AVIAN COMMUNITY PATTERNS IN THE LESSER CAUCASUS (NORTHEASTERN TURKEY)

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

GÜLDEN ATKIN GENÇOĞLU

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
BIOLOGICAL SCIENCES

DECEMBER 2007

Approval of the thesis:

AVIAN COMMUNITY PATTERNS IN THE LESSER CAUCASUS (NORTHEASTERN TURKEY)

submitted by **GÜLDEN ATKIN GENÇOĞLU** in partial fulfillment of the requirements for the degree of **Master of Biology in Biological Sciences, Middle East Technical University** by,

Prof. Dr. Canan Özgen ____________________
Dean, **Graduate School of Natural and Applied Sciences**

Prof. Dr. Zeki Kaya ____________________
Head of Department, **Biological Sciences**

Assoc. Prof. Dr. Can Bilgin ____________________
Supervisor, **Biological Sciences Dept., METU**

Examining Committee Members:

Prof. Dr. Zeki Kaya ____________________
Biological Sciences Dept., METU

Assoc. Prof. Dr. Can Bilgin ____________________
Biological Sciences Dept., METU

Prof. Dr. Meryem Beklioğlu ____________________
Biological Sciences Dept., METU

Prof. Dr. Selim Çağlar ____________________
Biology Dept., Hacettepe University

Dr. Uğur Zeydanlı ____________________
City and Regional Planning Dept., METU

Date: ____________________

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: Gülden Atkın Gençoğlu

Signature :

ABSTRACT

AVIAN COMMUNITY PATTERNS IN THE LESSER CAUCASUS (NORTHEASTERN TURKEY)

ATKIN GENÇOĞLU, Gülden
M. Sc., Department of Biological Sciences
Supervisor: Assoc. Prof. Dr. C. Can Bilgin

December 2007, 78 pages

Species composition, diversity and species-habitat relations are widely used to describe communities. This study aimed to document diversity, composition and habitat relations of avian communities of the Turkish Lesser Caucasus by using point counts and multivariate analyses. 2845 individuals of 101 bird species were observed at 215 stations located in the study area.

Point counts were revealed to be a useful method for terrestrial birds, especially passerines. Species richness and diversity changed significantly within parts of the study area and one particular sub-region was found to be considerably more diverse than the other three.

Division of the Lesser Caucasus region into sub-ecoregions may not be justified using bird assemblages since habitat parameters, especially the presence of woody vegetation, seemed to be a better predictor of species composition than geographical proximity.

Documented bird and habitat associations provide valuable information on the factors which affect bird occurrence or abundance. Baseline data provided by this study will help detect and understand changes in bird populations in the future.

Keywords: avian community, species composition, species diversity, point count method, bird-habitat relationship

ÖZ

AŞAĞI KAFKASLAR'DA (KUZEYDOĞU ANADOLU) KUŞ YAŞAMBİRLİĞİ PARAMETRELERİ

ATKIN GENÇOĞLU, Gülden
Yüksek Lisans, Biyolojik Bilimler Bölümü
Tez Yöneticisi: Doç. Dr. C. Can Bilgin

Aralık 2007, 78 sayfa

Tür kompozisyonu, çeşitlilik ve tür-habitat ilişkileri yaşambirliklerini tanımlamak için yaygın olarak kullanılmaktadır. Bu çalışma ile Türkiye Aşağı Kafkaslardaki kuş yaşambirliklerinin çeşitliliği, bileşimi, habitat ilişkileri nokta sayımları ve çok-değişkenli analizler kullanılarak belgelenmiştir. Alandaki 215 istasyonda 101 kuş türü ve toplam 2845 birey gözlemlenmiştir.

Nokta sayımları karasal kuşlar özellikle de ötücüler için yararlı bir yöntem olarak gösterilmiştir. Tür zenginliği ve çeşitliliği çalışma alanının alt bölgeleri arasında belirgin bir şekilde değişiklik göstermiştir ve bir alt bölge diğer üç alt bölgeden oldukça fazla çeşitlilik göstermiştir.

Aşağı Kafkaslar'ın alt ekolojik bölgelere bölünmesi kuş tür birliği ile kanıtlanmayabilir çünkü habitat özelliklerinin özellikle ağaçların varlığının tür bileşimini coğrafik yakınlıktan daha iyi öngördüğü görünmektedir.

