanlar seçildi. 0.4 km ve 10 km uzunluğunda LiDAR nokta bulutu verilerini kullanılarak Vejetasyon Sınıflaması ve Yükseklik Modeli (DEM), Sayısal Yüzey Modeli (DSM) ve Canopy Yüksekliği Modeli (CHM) analiz edildi. Çalışma alanlarındaki ağaç türleri ve ağaç büyüme düzeyindeki farklılıkları kontrol etmek için amenajman planı ve meşcere haritası verileri kullanılmıştır.

Sonuç olarak, genel CHMs eğilimleri benzer fakat tür habitatı zengin alanlar, düşük alanlardan '10 -20m' daha yüksekti. Ek olarak, DEM ile yapılan ölçümlerde kuş türü zengin alanda dik yamaçlar ve eğimler de bulunmaktaydı. Kuş türlerinin zengin olduğu alanda daha fazla ağaç türü vardı. Bu, orman türlerinin biyoçeşitliliği yüksek olduğunu göstermektedir. Gelişme çağları ise, kuş türlerinin zengin olduğu alanda çapları '8-19.9 cm' aralığında olan ağaçların oranı yüksekti. Tepe kapalılığı her iki alan da yüksek derecede tam kapalılığa sahip ormanlardı.

Sonuçlarımız LiDAR'ın orman sağlığını, verimliliğini ve habitat kalitesini değerlendirme etkinliğini göstermektedir. LiDAR gibi çeşitli teknolojiler kullanılarak ormanlar ve habitatlar üzerine yapılan araştırmalar, uygun habitat modelleri oluşturularak ekolojik orman yönetimi oluşturulmasına yardımcı olacaktır.

Habitat ve diğer föktörler,iklim değişikliği, ormanların yapısı vb. arasında kapsamlı ilişki analizleri gerekmektedir.Birki örtüsündeki değişim sırasındaki iklim ve fiziksel değişiklikler de tanımlanmalıdır.

1. INTRODUCTION

The importance of nature and biodiversity conservation is growing worldwide. Several studies have shown that natural destruction and the crisis of biodiversity are obvious facts, which cause various problems (WWF, 2018). Especially, vegetation is influenced by various environmental factors and is also naturally linked to the habitat of wildlife. In recent years, vegetation and forest management plans have been demanded that can take into consideration various factors of ecosystem together and can be managed integrally. Especially, a lot of research is going on in the world to establish an ecological vegetation with forest management plan considering wildlife habitat management (USDA, 2004).

1.1 Background of The Study

For proper ecological management planning, it is necessary to understand the relationship and correlation between vegetation, habitats and species distributions (Miller et al, 2003). Various methods are used to understand the relationship between vegetation and habitats, and suitable habitat models and monitoring methods are being developed. (Duro et al, 2007). In this study I focused on birds among wildlife in Turkey where a very important region for bird habitat and migration. As species of bird are shrinking significantly around the world, they need to be monitored and protected.

The most influential bird habitats are climate and vegetation, the entire plant biocommunity covering the surface. Among them, latitude, longitude and vegetation, which includes canopy, the direct home of most Birds, are more important factors in habitat modeling than climate. (Liang et al, 2018) Therefore, it is no exaggeration to say that the habitat parameter is the same as the vegetation parameter. Of course, with urbanization in recent years, urban habitats are emerging, but in fact they are alternative habitats for natural habitats. Inevitably, we should also consider urban vegetation in our efforts to provide habitat for birds in cities. (Vázquez and Wenlerle, 2013; Melles et al, 2003)

1.2 Moderate Resolution Imaging Spectroradiometer (MODIS)

Remote sensing technology has evolved in various ways to obtain accurate data from the global scale to the local scale. Ecological research using remote sensing also increasing Naturally, the use of data obtained through remote sensing for Species distribution models (SDM) is increasing. (Bonthoux et al, 2018) In this study, MODIS was used to identify the overall change in vegetation in Turkey. In addition, a study was conducted to confirm the relationship between forest structure and bird species using LiDAR targeting some regions of the Black Sea in Turkey. Although it has several limitations, it is expected to be a meaningful study with new possibilities. This can be found in the Appendix B. The main research is to identify the relationship between bird species and vegetation throughout Turkey.

Remote sensing techniques using satellite images are widely used to overcome the spatial and temporal limitations of actual data because they can acquire data on various changes in wide-area scale such as floods, snowfall, drought, and forest fires. In this study, MODIS data was used. (Dinan et al, 2015). MODIS has been used continuously for various studies for a long time. (Gross et al, 2000).

MODIS is the sensor installed in the NASA's TERRA spacecraft launched in December 1999. MODIS data provides high time periods up to four times a day in the mid-latitude region, various spatial resolutions of 250, 500, and 1000m, and multispectral data covering 36 discrete spectral bands, resulting in globally occurring regions of the surface and in the lower atmosphere. It has the advantage of being able to continuously monitor the meteorological changes, vegetation changes and natural disasters. In addition, more detailed measurements of land surface topography, plant growth, as well as global surface even sea level temperatures are now available. MODIS delivers images for a given pixel on land as often as AVHRR, but with special surface dynamics detection technology it provides much finer and more wavelength measurements. For these reasons, various natural disasters at the local or global scale and many related studies are actively conducted based on the MODIS satellite data. It can also be used ecologically to identify changes in ecosystems for vegetation and climate change.(Dinan et al, 2015; Url-1;2)

1.2.1 Normalized difference vegetation index (NDVI)

MODIS and other satellite imagery can be used to create various analytical indices. Among them, the most representative one related to vegetation is NDVI. The vegetation index NDVI, which can be obtained from satellite image data, can be used to quantitatively estimate vegetation vitality and change.(USGS,2013)**.** In this study, NDVI generated from MODIS data was used.

The concept of the Normalized Difference Vegetation Index(NDVI) was first described by Krigler at 1969. And Rouse et al (1973), proposed the first use case. Normalized Difference Vegetation Index (NDVI) is an image processing technique used to emphasize the presence or absence of vegetation. NDVI uses reflectance in the visible wavelength range, 350 nm to 700 nm, which is strongly absorbed by the chlorophyll of vegetation leaves from sunlight, and in the near-infrared wavelength range 700 nm to 1200 nm, which is strongly reflected due to internal scattering from cell walls and intercellular air. It is simply an index of plant growth using near-Infrared reflectance. (Kumar and Silva, 1973). The principle is that the near-infrared reflectance best represents the growth of the plant. NDVI is calculated from the red visible light and near-infrared light that vegetation reflects, while healthy vegetation absorbs most of the red visible light and reflects near-infrared light greatly. However, if it is not healthy or the vegetation is rare, it reflects a relatively large amount of visible light's red band and reflects relatively little near-infrared. (Piekuelek and fox, 1992).

This is calculated by dividing the difference in values between the near infrared and red light bands by the sum of the two bands. This value has no units and ranges from -1 to +1, Closer to +1 means higher vegetation distribution and activity. In other words, The closer to +1, the higher the density of green leaves. The value is close to 0 and -1 it means that vegetation is rare or absent. It is expressed equation (1.1), and various software can get NDVI as follows formula. (Dinan et al, 2015; USGS,2013)**.**

$$\frac{NIR - RED}{NIR + RED} = NDVI \tag{1.1}$$

NDVI has limitations for accurate vegetation monitoring due to weather effects and cloud shadows. Since images are taken very far from the surface, there are obviously errors due to various obstacles. Therefore, the accuracy is increased when using the average value for a long time. Thus, it is used in studies where a wide range of large areas and long-term vegetation averages are required.(USGS, 2013; Url-1)

1.2.2 Enhanced vegetation index (EVI)

EVI was created using more complex algorithms to complement the limitations of NDVI. EVI further considers changes in biomass. Simply, NDVI only checks for the presence of chlorophyll. EVI is an improved index for identifying vegetation distribution, taking into account canopy morphology and atmospheric effects. In particular, EVI is known to be more sensitive than NDVI to topography. In high mountain ranges and varying terrains, EVI is mostly smaller than NDVI. Therefore, when examining large areas with complex topography, many more variables, other factors must be considered. As EVI is more sensitive data, it requires a terrain-based filtering technique when using large area and long term data. (Matsushita et al, 2007). EVI formula for general application is as follows equation (1.2). However, since the accuracy is different, it is common to use EVI data which is mostly measured by standard. (Dinan et al, 2015)

$$2.5 \frac{NIR - RED}{NIR + 6\,RED - 7.5\,BLUE + 1} = EVI \tag{1.2}$$

Some countries with varying heights have found that NDVI is more appropriate as a national vegetation index. This depends on the environmental characteristics of the country. This requires various studies in different countries and regions. Thus, EVI is used for intensive and detailed investigation of non-wide areas, especially for research cropland changes, agricultural field. Some of countries leading agriculture use EVI to identify regional cropland changes and rainfall patterns.(Url-2; Moreira et al, 2010).

1.3 Purpose of the Study and Hypothesis

Previous studies have shown that vegetation changes affect the population and diversity of birds. (Seto et al, 2004; Liang et al, 2018) Although no universal rule or pattern is defined, some linkages have been identified between the vegetation index and bird species richness. Green areas and vegetation are very important role in the habitat of birds, so it is theoretically true that the diversity of birds increases as vegetation increases. (Oindo et al, 2000; Liang et al, 2018). But this needs to be proved through statistical analysis. Therefore, on the premise that there is a positive relationship between Bird Species richness and Vegetation. (USGS, 2013) This study aim to identify how the bird atlas breeding data prepared through field research and vegetation index of Turkey are correlated. In this study, the previous studies were identified and applied to Turkey, and attempted to analyze the correlation with bird species richness by calculating the NDVI mean, maximum, and standard deviation. (Seto et al, 2004; Oindo et al, 2000) The main analytical index was adopted as NDVI and additionally EVI was used for a better conclusion. EVI, which is sensitive to topography, is smaller than NDVI and is expected to be different pattern with NDVI. Prior to analyzing the correlation with bird species richness, it was also confirmed changes in Turkey's NDVI and EVI. That will allow for a more detailed analysis of the year and month, assuming that there has been a meteorological or physical change in the year and month when the vegetation index has changed significantly. This study only proceeded to identify the months and years that have changed within a period of time.

In other words, the purpose of this study is to use NDVI and EVI from MODIS data to identify vegetation changes throughout Turkey and, to find a correlation between the vegetation index and bird species richness from Turkish breeding bird atlas project.

1.4 Estmation of Forest Sturucture using Airborne LiDAR

In addition to the general and extensive research using MODIS, I did further research to try some more specific areas. I used LiDAR, which was newly used, and conducted a secondary study, which meant that some errors could be made. It is added separately after each chapter of this thesis. Thus, each chapter is divided into two parts. the main research using MODIS and the additional research using LiDAR.

Turkey’s black sea region need more protection, since many endangered birds are inhabited. In this study, I used Airborne LiDAR to compare forest metrics between two areas where have different bird species and population in Black sea region, based on Turkish Breeding Bird Atlas data. The tree composition of the forest management plans data was further checked to determine the influence on the species richness of birds.

1.4.1 Light Detection and Ranging (LiDAR)

Various remote sensing tools have been used since the past, including on-site research. Traditional field research require a lot of labor force to carry out research on a large area, and there are limitations in acquiring information on the entire area because data is acquired through sampling. In order to overcome the limitations of the field measurement method, a method of using remote sensing tools such as aerial photographs and Landsat satellite images has been developed. However, the use of remote sensing tools such as aerial photographs and satellite imagery has the disadvantage that errors can occur due to shadows due to steep slopes and the altitude of the sun, and because it deals only with data on two-dimensional planes (Baltsavias, 1999; Zellweger F et al, 2013).

Forestry advanced countries are using various remote sensing technologies for studies, Light Detection and Ranging also one of them. A method of measuring using a remote sensing sensor called LiDAR has been steadily researched and utilized. The LiDAR sensor computes the time of light emission by the active sensor and the time of sensing the light reflected by the target so that the shape of the target is represented by point cloud data having three-dimensional coordinates of X, Y, and Z values point cloud). It has been reported that the resolution of images acquired by LiDAR can be adjusted to be high or low, and that the accuracy of images is considerably high (Simard. 2011; Sasaki T, 2016). Among them, LiDAR data research using aircraft has the advantage of being capable of accurately outputting a large area object in the form of three-dimensional position coordinates with high resolution.

1.4.2 Purpose of the Study and Hypothesis

The purpose of this study is identifying factors that may affect bird diversity, to compare parameters between forests with high and low bird richness using Airborne LiDAR data and forest management plans data. The complex parameters of the forests was assumed to affect species richness. Especially, the Canopy Height Model of the two regions with different species richness of birds would have a big difference. I would like to find the answers to the following questions as follows objectives.

- Can LiDAR data explain the structure of forests that affect the bird species richness and distribution?

- What is the difference between the CHMs of the two regions with different species richness?

- What is the most important forest parameter for bird habitat in this study?

For a further purpose, it demonstrates the advantages of using LiDAR, and will make it possible to use LiDAR technology in many ecological studies in the future.

2. METHODOLOGY

2.1 Study Area

The study area is Turkey, part of the northern hemisphere between Europe and Asia, located at latitude 38.9637451 and longitude 35.2433205. The area is about 780,000km², long and extends east-west than north-south. The coastal regions of Turkey, facing the Mediterranean Sea, have a mild Mediterranean climate, with hot and dry summers and cold, wet and temperate climates in winter. Inland areas are very dry and have low rainfall. Inland of Turkey has a continental climate with very large seasonal differences due to the many mountain ranges close to the coast. Turkey has a wide variety of vegetation due to its large area and diverse climate. Therefore, a variety of animals are inhabited and these species vary from region to region. (Doga Dernegi, 2006)

In this study, analysis of vegetation parameters, Vegetation Indices, NDVI and EVI from MODIS, were conducted throughout Turkey. In the correlation analysis of vegetation indices and birds species richness data by atlas project were carried out, except for 12 squares where did not investigate. (Boyla et al, 2019)

2.2 Study Design

The main point of this study is to identify the correlation between bird species richness data in the Atlas project and NDVI, EVI selected by the vegetation parameter in each region. The Atlas project was performed from March to July every year from 2015 to 2017, with most areas investigated between 2016 and 2017. Therefore, MODIS data observed during the same period were used, March to July from 2015 to 2017.

It is necessary,to calculated the average of the vegetation indices NDVI and EVI from March to July each months, and then look at what has changed in Turkey's vegetation over the three years from 2015 to 2017. As in Bonthoux et al (2018), Habitat modeling is possible by using basic predictors not only in climate but also in a suitable period of NDVI. Additional NDVI and EVI values were calculated over the two years 2016 to 2017, since the atlas project most of field observations were made in 2016-2017. (Boyla et al, 2019). The two years of data were used more. Atlas squares were placed on theses NDVI, EVI maps of Turkey. Thus, each square has a different vegetation indices and bird species data. The study was conducted to confirm the correlation between bird species richness and vegetation index NDVI, EVI.

ENVI 5.3, QGIS 3.4, ArcGIS 10.2.2, Excel 2016 and R Studio 1.1.456 were used to analyze and process these data.

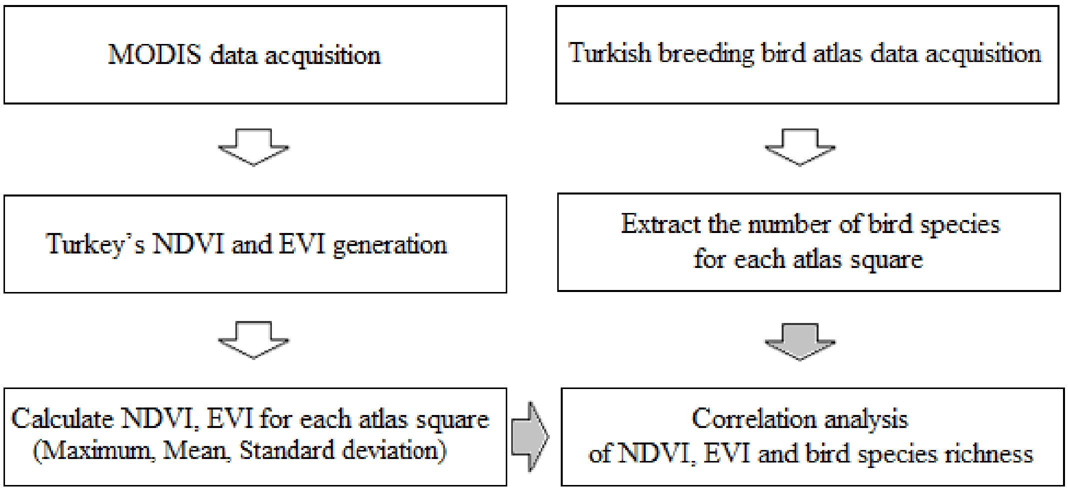


Figure 2.1: The whole process and steps of the study.

2.3 Data collection and Processing

For this study, data from two fields were collected and processed using different methods and different programs. The bird species of Turkey, the base of the study, used Turkish breeding bird atlas data and MODIS data to determine the vegetation of Turkey. The collection and processing of each data for analysis is described in detail below.

2.3.1 Turkish breeding bird atlas data

Bird species richness data were retrieved from the Turkish Breeding Bird Atlas which was started in 2014, and published in 2019 by WWF. It is one of the big project to birds monitoring. Atlas project was collects data on the existence, richness, and distribution of birds, studies them, deals with specific geographic areas, and includes mapping components (Dunn and Weston, 2008). Monitoring routes are systematically placed in the landscape in a 50x50km grid. Each route is 5x5km with two research points. The resarch is performed under favorable weather conditions by competent volunteers as well as professionals. All birds seen or heard are registered. It is desirable to conduct the reexamination every 2-3 years, but some are reviewed less regularly. Turkey has a total of 375 Atlas squares, 50x50 km grid size each, to all border. Field observation is the basis of Atlas research. In 2014, only two squares were visited, followed by a full survey until 2017. Some squares have been surveyed over the years, but most squares have been surveyed between 2016 and 2017. Based on this, I analyzed the Vegetation Index from 2015 to 2017.(Boyla et al, 2019)

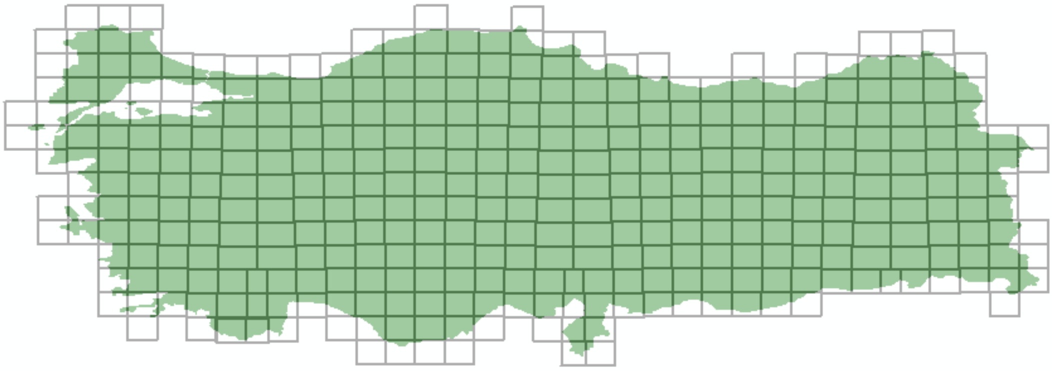


Figure 2.2 : Distribution of atlas squares in Turkish breeding bird atlas project.

Different bird species from different regions, squares data was extracted from The Turkish breeding bird atlas dataset. In atlas data, different numbers are assigned to atlas squares. Provides data containing the names of the birds observed in each square. The number of bird species in each Atlas square is summarized using Excel. Instead of thinking about population, without considering habitat or migration. I focused on the diversity of species of birds. Twelve of the 375 Atlas squares were not investigated in the Atlas project. Thus, only the bird species richness of 363 atlas squares, excluding 12 squares on the seas, is summarized (Table A.1).

This study focused on identifying the relationship between Species Richness as the vegetation distribution increased. Therefore, the relationship between the Species Richness and the minimum value of NDVI, which are mostly negative values, is not addressed. It did not cover. Naturally, the atlas data includes the number of birds living on the watersides or stones. However, not only the birds found in the habitat, but also the species observed while flying. The study was admitted that this could be an error. This section will then need to be studied separately by habitat. (Hobi et al, 2017)

2.3.2 MODIS data : Vegetation Index (NDVI, EVI)

The basic satellite data for identifying vegetation parameters was the DAAC Link: MOD13A3 V6 of MODIS Vegetation Indices Monthly L3 Global 1km. This was downloaded from the U.S. Geological Survey. (Url-3). I had to download six large region pieces of data to get one Turkey country boundary raster. Download and use MODIS Terra data from 2015 to 2017 each March to July when the Atlas project was carried out. The MODIS, MOD13A3 offers several bands, including near-infrared light and visible red light. In addition, they provide their own NDVI and EVI. In the process, NDVI was created by calculation using bands provided by MODIS, it is confirmed that there is noise and empty space in a part. It has shown additional noise reduction and pretreatment were required. (St-Louis et al, 2013; USGS, 2013). Therefore, the study decided to use the MODIS generation standard NDVI and EVI distributed by USGS. (Mingguo et al, 2011) In addition, as mentioned earlier, the main data to use and focus on is NDVI. EVI was used to further confirm this. Even if the flow is similar to NDVI, the relationship between vegetation change and bird species can be further explained. In addition, I tried to confirm the difference between Turkey's NDVI and EVI. (Garbulskya et al, 2014; Dehling et al, 2014)

First of all, Download six data sets covering the regions of Turkey. These data are provided in Hierarchical Data Format (HDF) files were converted to the Raster file as Tagged-Image File Format (TIF). ENVI 5.3's MODIS conversion Toolkit (MCTK) was used. And a pretreatment was needed to get a map of Turkey. Each of the six regional pieces were merged using QGIS and clipped to the boundaries of Turkey. Thus only Turkey was mapped separately, Repeat this process obtained the NDVI from March to July of each year. The 1-year NDVI was calculated as the mean value of the NDVI for 5 months.(Figure 2.3; Table A.2). In this way, the change in Turkey's NDVI over the period of time was identified.

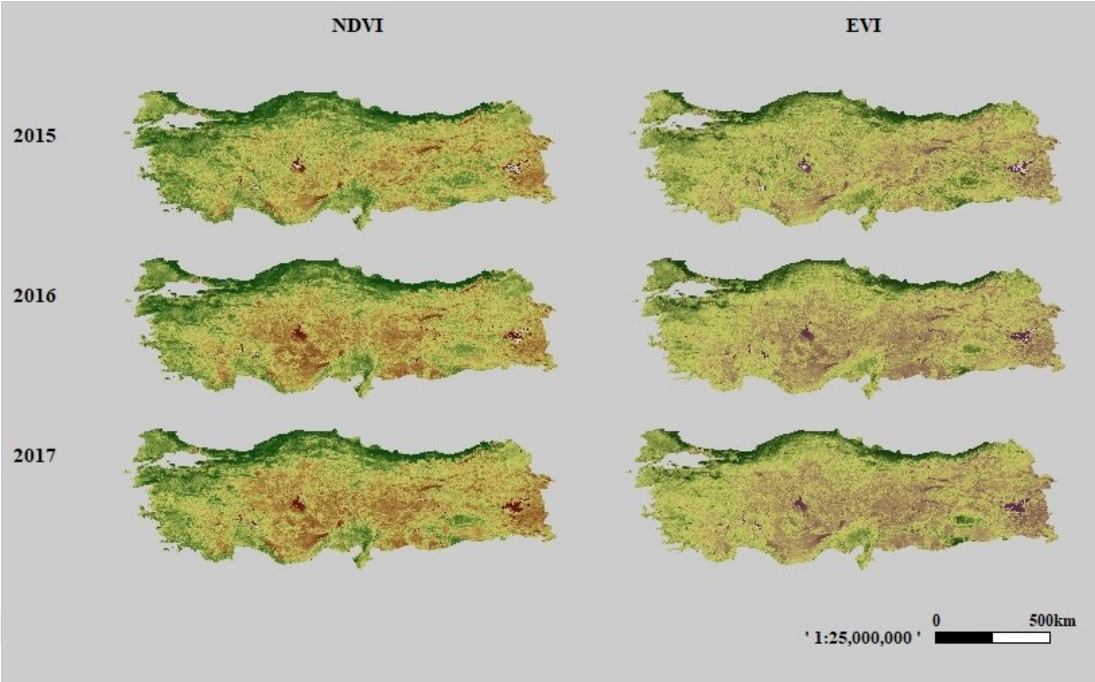


Figure 2.3: NDVI and EVI maps from 2015 to 2017 in Turkey

In this process, Mean, Maximum, Standard deviation values were calculated and used for analysis. The minimum value was not used because this study was conducted on the premise that the increase in vegetation proved by the previous studies had a positive relationship with increasing species richness. (Liang et al, 2018). In many studies using vegetation index, the mean value is generally used the most because the mean value is the most reliable. In addition, the relationship between the maximum values and the higher species diversity was also examined. If there has a correlation, whether it is smaller or larger than the correlation with mean value was also the main confirmation parts. Standard deviation is a value that can determine the degree of deviation from the average under the same conditions as the actual data value, and was selected as a sub-variable to check whether the correlation coefficient is properly obtained and has regularity. (Nieto et al, 2015; Oindo, 2002). Subsequently, I calculated three years of NDVI from 2015 to 2017, and two years of NDVI from 2015 to 2016 and 2016 to 2017. (Figure 2.4).

The EVI dataset also repeated the same process. (Figure 2.5). These processes were done through QGIS 3.4. In this way, Turkey's NDVI and EVI changes were checked. The obtained NDVI and EVI values shown the change of vegetation. And it is used as a variable to check the relationship between vegetation and bird species richness.