Belgelenen kuş ve habitat ilişkileri kuşların varoluş veya çokluğunu etkileyen etmenler hakkında değerli bilgi sağlar. Bu çalışma ile sağlanan referans verisi gelecekte kuş popülasyonlarındaki değişiklikleri tespit etmeye ve anlamaya yardımcı olacaktır.

Anahtar kelimeler: kuş yaşambirliği, tür kompozisyonu, tür çeşitliliği, nokta sayım yöntemi, kuş-habitat ilişkisi

To Gençer

ACKNOWLEDGEMENTS

I wish to express my deepest gratitude to Assoc. Prof. Dr. C. Can Bilgin for his guidance, advice, invaluable encouragement and support.

This study was based on the bird data collected within “TEMA-METU Gap Analysis of Lesser Caucasus Forests Project” funded by Baku-Tbilisi-Ceyhan (BTC) Pipeline Environmental Investment Programme. I am grateful to all of the people which had a contribution to the project. I especially want to thank to birdwatchers supporting the implementation of the fieldwork that are C.Can Bilgin, Okan Can, Özge Keşaplı Can, Imre Csikós, Jno Didrickson, Özgür Keşaplı Didrickson, Gençer Gençoğlu, Bart de Knegt, Merijn van Leeuwen, Jan Timmer and Taner Karagöz.

Special thanks to Ayşe Turak for her GIS support at this thesis. My colleagues Senem Tuğ, Banu Kaya and Damla Beton, thanks for your help and support. Damla, thanks for being understanding and supporting at the hardest moments and to make me feel better.

Thanks to my colleagues in Kuş Araştırmaları Derneği for their support and understanding during this thesis. Bilge Bostan followed the thesis process closely and listened my endless thesis speeches. Osman Erdem was tolerant about my working time especially for the last months of thesis writing.

Always encouraging, supporting, understanding, listening and helping; this sweet guy happens to be my husband Gençer Gençoğlu. It was also a chance that you were one of the birdwatcher of the fieldwork and sure a good one. My mother, Fatma Atkın, it was really a great chance that you were here in Ankara during the last 4 months of my thesis and after 7 years far from you I felt the deepest love and support from you. My father Nazım Hikmet Atkın always supported me through this master and also my sisters Canan Kırca and Gülcan Atkın who believed and encouraged me in this process. Melike Hemmami, thanks for being ready to help when I asked.

Before this study, I spent much time and effort on another subject and I would like mention names of people contributed. We achieved to get good results and I believe that it will be carried out by a colleague. I am grateful to Çiğdem Akın for sharing her knowledge, help and support at all stages. She was always so optimistic and encouraging. Petr Prochazka, thanks for being so friendly and kind, not hesitating to answer my questions and sharing your knowledge all the time. I wrote to one of the writer of article related my subject and I was really surprised with his interest. Michael Sorenson really helped me to reach the result. Even if Metin Bilgin was involved at the last stage, he contributed much. Thanks to Cengiz Özalp and Evren Koban for sharing their knowledge and experience for my experiments.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

CHAPTER 1

INTRODUCTION

1.1 Community Structure

There are many definitions of "community" by ecologists in the literature. Whittaker (1975) defines a community as "an assemblage of populations of plants, animals, bacteria and fungi that live in an environment and interact with one another, forming together a distinctive living system with its own composition, structure, environmental relations, development and function" (in Morin 1999). However the most definitions include the idea of spatial boundaries such as Krebs's (1985) definition of a community as "a group of populations of plants and animals in a given place" (in Magurran 1988). Based on the different definitions in the literature the community is simply an interacting group of various species in a common location.

All communities have certain characteristics that define their biological and physical structure and these characteristics vary in both space and time (Smith and Smith 1998). Biological structure of communities includes the number of species, measures of diversity, which reflect both the number of species and relative abundance, and distribution of species abundances (Morin 1999).

The communities are characterized not only by biological structure but also by physical features. The form and structure of terrestrial communities reflect vegetation. Each community has a distinctive vertical structure. The degree of vertical layering has a significant influence on the diversity of animal life in the community (Smith and Smith 1998). Increased vertical structure means more resources and living space and a greater diversity of habitats.

The biological and physical structure of community change both temporally and spatially in response to environmental conditions. Community patterns are the consequence of a hierarchy of these processes that interact in complex ways. There is a strong relation between the communities and environment. Differences among habitats were often represented by species composition or structural complexity of vegetation.

1.2 Ecological Diversity

Diversity measures are classified as species richness measures or heterogeneity measures (Krebs 1999). Species richness, that is the number of species in the community, is a straightforward measure of diversity. Heterogeneity measures combines species richness and evenness of diversity, that is how equally abundant the species are (Magurran 1988).

No community consists of species of equal abundances. The majority of the species in the community is rare while a number of species moderately common. Dominant species play an important role to define the communities. Species richness is the simplest way to describe community and regional diversity (Magurran 1988) and it underlies many ecological models and conservation strategies (Gotelli and Colwell 2001). Investigations of diversity are often restricted to species richness that is a straightforward count of the number of species present. Ecologists are interested in ecological diversity and its measurement because diversity remained a central theme in ecology, diversity measures can be used indicators of the well being ecological systems and there are still considerable debates for the measurement of diversity (Magurran 1988).

Total species richness is estimated by extrapolating species accumulation curves, fitting parametric distributions of relative abundance and using non-parametric techniques based on distribution of individuals among species or of species among groups (Colwell and Coddington 1994). Heterogeneity measures are based on species abundance models and non-parametric species diversity indices (Southwood and Henderson 2000).

To define and delimit the community Whittaker's (1972) classification is used in any investigation of ecological diversity (in Southwood 2000). This classification is alpha, beta and gamma diversity. Alpha diversity is the diversity of set of species within a community or habitat. Beta diversity is called species turnover or differentiation diversity is a measure of how different samples or habitats (or similar) are from each other in terms of species composition. Gamma diversity represents the diversity of landscape including species replacement over large geographical regions. Alpha diversity is the property of defined spatial unit whereas beta diversity reflects biotic change or species replacement (Magurran 2004). It is the variation in the species composition between areas of alpha diversity and usually reflects habitat diversity. There are two approaches to view beta diversity which are to look at how species diversity changes along a gradient or to compare the species compositions of different communities (Magurran 1988). The degree of association or similarity of sites or samples can be investigated by using similarity measures, classification and ordination methods.

1.3 Habitat-Bird Communities Relationships

Documentation of the relationships between habitat and bird communities has been a major part of avian ecology for decades. Numerous studies have shown the impact of vegetation on the distribution and diversity of bird species (MacArthur and MacArthur 1961; Rotenberry and Wiens 1980; Karaçetin 2002; Lee and Rotenberry 2005). The physical structure or configuration of the vegetation (physiognomy) and its plant species composition (floristic) are the two aspects of vegetation affecting birds and relative influence of these two varies over the spatial scales studied (Lee and Rotenberry 2005).

MacArthur and MacArthur (1961) found that the structural diversity, the number of vertical layers present and the abundance of vegetation within them was a much better predictor of bird species diversity than floristic diversity in temperate woodlands of North America. This was supported by another study in which bird species diversity increased as vertical complexity increased in steppe vegetation of North America (Rotenberry and Wiens 1980).

Rotenberry's study (1985) on the grassland and shrubsteppe vegetation types showed that physiognomic features seemed to be more important over large biographical scale while floristic features seemed to be more important at finer scales within regions (in Lee and Rotenberry 2005). Karaçetin (2000) also showed that there is a strong relationship between number of trees and number of birds. The role of physiognomy versus floristic were examined especially in forested ecosystems in which trees present high diversity with respect to both their structure and species composition. Lee and Rotenberry (2005) found that there was a significant relationship between bird species assemblages and tree species assemblages independent of structural variation in the eastern forests of North America. This relationship is based on foraging opportunities and resources provided by different tree species coupled with the diet and foraging behavior of birds.

Other physical features affecting the community structure of the birds include geographical location, topography, temperature, rainfall, altitude, water features, presence of bare and rocky ground and frequency of disturbance (Bibby et al. 1998).

1.4 Bird Surveys

Birds are relatively easy to census as they are well known, easily recognizable and simpler to locate than many other taxonomic groups (Bibby et al. 2000).

The bird surveys are basically used to estimate population size or index and density of particular species in a given area or to assess species composition of a given area and habitat associations. When the study is repeated at regular intervals, it also provides information about the population changes in particular area and compare this with different areas. In turn trend of a particular species over time can be used for conservation concerns such as setting priorities for particular species and areas which is called monitoring. By a well designed monitoring program it is also possible to find out the underlying causes of population trends and take conservation actions.