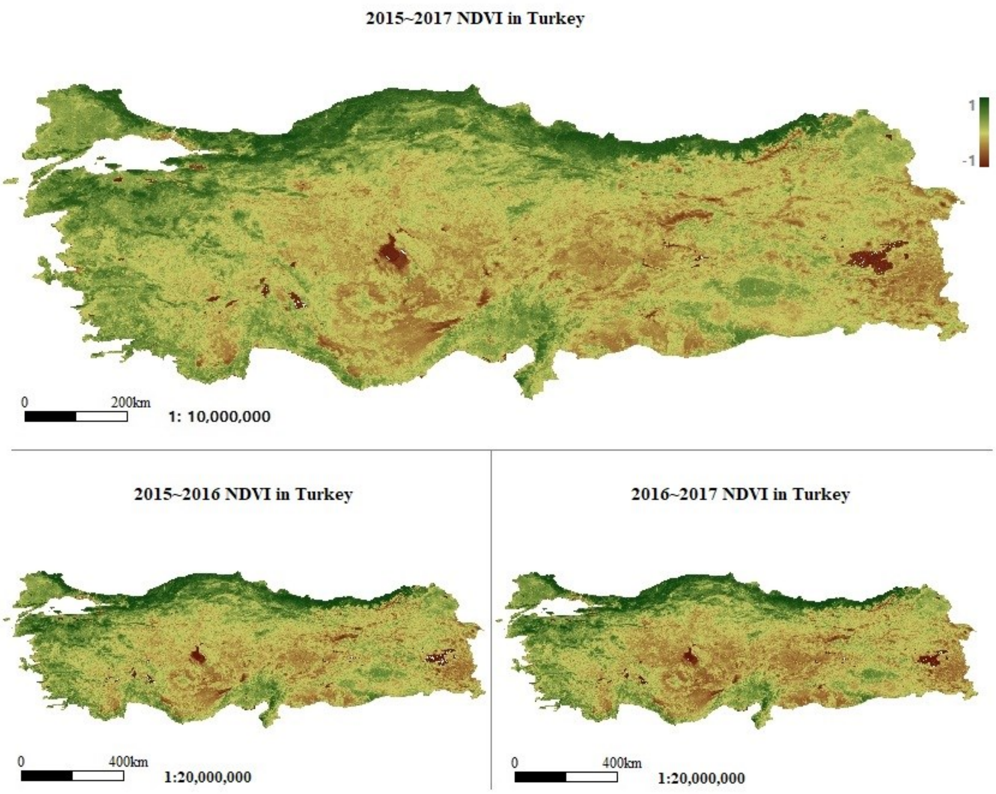


Figure 2.4 : NDVI maps for three years and two years in Turkey.

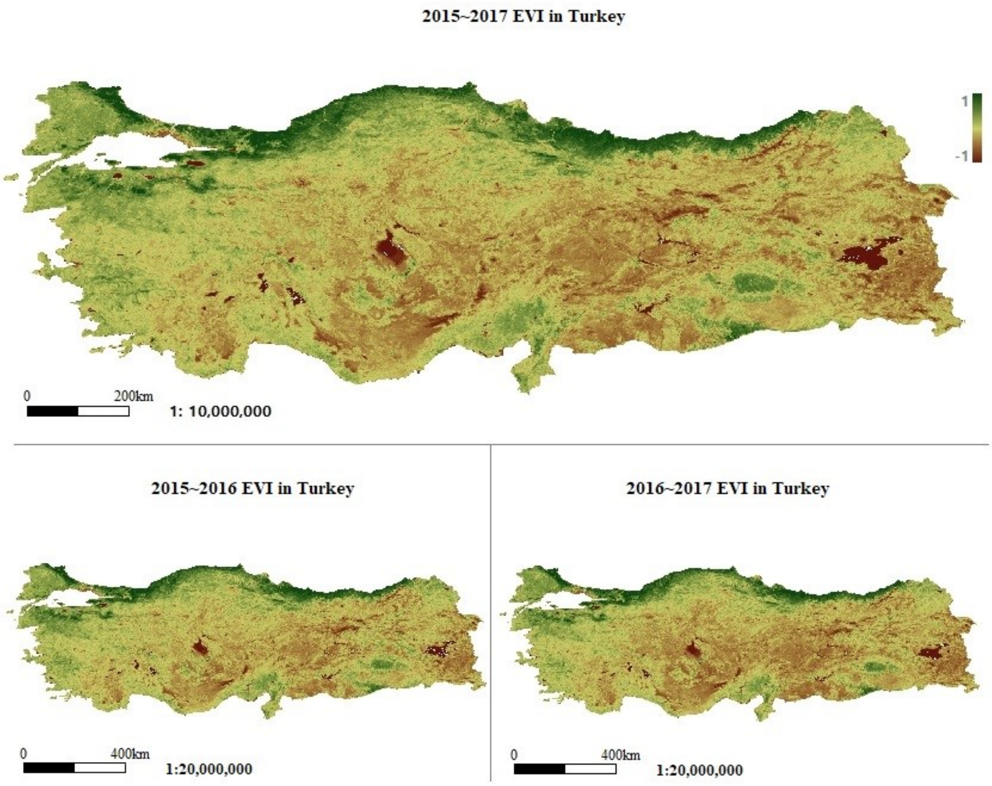
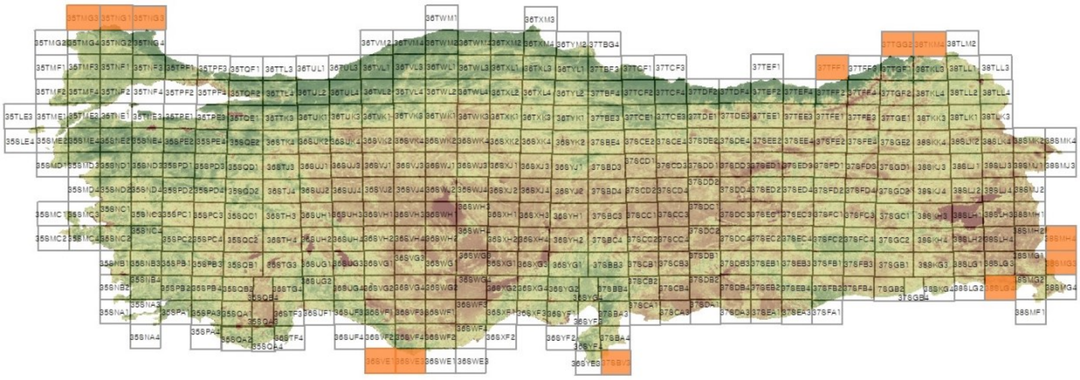


Figure 2.5: EVI maps for three years and two years in Turkey.

The NDVI and EVI values for each square of Atlas data were calculated using QGIS's Zonal Statistics tool. The dataset is created that contains the NDVI mean, maximum, and standard deviation for each square with Atlas 50x50km grid 375 squares layer (Figure 2.6).The datasets were obtained separately, for one year, two years, and three years of NDVI and EVI values.



*The area marked in red are oceans, bird observation is not made

Figure 2.6 : Atlas squares dataset layered with NDVI maps.

As a final step, I analyzed the correlation between bird species richness and mean, maximum, and standard deviation of NDVI and EVI. In the R studio, Regression analysis was used. The relationship was evaluated using R's summary function and Pearson's Product-Moment Correlation test.

First of all, a simple regression analysis with two variables was performed by summary function in R studio. Significance probability, P-value, indicates the level of significance. Smaller values mean that the regression coefficient is significant and that there is a correlation between the variables. The significance codes indicate how much the coefficient can affect the dependent variable. The star mark '*' is printed according to the significance codes. Since the significance level is set at 5%, it can be said that there is a correlation between variables even if only one star is printed. Since the significance level is set at 5%, If the value is greater than 0.05, there is no regression relationship. The regression coefficients are not statistically significant at this time. (Url-4; Dinan et al, 2015)

Pearson's correlation coefficient also measures the statistical relationship between two variables. The value of the correlation is between -1 and 1. The correlation coefficient is negative if one variable increases and the other tends to decrease. Conversely, if two variables tend to increase together, the correlation coefficient is positive. The larger the number, the greater the slope, and the stronger the correlation. In general, a value of greater than 0.2, the absolute value, is considered to be a definite correlation. The table explains what Pearson's correlation coefficient (r) represents. (Table 2.1).

Table 2.1 : The meaning of the Pearson correlation coefficient (r).

Correlation coefficient(r)	How to understand the correlation coefficient (r)
r=1	Indicates a strong positive relationship.
0	Indicates no relationship at all.
r=-1	Indicates a strong negative relationship.
0<|r|	larger value indicates the stronger relationship.

2.4 Estmation of Forest Sturucture using Airborne LiDAR

The Black Sea region is very important in terms of biodiversity, with balanced precipitation and wetlands, high mountains and lakes. Several birds, including European protected species, also live in the Black Sea region and are used as transit. (Doğa Koruma Merkezi, 2011). Based on the Turkish breeding bird atlas, I was set the study area to the eastern forests of Ulus and İnaltı regional forest with different Bird richness.

Black Sea regions square specified in Turkish breeding bird atlas data, the squares showing the greatest difference in bird richness and inside each squares the forest areas, as width 400m length 10km, that not the most artificially developed were selected to this study. The selected two areas were divided into A and B, and forest metrics were examined using Lidar data. In addition, I used forest management plans data to identify the differences in tree species and growth levels in the areas.

Figure 2.7 : Study area. The white part is the Atlas squares used for the study.

The yellow part is the two forest regions where the Airborne LiDAR data are collected (Figure 2.7). The areas where the collected Lidar data, 0.4 km wide and 10 km wide, respectively may have many limitations and errors because they are relatively small in Atlas square (50 km x 50 km). However, considering that the living around habitat distance of birds is not short, they don't stay only one place, and the forests are also close to each other, I think that can find even difference flow (Stratford & Şekercioğlu, 2015; Jokimäki & Solonen T., 2011). The research conducted under the assumption that birds observed in the Atlas squares (50km x 50km) could live in or stay in all the forests in the square.

I used Lidar360, Terrasolid's TerraScan software, ArcGIS 10.2.2 and R studio for processing and analysis of data. The canopy horizontal and vertical structures by LiDAR data. It could successfully identified as predictors of bird species richness in forests (SJ Goetz et al, 2007). I analyzed Canopy height model (CHM), Canopy cover and tree density using cloud point LAS data of airborne LiDAR data, and calculated Raster models, DSM and DEM. After then I combined it with other data to see what the difference is between the two regions.

2.4.1 Data collection and processing

For this further research, I collected data and processed each data in a different way. Base data on bird species that inhabit the forest has used the Turkish breeding bird atlas data in a slightly different way as previously progressed main research. The most important Airborne LiDAR data used for further study. Finally, field survey data used to extract the necessary portion of Forest management plans data (Amanajman).

2.4.1.1 Turkish breeding bird atlas data

The Turkish breeding bird atlas project is a large birds monitoring project in Turkey, started in 2014 and carried out and arranged by competent volunteers and experts, field observations continued until 2017, and were realeased through the WWF in 2019. The results of this project provided as open data free access to detailed information on Turkey's birds. (Kerem A. B., et al, 2019).

All bird species are registered in the atlas data. However, not all species were of interest in this study. Only forest-associated species were included, a total of 107 species listed in Table A.3. Non-forest species were excluded. In order to classify the habitat, I searched for IUCN and eBIRD websites by species name (Url-2; Url-3). I include species that have Forest and shrubland as habitats, and other species do not have such as wetlands, savannas, artificial/aquatic and marine, artificial/terrestrial, caves and subterranean habitats (Table A.3).

The square 'a' species richness is higher than 'b'. The number of bird species observed in both atlas squares ‘a’ and ‘b’ is 32. Twelve birds were observed in area ‘a’ and only one species was in ‘b’. (Figure 2.8). I used only forest-associated species of A and B.

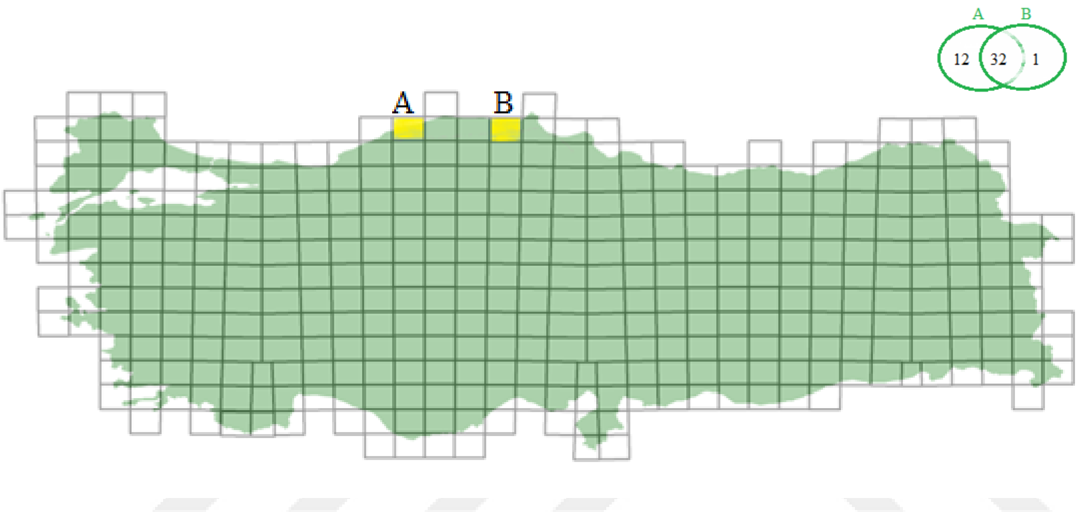


Figure 2.8 : The research point squares of Turkish Breeding Bird Atlas project.