Habitat is likely to be an important determinant of the distribution and number of birds (Bibby et al. 1998). This makes them a good indicator of environmental health. Bird surveys collecting habitat data can be used also to predict the effects of changing land-use and in Environmental Impact Assessment or management of conservation areas (Bibby et al. 2000).

Determining diversity of birds present is important to assess conservation of the region and relative values of different habitats. The study provides baseline conservation data on the richness of the region and different habitats and make possible to compare different habitats. The diversity of the bird species in the region can be used as indicators of the importance of different sites or habitats for bird conservation (Bibby et al. 1998).

Recently, an effort was launched in Turkey to census birds in a standardized and repeated way. Modeled after the Common Bird Census methodology in the UK and elsewhere in Europe, it aims to count birds annually at semi-randomly selected squares of 1 square kilometer size through transects of fixed width (J. Tavares, pers.comm.). The first census was carried out at a limited number of sites in 2007.

1.4.1 Bird Census Techniques

Development of bird survey and census methods goes back almost 40 years ago (Bibby 2004). All methods have potential biases. However, there are many studies in the literature on bird population sizes, distributions and trends and many of them used simpler methods (Bibby 2004). It is more important to have standard approach so easier to compare with different studies.

There are a variety of different bird census techniques. Most commonly used ones are transects (line transect and point count) and mapping (territory or spot mapping). Most importantly one should select most appropriate sampling strategy and field method with accordance of study objectives. The choice of field method depends on target species, type and characteristics of ecological communities selected, habitats sampled and level of information required.

Line transects and point transects (known as point counts) are the most commonly used methods in censusing and more accurate and more efficient compared to mapping (Bibby et al. 2000 and Gregory et al. 2004). Both are based on recording the birds along a predefined route in predefined area. In point count observers stop at predefined spots for predefined periods rather than continually walking and recording the birds either side of the route as in fixed-width transect. Both of the methods are easy to adapt to different species and habitats. Point counts are easier to locate points and easier to access in dense habitats and incorporate the habitat data to bird species. However, time is lost by walking between the stations. Point counts are also more suitable for cryptic, shy and skulking species.

1.4.2 Point Count Method

Point count method is basically defined as tallying all birds observed by sight or sound for a specific time interval at a given location at either fixed distance or unlimited distance (Ralph et al. 1993 and Huff et al. 2000).

Point-count method is a widely used method to monitor bird populations. It is the main method to monitor the population changes of breeding land birds in many countries (Ralph et al. 1993). As well known, The North American Breeding Bird Survey (BBS) uses this method to monitor status and trends of North American bird populations since 1966. Rosentock et al. (2002) reviewed 224 papers and found that point counts are most frequently used methods with 46 percent.

Point count method is used to find out abundance patterns of bird species, yearly changes of bird populations at fixed points and differences in bird species composition between habitats (Ralph et al. 1993 and Huff et al. 2000). According to Ralph et al. (1993) the point count method is probably the most efficient and data-rich method as compared to other methods. It is the preferred in forested habitats or difficult terrain (Ralph et al. 1993).

Point count data that can be associated with habitat measures. There are two general approaches to point-count monitoring: a population-based approach without specific consideration for habitat at each location and a habitat-based approach done in specific habitats. It is difficult to understand bird and habitat relations in populations based approach whereas possible in habitat-based approach.

Point count method also can be used for density estimations by using distance sampling methods. Relative density estimates are used to provide a baseline to know whether number of particular species increase or decrease by comparison to data collected in the same way in the future. The distance to each bird detected can be recorded and used for density estimation with certain assumptions. On the other hand, density estimates from point counts have some disadvantages. Since the area surveyed changes with square of the distance from the observer, there will be a bias in the case of inaccurate distance estimation (Bibby et al. 2000).

There are also some disadvantages of point count method. Point counts are not efficient in measuring year to year changes in small area and estimating the density of very small populations (Bibby et al. 2000).

1.5 Ecoregion as an Ecological Unit

An ecosystem is a functioning entity of all the organisms in a biological system generally in equilibrium with the inputs and outputs of energy and materials in a particular environment. It is the basic ecological unit of study. The earth is divided up into ten major ecosystems, which are called as biomes. Biomes are the major regional groupings of plants and animals discernible at a global scale. Their distribution patterns are strongly correlated with regional climate patterns and identified according to the climax vegetation type. Another approach is mapping the relatedness of animals and plants. By this approach, similar biomes on different continents are classified to different biogeographic "regions". These are called as biogeographical realms which are geographical regions out of which particular assemblages of plants and animals evolved and dispersed.