2.4.1.2 Airborne LiDAR data

This Lidar data collection took place from 5 to 15 July 2018. From Bartın to the Sinop region in northern Turkey, the data were measured 400m wide and 317km in total length. The original purpose of data collection was for the energy transmission line project. Based on the Bird Atlas data, I asked for data on areas where birds are observed and less observable. With the help of the Deltalidar that company of made the measurements, LiDAR data of two regions, each about 10 km in length, could be obtained for research purposes.

The Airbone LiDAR data collection was performed at 20 points per square meter using the 'Riegl ALS-Q680i' laser scanner installed on the 'Cessna 206' model aircraft and the 'IGI Digicam H39' camera. The acquired data were converted to WGS 84 UTM 36 coordinate system for analysis implementation.

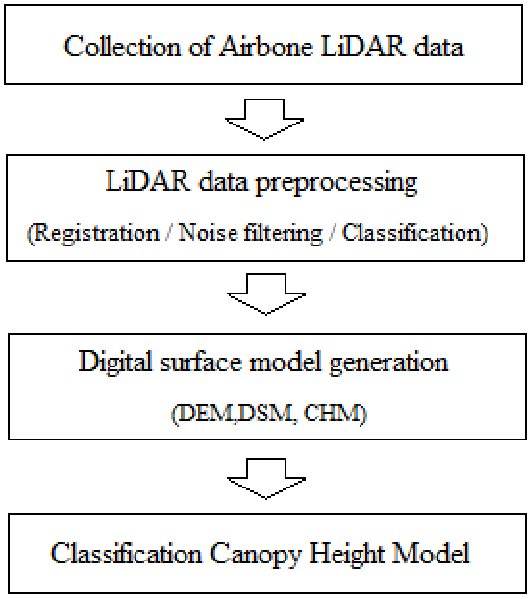


Figure 2.9 : Data processing and Analysis flow.

Point cloud classification

The collected raw Lidar data using the algorithm within the software TerraScan and Lidar360 proceeded to point cloud filtering and classification tasks. When scanning with a LiDAR sensor, areas where buildings or birds fly are reflected, point data may be generated at distances farther than normal. The points were removed using the TerraScan and Lidar360 software. The filtered point cloud data are classified into height from the ground, vegetation and building(Table 2.2; Figure 2.10). Comparisons with CHMs to be made later are also possible and useful.

Table 2.2 : Point cloud classification.

Classification	Vegetation height and classification method.
High Vegetation	250 cm – above
Medium Vegetation	30 cm - 250 cm
Low Vegetation	0-30 cm
Buildings	Check the point cloud shape
Water	Check the point cloud shape
Ground (Topography)	Find the spot where Light Detection was last retrieved.

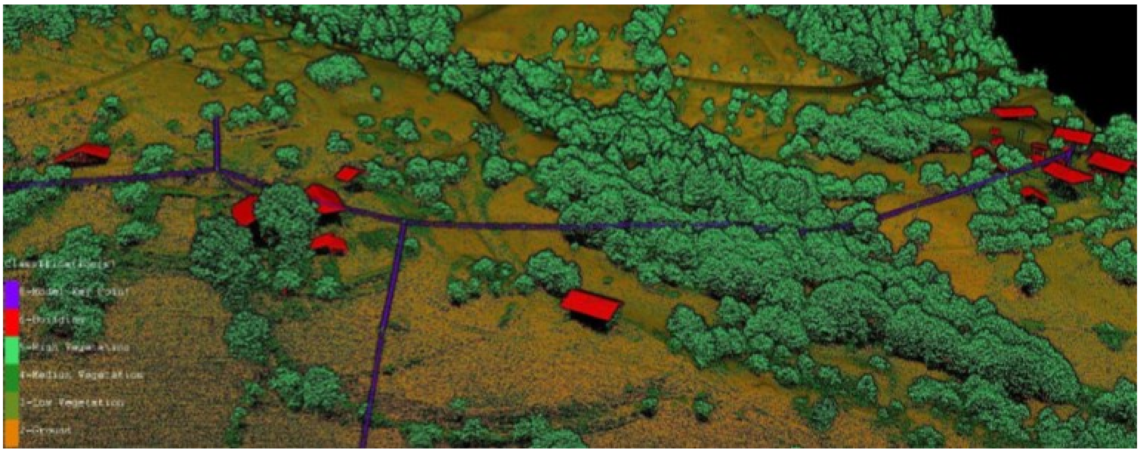


Figure 2.10 : Point cloud classification.

Production of DEM/DSM

After the classification process, a digital elevation model (DEM) was created using the ground layer, and a digital surface model (DSM) was created using the other layers as a top of the surface representing the forest canopy line. The resolution was 20 cm (Figure 2.11).

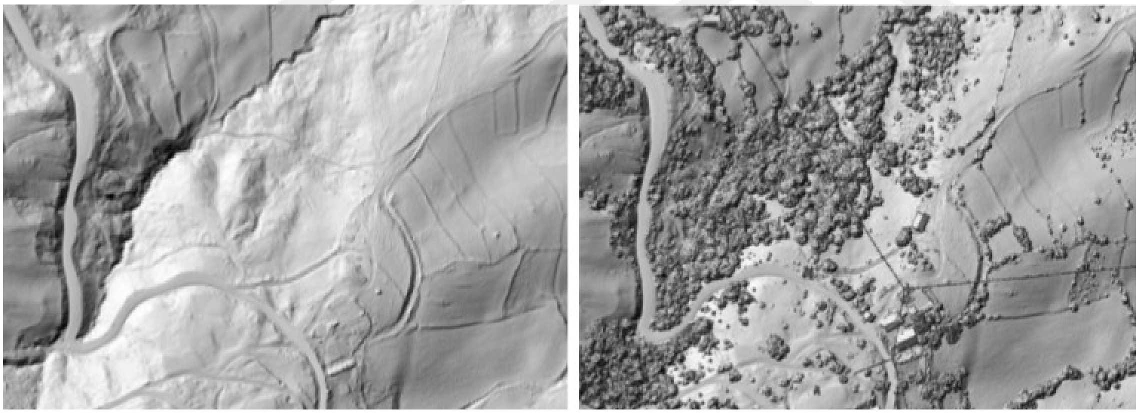


Figure 2.11 : Digital Elevation Model (Left), Digital Surface Model (Right).

Canopy height model (CHMs)

Canopy has been identified as the most important forest metrics for species distributions and richness (Bakx et al., 2019). Canopy structure is proposed as an important factor affecting forest sustainability (Hardiman et al., 2013). Since tree canopy is a place where plant-environment interactions occur, and it is known to react immediately to other disturbance elements, it is necessary to know when to assess the health status of forests (Norman and Campbell, 1989).

In Europe, LiDAR based canopy heights and percentage of canopy cover correlated well with bird distributions in lowland British conditions. To calculate the density of canopy, DSM and DEM raster were confirmed using ArcGIS. The CHM is part of DSM except DEM as shown below. Therefore, it is obtained by DSM-DEM. the CHM was created using R studio's raster package. The generated CHMs are classified as shown in (Figure 2.12) according to the height.

The accuracy of DEM and DSM is often lowered through satellite images. With LiDAR, however, there is a big advantage that accuracy can be enhanced through point clouds and direct uncertainties can be directly checked in part. In fact, I was able to make DEM and DEM relatively simple.

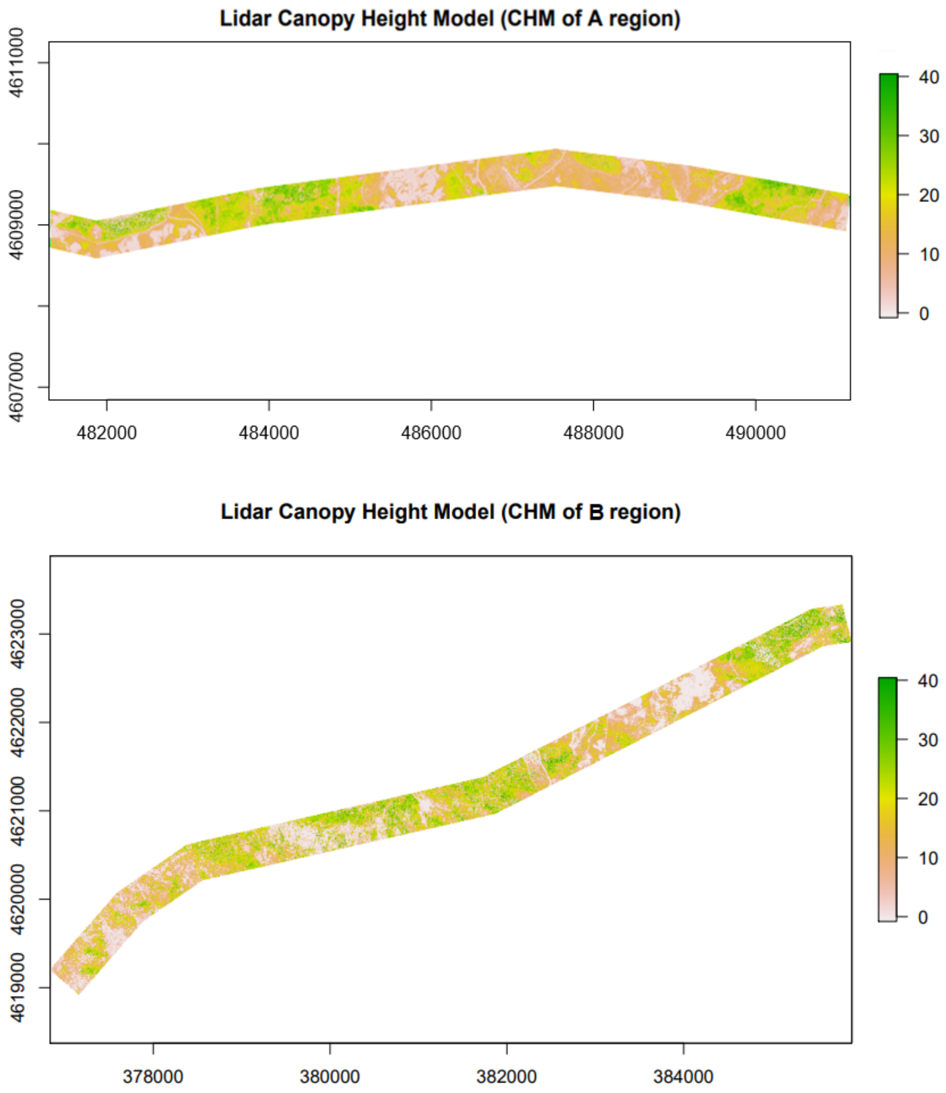


Figure 2.12 : Canopy Height Model

2.4.1.3 Forest management plans data (Amanajman)

Forest management plans (Amenajman) data has been performed and updated for a long time. It was planned and carried out to develop a forest management model plan for Turkey. As the significance of forests has increased in modern times, it has been pursued in order to pursue economic feasibility in the multipurpose use of forests, and to solve the problems that may arise and manage them smoothly (Unal and Ahmet, 1993).

The type, age, and degree of closure of trees are very important for birds habitat. Because the species used for habitat varies from species to species, it is necessary to conduct long-term research on habitats of specific species. (Sasaki T, 2016). In the Meşcere polygon Type data of Turkey's forest management plans provided by the Forest Resources Department, I extracted the Wood type, Development Diameter at breast height (DBH), and closedness by the canopy density values of the plolygons in the A and B regions (Table 2.3). However, since the size of the geographically divided plots are different, it is inevitably selected as a polygon somewhat larger than the area where Lidar data was collected (Figure 2.13).

Region A Region B

Figure 2.13 : Forest management plans data plot polygons(Bölmecik).

Table 2.3 : Development Diameter at breast height (DBH by 1,30m).

Classification	Diameter at breast height (at 1,30m)
A	< ,= 7,9 cm "youth"
B	Between 8-19.9 cm "poles"
C	Between 20-35,9 cm "thin wood"
D	Between 36-51,9 cm "middle wood"
E	>,= 52 cm "Thick wooded"
0	Defined as an empty or emptied forest area.

Data was not examined and the data was not accurate or empty. Therefore, the section labeled 'Other plant (Other Yaprakli)' was excluded. Because I only need forest areas, I also excluded Settlement area and Cemetery (Is). Mixed forests with two or three trees in one plot/polygon(Bölmecik) were calculated assuming that each tree occupied the same proportion (Table 2.4). For exampel, tree 1 and tree 2 has 10ha, It was used in the calculation as follows : 5 ha has tree 1, 5ha has tree 2. In the case of Age by DBH, the mixture was extracted in thinner stages. For example, when B, C mixture, It treated as B.

At last, to understand the top crown closure level, it is recommended to look at the photo in the appendix, Figure A.1.

Table 2.4 : Top crown closure level

Classification	Top crown closure level
1	Top closure 11-40% “Loose closed”
2	Top closure 41-70% “Medium closed"
3	Top closure 71-100% “Full closed”

3. RESULTS

3.1 Vegetation changes in Turkey

To understand the overall scope of the change, the first identified Vegetation changes in Turkey through three years of NDVI and EVI changes. After identifying this change, an analysis with Bird spcies data was performed.

3.1.1 The normalized difference vegetation index (NDVI)

NDVI distribution in Turkey was performed using MODIS imagery, for three years from 2015 to 2017, each year from March to July. As shown in Table 3.1, the NDVI Maximum value was highest at 0.87 in 2016, followed in 2017 and 2015. The NDVI Mean value was the highest 2015 with 0.30, the second in 2016 and the third in 2017. In addition, it can be seen that the NDVI value decreases by about 0.011 every year.

Table 3.1: NDVI value by years (2015~2017)

Year	MAXIMUM	MEAN
2015-2016	0.85326	0.29634
2016-2017	0.86092	0.28497
2015-2017	0.84975	0.29062
2015	0.84640	0.30192
2016	0.87178	0.29076
2017	0.85054	0.27918

Each month, the NDVI has the pattern shown in Figure00. It can be understood that the maximum value did not show the same flow for three years, but the mean value showed a similar flow. Maximum values were highest in May in 2015, March in 2016, June and July in 2017. In total 15months, June and July of 2017 had the highest values. Simply, June and July of 2017 had the highest green density from 2015 to 2017, in Turkey. In the case of NDVI Mean, May was the highest in 2015 and 2016, June in 2017. In the 15 months, the mean value in May 2015 was 0.34, the highest. Full details can be found in Table A.2.

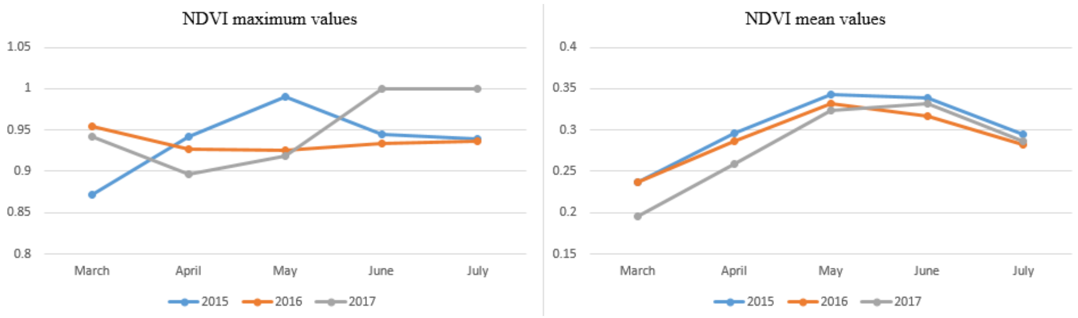


Figure 3.1: NDVI value by month (March~July, 2015~2017)

3.1.2 The Enhanced Vegetation Index (EVI)

The EVI tended to be slightly different from the NDVI, The the highest value of EVI maximum at 0.6648 in 2016, next is 2015, 2017. The highest value of EVI mean was 0.1855 in 2015, followed by 2016, and the lowest of three years was 2017. (Table 3.2)

Table 3.2 : EVI value by years (2015~2017)

Year	MAXIMUM	MEAN
2015-2016	0.64911	0.18334
2016-2017	0.62259	0.17593
2015-2017	0.62619	0.17914
2015	0.63886	0.18556
2016	0.66482	0.18111
2017	0.61688	0.17076

The EVI Maximum values were highest in June 2015, 2016 and 2017 was April. This can be seen in Figure 3.2. April 2016 was the highest at 0.865 of all 15 months. EVI Mean values were highest in June 2015, May 2016, and June 2017. In the total 15 months, June 2015 was the highest with 0.2195. EVI decreased by 0.00445 from 2015 to 2016 and 0.0135 from 2016 to 2017. The decrease rate increased.

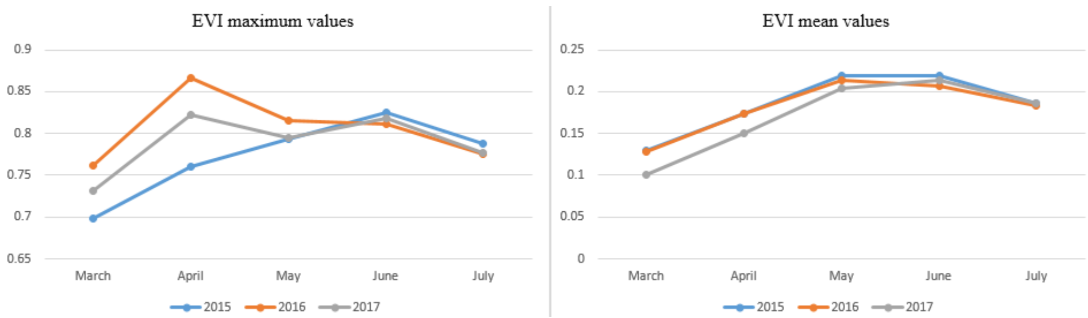


Figure 3.2 : EVI value by month (March~July, 2015~2017)

In both NDVI and EVI, the average value was the highest in 2015 during three years and gradually decreased.

3.2 Correlation between Bird Species Richness and Vegetation Indices

In this study, the relationship between vegetation index and Bird Species Richness was analyzed using R summary Function and Pearson's Product-Moment Correlation test. The relationship between the variables is represented by Scatter plots and linear regression graphs.

3.2.1 Bird species richness and NDVI

The significance probability, p-value, and The correlation coefficient, r, representing the relationship between Species richness and NDVI are shown in Table 3.3 and Table 3.4. The overall trend can be seen in scatter plots, linear regression graphs. (Figure 3.3; 3.5). Scatter plots show the NDVI and bird species richness values for the same square. The slope of the blue line indicates their degree of correlation.

First, the relationship with the NDVI mean value is spread over a wide range in terms of scatter plot. Species richness spreads in varying amounts when NDVI mean is between 0.2 and 0.6. The relationship is positive but not distinct. (Figure 3.3)

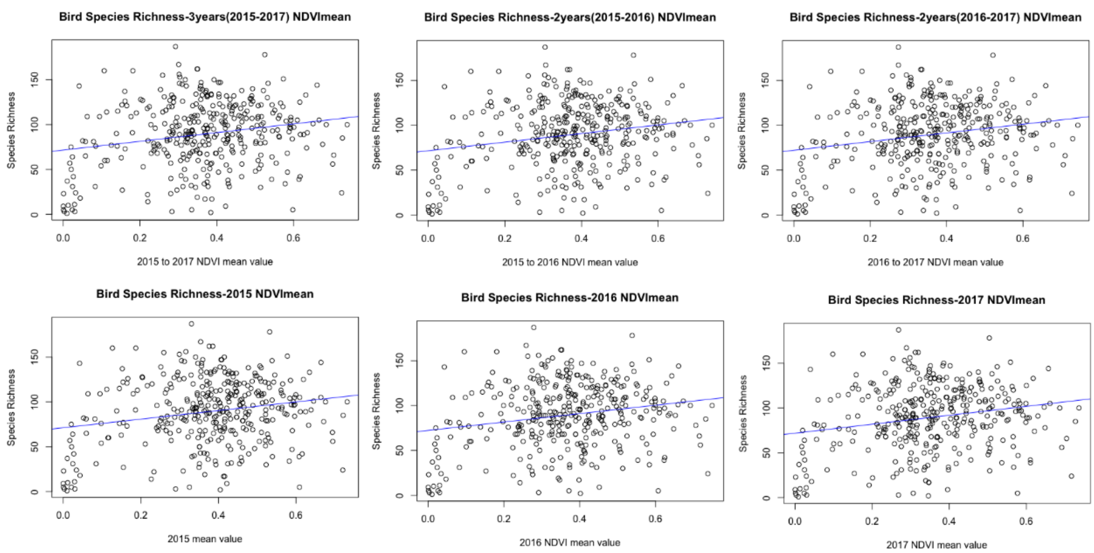


Figure 3.3 : Relationship between Bird species richness and NDVI mean.

The Figure 3.4 shows the relationship between NDVI maximum and species richness. Species richness of atlas squares with large NDVI maximum values tends to be more diverse and is clustered to one side. Relatively clear compared to result of species richness and NDVI mean value.

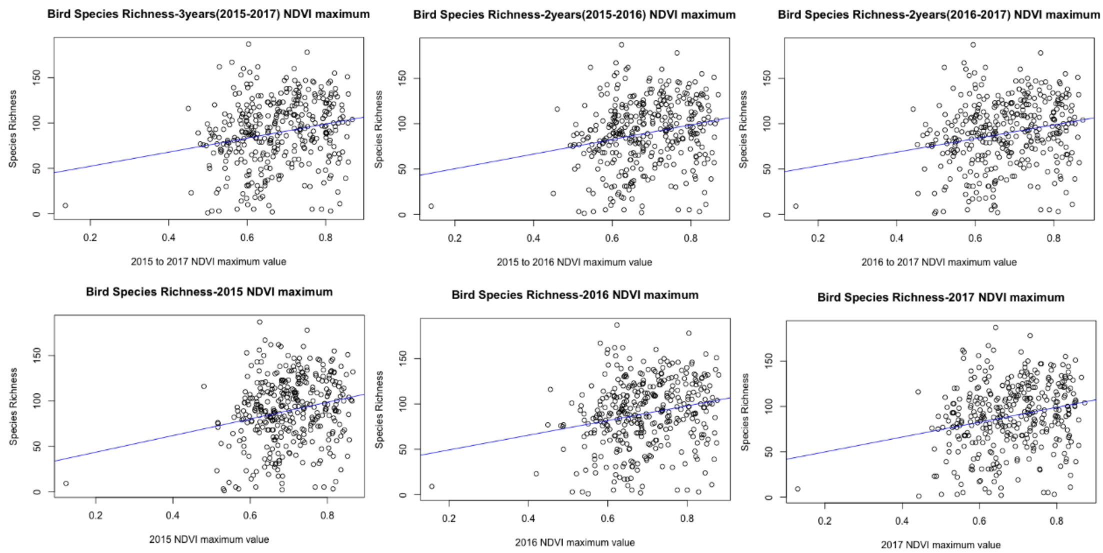


Figure 3.4 : Relationship between Bird species richness and NDVI maximum.

The trend of the standard deviation, which represents the degree of deviation from the mean, is shown in figure 3.5. Most of the values of the NDVI standard deviation are distributed around 0.1. Some points with a value of 0.2 or higher can be expected where the maximum and minimum values are present. (Figure 3.5)

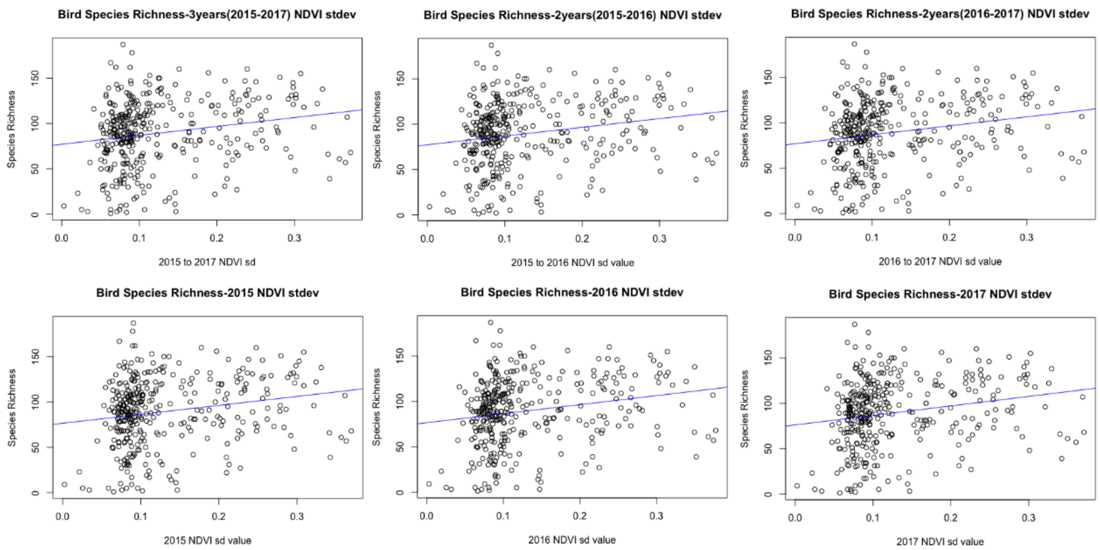


Figure 3.5 : Relationship between species richness and NDVI standard deviation.

In the case of NDVI, the p-value of each variable was lower than the set significance level of 5%. Thus, it was confirmed that there is correlation significance through the p-value. However, because the value is very small, I additionally checked Pearson's correlation coefficient. In general, if the value of Correlation Coefficient is 0.2 or more, it is estimated to have a small but acceptable correlation. (Table 3.3)

The Pearson's correlation coefficients between the species richness and NDVI were all greater than 0.2, especially the NDVI Maximum values (Table 3.4). This indicates that Maximum has the highest correlation with the species richness among Mean, Maximum and Standard deviation of NDVI.

Table 3.3 : Correlation P-value between Species richness and NDVI

P-value			
Year	Mean	Max	Stdev
2015~2017	8.58e-05 ***	3.36e-05 ***	0.000112 ***
2015~2016	0.000102 ***	3.43e-05 ***	0.000126 ***
2016~2017	8.28e-05 ***	2.83e-05 ***	9.49e-05 ***
2015	0.000115 ***	2.88e-05 ***	0.000158 ***
2016	0.000112 ***	2.38e-05 ***	8.7e-05 ***
2017	6.47e-05 ***	8.28e-06 ***	28e-05 ***

Table 3.4 : Pearson's correlation coefficient between Species richness and NDVI

Pearson's correlation coefficient (r)			
Year	Mean	Max	Stdev
2015~2017	0.2046647	0.2158804	0.201423
2015~2016	0.2025204	0.2156189	0.199924
2016~2017	**0.2050937**	**0.2178351**	**0.203425**
2015	0.2010788	0.2176493	0.197006
2016	0.2013868	0.2198615	0.204489
2017	**0.2080979**	**0.2315893**	**0.206667**

The mean value of NDVI the three years has positive correlation with Species richness, but were lower than the two years between 2016 and 2017. This can be expected because most of the research were conducted mainly in 2016 and 2017. This can be confirmed from a yearly value. (Boyla et al, 2019). In 2017, NDVI has the strongest relationship with Species richness. 2015 has the lowest relationship.

3.2.2 Bird species richness and EVI

In the same process, the relationship between EVI and specie richness was analyzed. The scatter plots are represent the correlation between species richness and EVI (Figure 3.6 ; 3.8). The EVI spreads between 0.1 and 0.4, lower than NDVI. The relationship is positive but not very clear.

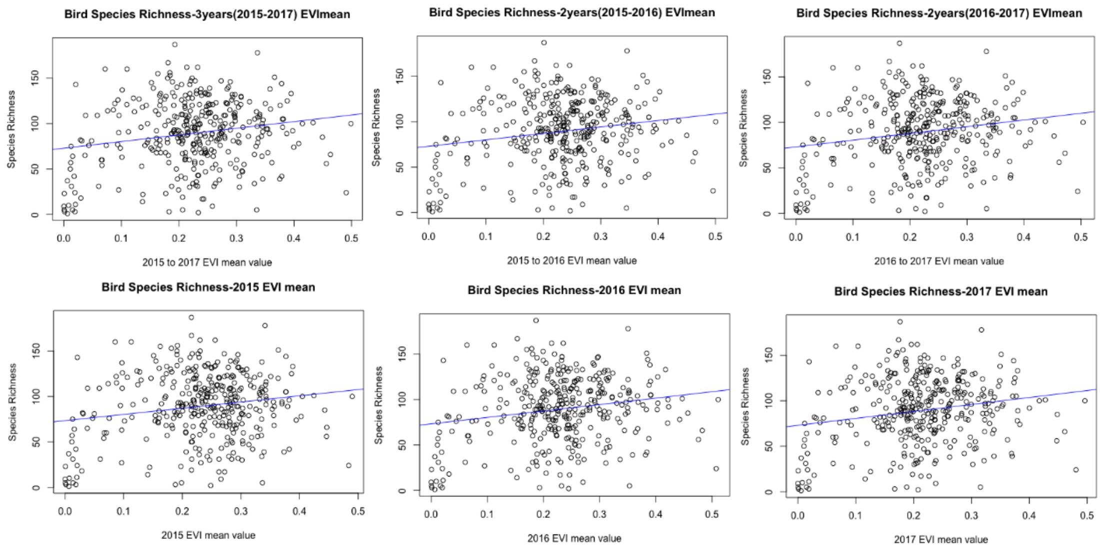


Figure 3.6 : Relationship between species richness and EVI mean.

Scatter plots of EVI maximum and species richness were not different from the EVI mean values analyzed. The range of EVI maximum is wider than the analysis with the NDVI maximum. As with the EVI mean values, they have a positive correlation but cannot said to be more obvious. (Figure 3.7)

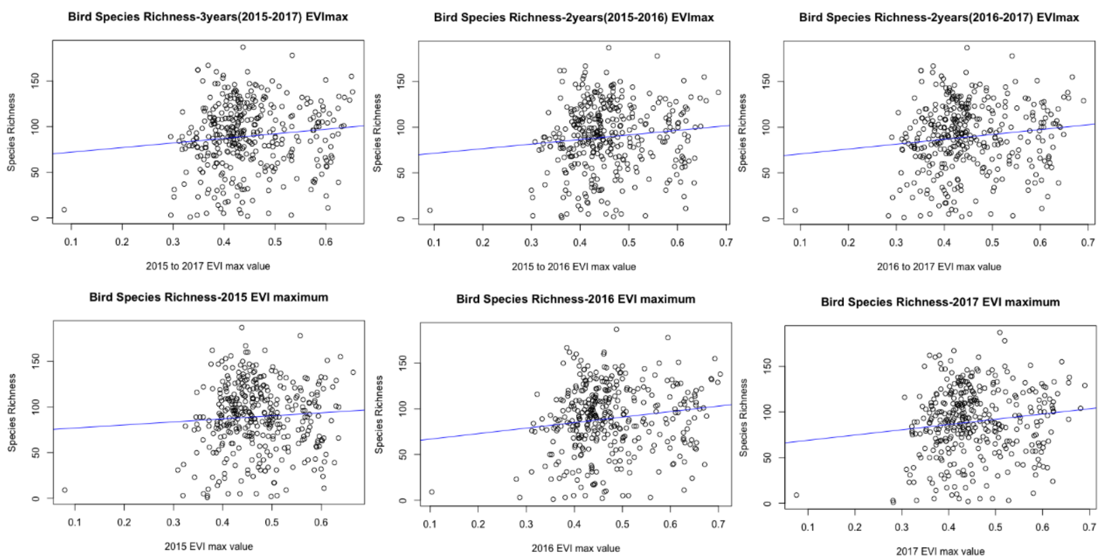


Figure 3.7 Relationship between species richness and EVI maximum.

The trend of EVI standard deviation is mostly distributed around 0.05 as shown in Figure 3.8. As the standard deviation is affected by the mean value, the positive correlation can be checked as well as the analysis with EVI mean.

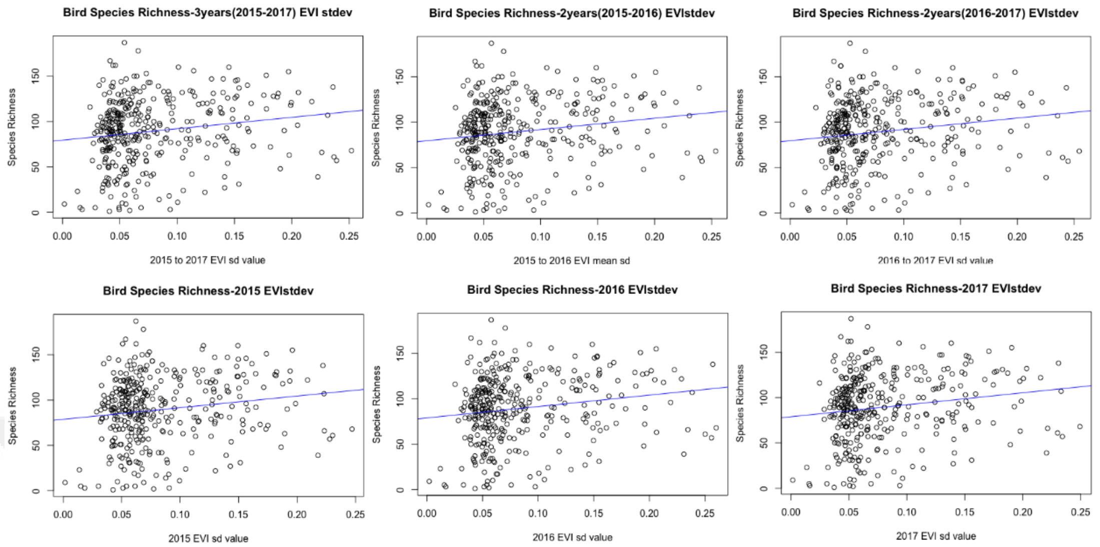


Figure 3.8 : Relationship between species richness and EVI standard deviation.

The relationship between them can be confirmed numerically. I tried to compare these relationships numerically in the same way as NDVI.

Species richness and EVI showed lower P-values and correlation coefficients than NDVI values. Values less than 0.2 indicate very weak significance. In addition to analysis through the Pearson correlation coefficient, other statistical verification is required. In particular, it showed the highest correlation with Mean 2017, and from 2016 to 2017 values of EVI. A notable difference from the analysis using NDVI was the correlation with the Maximum values. Correlation with Maximum value was lower than Mean value. The p-value using the Maximum value in 2015 was 0.198, a value greater than 0.05, indicating no regression relationship. (Table 3.5)

Pearson's correlation coefficient constant has a very low correlation with Maximum. As shown in Table 3.6, 2016 is especially higher than 2017. Standard deviation also showed the same trend. Since EVI is heavily influenced by terrain, it is more difficult to find the maximum value. In other words, it can be said that the EVI measurement for the most vegetation activity was different from the NDVI. When the P-value is higher than 0.05, as in EVI 2015, there is no statistical significance. Thus, EVI maximum is not a significant variable, It cannot be used as a variable to indicate the relationship between Species richness and vegetation. Therefore, it can be seen that it is more meaningful to use the NDVI value for the Maximum as well as the Mean. However, as with the NDVI mean, EVI's 2017 mean showed the highest correlation and 2015 tended to be low. In thses respects, the overall EVI results can support the results of the NDVI.

Table 3.5 : Correlation P-value between Species richness and EVI

P-value			
Year	Mean	Max	Stdev
2015~2017	0.000351 ***	0.0322 *	0.00158 **
2015~2016	0.000448 ***	0.0331 *	0.0016 **
2016~2017	0.000256 ***	0.0141 *	0.00144 **
2015	0.000841 ***	0.198	0.00247 **
2016	0.000305 ***	0.00501 **	0.0012 **
2017	0.000228 ***	0.0108 *	0.00154 **

Table 3.6 : Pearson's correlation coefficient between Species richness and EVI

Pearson's correlation coefficient (r)			
Year	Mean	Max	Stdev
2015~2017	0.1865836	0.1124243	0.165303
2015~2016	0.1832859	0.1118585	0.165048
2016~2017	0.1908175	0.1287678	0.166669
2015	0.1744972	0.06776375	0.158443
2016	0.1884654	0.1470165	0.169349
2017	0.1922865	0.1335742	0.165667

The NDVI showed a clearer correlation between bird species richness and vegetation. In 2017, the relationship was even greater. It was also able to identify the relationship bird species richness with EVI, except 2015. Since EVI was part of additional analysis, no further validation analysis was conducted on these results.

In short, both index show the positive correlation between Bird Species richness and NDVI, EVI. This means that in Turkey, Vegetation and Bird species increase and decrease together.

3.3 Estmation of Forest Sturucture using Airborne LiDAR

In the study area, Canopy Hight Model (CHM) was created using LiDAR data. The field of forest management plans data was then used to identify The State of The Trees. The relationship was derived using these data and Bird Species data.

Canopy Hight Model (CHM)

LiDAR enabled accurate analysis of canopy height and canopy cover. These are considered to have the greatest impact on bird habitat.

The maximum value of CHM in Region A is 36.35 m, and the maximum value of CHM in Region B is 34.88 m. As shown in Figure 3.9; 3.10. CHM of A region is 0-10m, 0-20m is the highest and occupies a similar ratio. The CHM of B region is the highest distribution 0-10m. As a result, it was found that A region has higher CHM than B region. Futhermore, Through the DEM, A region had many ridgelines with steep slopes than B region.

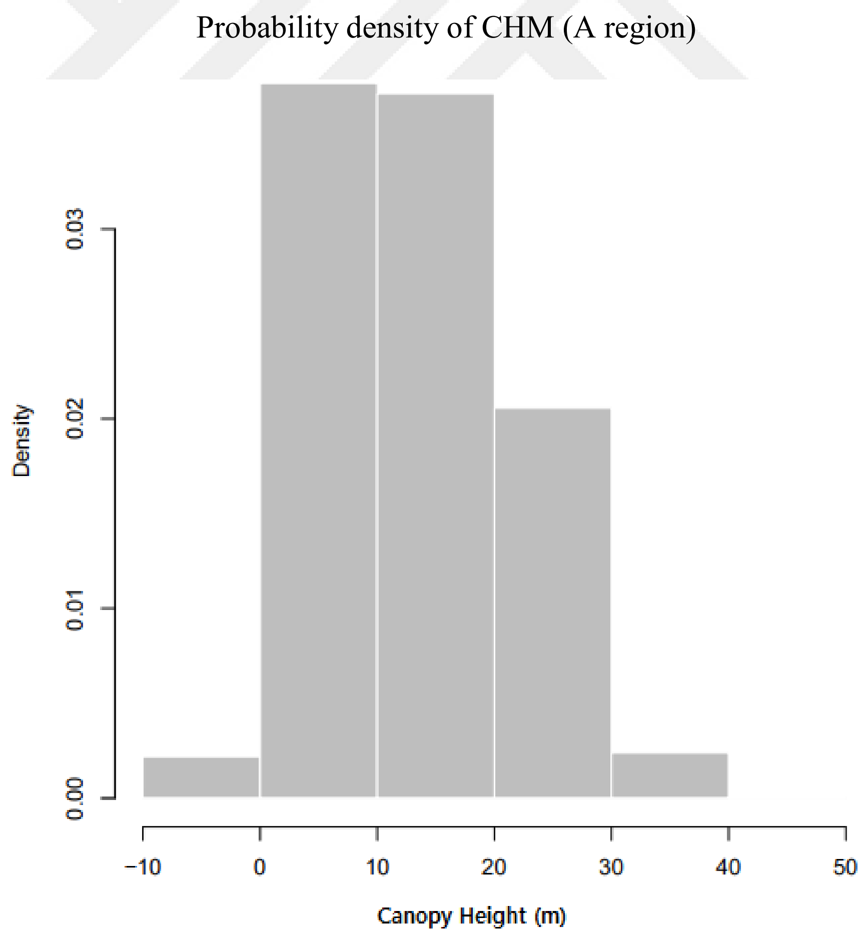


Figure 3.9 : Probability Density of CHMs of A region.

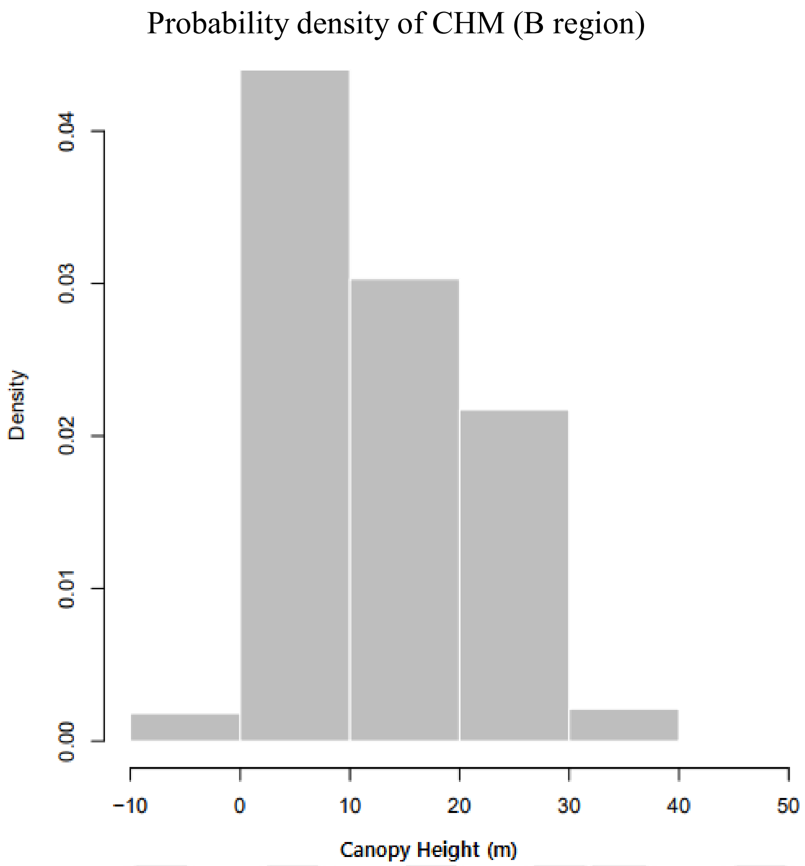


Figure 3.10 : Probability Density of CHMs of B region.

The State of The Trees

Forest management plans data were used to identify each tree species in the A region and B region. Except for uncertainties explain polygons when calculated area distribution. A region has more variety of species than B region. *Faqus sylvatico* is the most common species in both regions. In A region, *Quercus cerris* for the second, and *Pinus nigra* for the third. *Pinus sylvestris* was the second largest in B region as seen in Table 3.7 and Table 3.8. Especially, the ratio of *Pinus nigra* and *Pinus sylvestris* in the two areas was very different.

Table 3.7 : Distribution of tree species (A region)

Tree species (en)	Tree species (tr)	Area (%)
Podocarpus macrophyllus	Maki	5.8
Faqus sylvatico	Kayın	53.53
Quercus cerris	Meşe	16.7
Abies nordomanniana	Göknar	6.37
Carpinus japonica	Gürgen	6.1
Pinus nigra	Karaçam	10
Pinus sylvestris	Sarıçam	1.45
Quercus frainetto	Macar meşesi	0.05

Table 3.8 : Distribution of tree species (B region)

Tree species (en)	Tree species (tr)	Area (%)
Abies nordomanniana	Göknar	28
Faqus sylvatico	Kayın	50
Quercus cerris	Meşe	9.34
Pinus nigra	Karaçam	1.54
Pinus sylvestris	Sarıçam	11.12

The DBH, measured at a height of 1.3 m, the ratio of poles type that between 8cm and 19.9cm was the highest in the region A. Region B had ticker type, the highest ratio of DBH between 20cm and 35.9cm. (Table 3.9)

Table 3.9 : Development Diameter at breast height (at 1,30m)

Region	A	B	C	D
A region	4.78%	79.16%	10.7%	5.36%
B region	22.87%	11.42%	52.49%	8.22%

At the top crown closure level both areas were dense forests with a high degree of closure. The second level of closure is higher in A region (Table 3.10)

Table 3.10 : Top crown closure level

Region	1	2	3
A region	0%	15.37%	84.63%
B region	0.9%	5.45%	93.65%

The CHMs was similar in overall trend, but A region had a higher proportion of '10 - 20m ' than B. Through the DEM, I could find many ridgelines, including steep slopes in the A region. In addition, A region had more varieties of trees than B region. DBH proportion was '8-19.9cm' is highest at A rigion.

In particular, the difference between the two regions was the slope and development diameter at breast height. Therefore, the most important forest parameters for bird habitats found in this study are Slope and Tree Age (DBH).

4. CONCLUSIONS AND RECOMMENDATIONS

The analysis of NDVI and EVI changes in this study showed that Turkey's vegetation is continuously decreasing every year from 2015 to 2017, but maximum value was the largest in 2016. It can be expected that there were impacts and climatic changes throughout Turkey, including deforestation, forest fires, urbanization and cropland. Further research should be followed to determine the cause based on various investigation data conducted over the same period.

In terms of the relationship between Atlas data of bird species richness and NDVI, EVI, Bird species richness and vegetation were found to have a positive correlation. Although the correlation value of EVI was very small. But the main analytical factor was NDVI, the same trend could be considered significant. Most of the Atlas project's observations were performed in 2017. As this proves, the highest correlation with Species richness was the 2017 data from NDVI and EVI.

As a result, it was confirmed that the change of vegetation, especially NDVI, over a certain period could be a significant parameter for predicting the change of bird species. Bird species data that change from year to year or cycles are also required to act as a single parameter. Furthermore, even without detailed bird species data, the combination with the Dynamic Habitat Index (DHI) or Species Distribution Mode (SDM) will provide a better understanding of the pattern of change.

At the beginning of the study, the correlation between the Vegetation index and Bird species over three years, and two or one year were not expected to be different. This indicates that habitats have changed as much as three years, just like changes in NDVI over three years. Except for migratory birds, birds inhabit similar habitats in very large numbers. (Alerstam and Hogstedt, 1982). Recently, however, the average number of years that birds live in one habitat is changing. (Vázquez and Wunderle, 2013; Melles, 2003). The results of this study also show that habitats change rapidly. These identified changes will assist in the development of the dynamic habitat index (DHI).

As expected before the study, EVI values were lower than NDVI. This is because Turkey's topographical features, which vary widely in shape, influence the sensitive EVI values for measurement. Because it was a wide scale study covering the whole of Turkey, the NDVI showed a more comprehensive value than the EVI. (Matsushita et al, 2007) However, it cannot be concluded that NDVI is more suitable for vegetation research in Turkey. Based on NDVI, verification is required with other remote sensing observations or other indices.

It is needed on which index is better suited for different habitat research areas in Turkey. Of course, alternative predictions are possible with just NDVI or EVI alone. (Seto et al, 2004). Further, new approaches should be attempted to classify the categories of vegetation to account for the spatial diversity in which birds live. NDVI and EVI still have limitations that are vulnerable to various obstacles and light reflections. Therefore, in areas where intensive and more detailed verification is required, it is advisable to use additional techniques that allow more detailed observations, and to conduct actual research as far as possible. Using LiDAR as in Appendix B may be helpful.

Efficient conservation of bird species requires monitoring and growth of vegetation in which natural habitats can be maintained. Of course, each species has a preferred degree of vegetation, so there will be a range of values expressed in vegetation indexes.(Nieto et al, 2015) However, as in this study, the bird species richness at the high vegetation index is high when looking at the overall species diversity. Therefore, protection and maintenance of fragmented residual forests identified through the NDVI and EVI maps is important. Futhermore, the ecological characteristics of each specie are different, it is also necessary to evaluate habitat connectivity of vegetation and forest structure by considering the characteristics of each species, especially those species that are extinct. Naturally, several SDMs must also be developed.

Turkey's NDVI and EVI mappings obtained through MODIS were not difficult. Also, their numerical results are different, but the patterns are similar. The use of remote sensing data and data obtained through actual field observations, such as the Atlas project, can be used to better understand the ecosystem. Using more diverse datasets, pattern changes in vegetation parameters can be provided as a tool to assess and predict species diversity.

In future research, it is necessary to expand not only vegetation index change analysis, but also to identify the impacts of various climate and topographical factors. (Coops et al, 2009).Considering the climate, I would like to explore GPP (Gross Primary Production) and Turkey's Fraction of photosynthetically active radiation (fPAR), DHI, understand and study the relationship with bird diversity, and expand further. (Waring et al, 2006).

The cause of the vegetation change should be determined whether it is natural disasters or caused by physical force, and should make a countermeasure taken accordingly. As part of a sustainable management approach, monitoring using various remote sensing techniques should also be continued. By understanding the past and present patterns of species diversity, it is important to identify environmental and biological interactions about how nature is affected each other. This will continue to drive efforts to predict how global change will happen in the future. Comprehensive study should be carried out considering the diversity of ecosystems in Turkey and World wide.

In addition, conclusions from further study using LiDAR were drawn separately to avoid confusion with content using MODIS. It is as follows : Through the further study, second study, forest metrics analysis using LiDAR was relatively simple and accurate. Canopy Height, Density and Slope, Tree species and DHB affect bird species richness. In addition, I will perform statistical analysis including the correlation between the forest parameter confirmation using LiDAR and the results obtained.

LiDAR can be measured from fine-scale to global-scale. It is also a great advantage to be able to identify not only large trees but also low trees with high accuracy. By using some software, you can input the ID by inputting the average value as a feature of each tree type, and it is possible to check the structure of each tree and the individual tree level of specific trees in the forest. In addition, it is possible to create a suitable habitat model with the characteristics of the habitat that a bird has. This high-resolution LiDAR data helps assess forest health, productivity and biodiversity (Zellweger, F et al, 2016). The use of LiDAR is expected to be very useful for isolated or very deep forest monitoring.

The biggest limitation of this study is that the area where LiDAR data is obtained is smaller than the Atlas square which is a bird species data area, about 600: 1. It is difficult to objectify the results even if random forest regression is applied (Aberg et al., 2003). However, it can be said that it is meaningful considering at least the distance between the two regions is more than 100km, the possibility of having different structure, and bird living area around habitat is wide (Meyer, 2015). In fact, I can confirm that the forest structure of the two study areas is very different through the slope and CHMs.

The Airborne LiDAR data used in this study is data from July 2018, which was acquired by the company before the start of the study. Forest management plan data, on the other hand, raises limitations in the time difference between the measurement timing and the update timing of each plot (polygon). LiDAR data is the most recent and I tried to overcome the limit by classifying according to the size of tree separately using LiDAR cloud point.

Ecosystem diversity research using remote sensing requires a method to derive objective numerical values for the parameters of anthropogenic disturbance, time difference, to normalize biased data (Lausch, 2016). Species richness of birds should also be accompanied by studies involving factors directly affecting the population.

In future research, I will overcome the above limitations, compare the forest parameters of a wide area, identify the correlation with Species richness of bird, and concentrate on developing suitable habitat modeling using LiDAR. It is expected that many researches for biodiversity will be realized along with the development of various technologies.

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Url-5 < *https://earthexplorer.usgs.gov*> USGS.

Url-6 <*https://cran.r-project.org*> R Guide.

APPENDICES

APPENDIX A: Tables and Figure

APPENDIX A

Table A.1 : Number of Bird species extracted from Atlas data**.**

Name	S.R.	Name	S.R.	Name	S.R.	Name	S.R.	Name	S.R.	Name	S.R.
35SLE4	81	35TMG2	10	36SVJ2	70	36TUL4	85	37SDC1	84	37TEE1	115
35SMC1	50	35TMG3		36SVJ3	132	36TVK1	146	37SDC2	103	37TEE3	134
35SMC2	75	35TMG4	103	36SVJ4	93	36TVK3	140	37SDC3	82	37TEF1	5
35SMC3	160	35TNE1	72	36SVK2	139	36TVL1	66	37SDC4	110	37TEF2	74
35SMC4	92	35TNE3	131	36SVK4	162	36TVL2	144	37SDD1	93	37TEF4	96
35SMD1	73	35TNF1	57	36SWE1	31	36TVL3	105	37SDD2	78	37TFE1	133
35SMD3	140	35TNF2	89	36SWE3		36TVL4	34	37SDD3	84	37TFE3	147
35SMD4	115	35TNF3	92	36SWF1	89	36TVM2	114	37SDD4	79	37TFF1	
35SME2	128	35TNF4	54	36SWF2	99	36TVM4	107	37SDE2	131	37TFF2	151
35SME4	89	35TNG1		36SWF3	91	36TWK1	83	37SDE4	100	37TFF3	57
35SNA1	82	35TNG2	116	36SWF4	156	36TWK3	68	37SEA1	68	37TFF4	132
35SNA3	76	35TNG3		36SWG1	43	36TWL1	91	37SEA3	68	37TGE1	96
35SNA4	3	35TNG4	138	36SWG2	98	36TWL2	79	37SEB1	56	37TGF1	104
35SNB1	146	35TPE1	155	36SWG3	101	36TWL3	105	37SEB2	67	37TGF2	120
35SNB2	126	35TPE3	129	36SWG4	110	36TWL4	100	37SEB3	68	37TGG2	
35SNB3	102	35TPF1	132	36SWH1	77	36TWM1	3	37SEB4	42	38SKG3	77
35SNB4	130	35TPF2	109	36SWH2	65	36TWM2	100	37SEC1	31	38SKG4	78
35SNC1	138	35TPF3	118	36SWH3	63	36TWM4	42	37SEC2	78	38SKH3	133
35SNC2	126	35TPF4	122	36SWH4	40	36TXK1	34	37SEC3	42	38SKH4	83
35SNC3	129	35TQE1	110	36SWJ1	71	36TXK3	112	37SEC4	89	38SKJ3	58
35SNC4	86	35TQF1	63	36SWJ2	120	36TXL1	47	37SED1	98	38SKJ4	86
35SND1	97	35TQF2	120	36SWJ3	68	36TXL2	91	37SED2	57	38SKK4	50
35SND2	107	36STF3	134	36SWJ4	30	36TXL3	97	37SED3	143	38SLG1	39
35SND3	94	36STF4	109	36SWK2	90	36TXL4	121	37SED4	31	38SLG2	60
35SND4	81	36STG3	134	36SWK4	31	36TXM2	39	37SEE2	117	38SLG3	3
35SNE2	78	36STG4	86	36SXF1	95	36TXM3	121	37SEE4	60	38SLG4	
35SNE4	96	36STH3	110	36SXF2	64	36TXM4	48	37SFA1	31	38SLH1	76
35SPA1	145	36STH4	112	36SXF3	126	36TYK1	123	37SFB1	118	38SLH2	114
35SPA3	128	36STJ3	109	36SXG1	93	36TYL1	89	37SFB2	75	38SLH3	127
35SPA4	81	36STJ4	38	36SXG2	125	36TYL2	178	37SFB3	123	38SLH4	71
35SPB1	60	36STK4	115	36SXG3	150	36TYM2	127	37SFB4	81	38SLJ1	36
35SPB2	93	36SUF1	113	36SXG4	123	37SBA3	83	37SFC1	47	38SLJ2	94
35SPB3	121	36SUF3	147	36SXH1	27	37SBA4	65	37SFC2	94	38SLJ3	84
35SPB4	79	36SUF4	9	36SXH2	106	37SBB3	109	37SFC3	34	38SLJ4	130
35SPC1	49	36SUG1	119	36SXH3	130	37SBB4	124	37SFC4	79	38SLK2	56
35SPC2	55	36SUG2	109	36SXH4	187	37SBC3	85	37SFD1	43	38SLK4	153

35SPC3	96	36SUG3	119	36SXJ1	17	37SBC4	88	37SFD2	9	38SMF1	1
35SPC4	55	36SUG4	122	36SXJ2	87	37SBD3	106	37SFD3	80	38SMG1	83
35SPD1	5	36SUH1	121	36SXJ3	77	37SBD4	68	37SFD4	2	38SMG2	79
35SPD2	80	36SUH2	123	36SXJ4	99	37SBE4	71	37SFE2	103	38SMG3	
35SPD3	87	36SUH3	102	36SXK2	102	37SBV3		37SFE4	133	38SMG4	22
35SPD4	30	36SUH4	76	36SXK4	99	37SCA1	76	37SGB1	113	38SMH1	14
35SPE2	133	36SUJ1	51	36SYE3	73	37SCA3	100	37SGB2	90	38SMH2	53
35SPE4	108	36SUJ2	89	36SYF1	112	37SCB1	19	37SGB4	68	38SMH4	
35SQA1	109	36SUJ3	121	36SYF2	23	37SCB2	111	37SGC1	64	38SMJ1	139
35SQA2	131	36SUJ4	89	36SYF3	27	37SCB3	103	37SGC2	83	38SMJ2	91
35SQA3	89	36SUK2	94	36SYF4	81	37SCB4	107	37SGD1	5	38SMJ3	24
35SQA4	93	36SUK4	136	36SYG1	107	37SCC1	116	37SGD2	17	38SMK2	120
35SQB1	150	36SVE1		36SYG2	86	37SCC2	87	37SGE2	96	38SMK4	65
35SQB2	104	36SVE3	60	36SYG4	122	37SCC3	76	37TBE3	113	38TKK3	88
35SQB4	109	36SVF1	91	36SYH1	143	37SCC4	23	37TBF3	122	38TKL3	132
35SQC1	69	36SVF2	96	36SYH2	162	37SCD1	81	37TBF4	125	38TKL4	97
35SQC2	138	36SVF3	92	36SYJ1	69	37SCD2	67	37TBG4	143	38TKM4	
35SQD1	51	36SVF4	72	36SYJ2	108	37SCD3	89	37TCE1	68	38TLK1	107
35SQD2	99	36SVG1	99	36SYK2	79	37SCD4	89	37TCE3	107	38TLK3	120
35SQE2	105	36SVG2	114	36TTK3	100	37SCE2	95	37TCF1	61	38TLL1	147
35TLE3	37	36SVG3	81	36TTL3	90	37SCE4	120	37TCF2	56	38TLL2	103
35TME1	109	36SVG4	50	36TTL4	101	37SDA1	160	37TCF3	11	38TLL3	18
35TME3	128	36SVH1	32	36TUK1	84	37SDA3	82	37TCF4	24	38TLL4	110
35TMF1	5	36SVH2	108	36TUK3	122	37SDB1	87	37TDE1	88	38TLM2	42
35TMF2	137	36SVH3	60	36TUL1	57	37SDB2	167	37TDE3	112		
35TMF3	84	36SVH4	77	36TUL2	100	37SDB3	133	37TDF2	66		
35TMF4	64	36SVJ1	72	36TUL3	68	37SDB4	108	37TDF4	39		

Name = Atlas square name, S.R. = Bird Species Richness. 363 of the total 375 were investigated. 12 were not observed by the sea. These squares are marked in red the table.

Table A.2 : Turkey's NDVI and EVI from March to July during 2015 to 2017

NDVI	MAX	MEAN	MIN	STDEV	**EVI**	MAX	MEAN	MIN	STDEV
2015_03	0.87240	0.23717	-0.19800	0.23796	2015_03	0.69840	0.12956	-0.15980	0.13413
2015_04	0.94170	0.29575	-0.19890	0.25206	2015_04	0.76070	0.17365	-0.13950	0.15377
2015_05	0.99040	0.34350	-0.19920	0.27762	2015_05	0.79320	0.21842	-0.09320	0.18262
2015_06	0.94500	0.33887	-0.20000	0.28337	2015_06	0.82570	0.21953	-0.16340	0.19079
2015_07	0.93940	0.29429	-0.20000	0.26654	2015_07	0.78850	0.18665	-0.16530	0.17186
2016_03	0.95500	0.23674	-0.19710	0.23621	2016_03	0.76100	0.12864	-0.17180	0.13233
2016_04	0.92680	0.28683	-0.19710	0.25286	2016_04	0.86590	0.17358	-0.16710	0.15851
2016_05	0.92590	0.33169	-0.19780	0.27783	2016_05	0.81560	0.21422	-0.15080	0.18623
2016_06	0.93330	0.31623	-0.20000	0.27471	2016_06	0.81090	0.20640	-0.19960	0.18475
2016_07	0.93670	0.28231	-0.20000	0.26119	2016_07	0.77510	0.18271	-0.19360	0.17220
2017_03	0.94170	0.19574	-0.19480	0.21482	2017_03	0.73170	0.10074	-0.13730	0.11244
2017_04	0.89670	0.25871	-0.19510	0.23606	2017_04	0.82160	0.14966	-0.17680	0.13996
2017_05	0.91870	0.32381	-0.20000	0.27016	2017_05	0.79540	0.20463	-0.16940	0.17723
2017_06	1.00000	0.33185	-0.19850	0.28071	2017_06	0.81860	0.21319	-0.18250	0.18530
2017_07	1.00000	0.28578	-0.19770	0.26011	2017_07	0.77670	0.18556	-0.19920	0.17194
2015	0.84640	0.30192	-0.13844	0.24679	2015	0.63886	0.18556	-0.05692	0.15238
2016	0.87178	0.29076	-0.09502	0.24563	2016	0.66482	0.18111	-0.08658	0.15435
2017	0.85054	0.27918	-0.12788	0.23799	2017	0.61688	0.17076	-0.08878	0.14592
2015-2016	0.85326	0.29634	-0.06988	0.24453	2015-2016	0.64911	0.18334	-0.04329	0.15190
2016-2017	0.86092	0.28497	-0.07143	0.24071	2016-2017	0.62259	0.17593	-0.05561	0.14921
2015-2017	0.84975	0.29062	-0.05787	0.24179	2015-2017	0.62619	0.17914	-0.04366	0.14944

1. Top closure 11-40% “Loose closed”

2.Top closure 41-70% “Medium closed"

3.Top closure 71-100% “Full closed”

Figure A.1 : Top crown closure level (Mısır, 2016, p16)

Table A.3 : The presence of birds in 'a;36TVM4' and 'b; 36TXM2' Atlas squares.

Species name	a	b	Species name	a	b	Species name	a	b
Accipiter nisus	O	O	Passer montanus	X	O	Sylvia curruca	O	X
Columba palumbus	O	O	Ciconia nigra	O	X	Regulus regulus	O	X
Streptopelia decaocto	O	O	Circaetus gallicus	O	X	Regulus ignicapilla	O	X
Jynx torquilla	O	O	Buteo buteo	O	X	Ficedula parva	O	X
Picus ((viridis)) viridis	O	O	Buteo rufinus	O	X	Aegithalos caudatus	O	X
Hirundo rupestris	O	O	Aquila chrysaetos	O	X	Poecile palustris	O	X
Hirundo daurica	O	O	Falco tinnunculus	O	X	Sitta krueperi	O	X
Delichon urbica	O	O	Falco subbuteo	O	X	Sitta europaea	O	X
Cinclus cinclus	O	O	Falco peregrinus	O	X	Certhia familiaris	O	X
Troglodytes troglodytes	O	O	Columba livia	O	X	Lanius minor	O	X
Erithacus rubecula	O	O	Columba oenas	O	X	Pica pica	O	X
Luscinia megarhynchos	O	O	Streptopelia turtur	O	X	Sturnus vulgaris	O	X
Phoenicurus phoenicurus	O	O	Cuculus canorus	O	X	Serinus serinus	O	X
Turdus merula	O	O	Strix aluco	O	X	Chloris chloris	O	X
Turdus philomelos	O	O	Caprimulgus europaeus	O	X	Pyrrhula pyrrhula	O	X
Sylvia communis	O	O	Apus apus	O	X	Emberiza cirlus	O	X
Sylvia borin	O	O	Apus melba	O	X	Emberiza cia	O	X
Sylvia atricapilla	O	O	Merops apiaster	O	X	Emberiza hortulana	O	X
Phylloscopus collybita	O	O	Picus canus	O	X	Emberiza melanocephala	O	X
Muscicapa striata	O	O	Dryocopus martius	O	X	Milvus migrans	O	X
Periparus ater	O	O	Dendrocopos major	O	X	Accipiter gentilis	O	X
Cyanistes caeruleus	O	O	Dendrocopos syriacus	O	X	Otus scops	O	X
Parus major	O	O	Dendrocopos medius	O	X	Asio otus	O	X
Oriolus oriolus	O	O	Dendrocopos leucotos	O	X	Oenanthe isabellina	O	X
Lanius collurio	O	O	Dendrocopos minor	O	X	Oenanthe oenanthe	O	X
Garrulus glandarius	O	O	Lullula arborea	O	X	Sylvia melanocephala	O	X
Corvus cornix	O	O	Prunella modularis	O	X	Poecile lugubris	O	X
Corvus corax	O	O	Phoenicurus ochruros	O	X	Certhia brachydactyla	O	X
Passer domesticus	O	O	Saxicola rubicola	O	X	Corvus monedula	O	X
Fringilla coelebs	O	O	Turdus viscivorus	O	X	Carduelis spinus	O	X
Carduelis carduelis	O	O	Hippolais pallida	O	X	Coccothraustes coccothraustes	O	X
Carpodacus erythrinus	O	O						

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