There have been many attempts to classify geographic areas into zones of similar characteristics by using climate, vegetation, soil, landform, physiography and ecology (Wright et al. 1998). Ecoregion is defined as a large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions (WWF International 2007). Ecoregions are also defined by Omernik (1995) as geographic ``...regions that generally exhibit similarities in the mosaic of environmental resources, ecosystems, and effects of humans." and by Bailey (1983) as ``...geographic zones that represent geographical groups or associations of similarly functioning ecosystems." (in Wright et al. 1998). Ecoregions are relatively homogenous regions in terms of their ecological systems, organisms and environment. There are 142 terrestrial, 53 freshwater, and 43 marine ecoregions on earth.

1.6 Scope and Objectives

This study was based on the bird data collected within "TEMA-METU Gap Analysis of Lesser Caucasus Forests Project" which documented distribution of bird species in the area. This study aimed to document diversity, composition and habitat relations of avian communities of the Turkish Lesser Caucasus by using point counts and multivariate analyses. Baseline data provided by this study will help detect and understand changes in bird populations in the future.

The specific objectives of this study were as follows:

- To document the bird composition and diversity of the Lesser Caucasus region,

- To compare bird composition, species diversity and habitat diversity of sub-ecoregions,

- To determine the patterns of species diversity and the environmental parameters affecting the avian community structure.

CHAPTER 2

MATERIALS AND METHODS

2.1 Study Area

2.1.1 Geographical Position

The study area falls into the north-eastern part of Turkey (Figure 2.1). It covers roughly 35,000 square kilometers wide and contains all of Ardahan, southern and eastern parts of Artvin, north-eastern parts of Erzurum and western and central parts of Kars provinces.

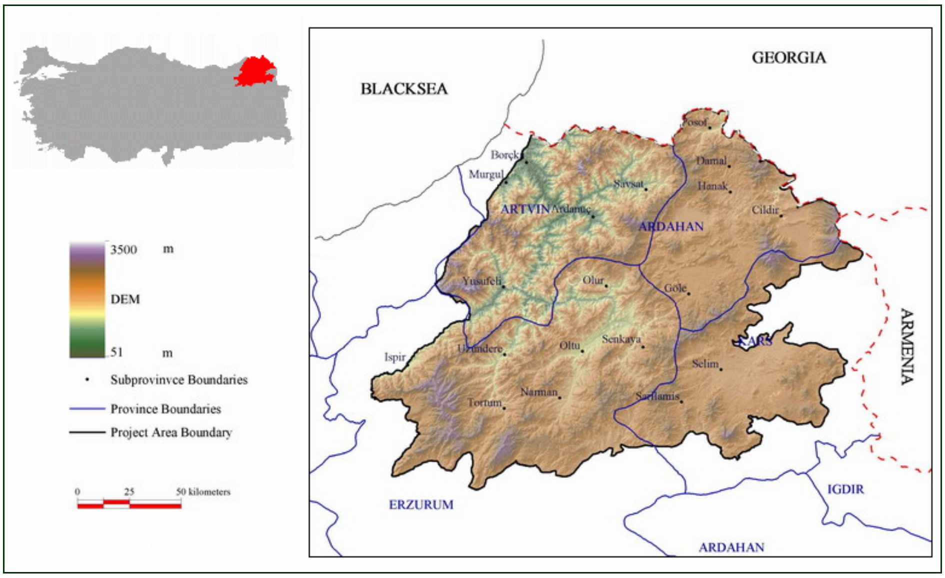

Figure 2.1. The study area falls into the north-eastern part of Turkey (Kaya 2006)

2.1.2 General Characteristics

The study area is often called as the Lesser Caucasus which is a part of the global 200 ecoregion which is named as *Caucasus-Anatolian-Hyrcanian Temperate Forests* on WWF’s Global 200 list of the world's most important areas (WWF International 2007). The ecoregion covers 520,000 km² and spans the region between Black Sea and the Caspian Sea within seven countries: Georgia, Azerbaijan, Armenia, Russia, Ukraine, Turkey and Iran. It is also shown among the Planet’s 25 most diverse and endangered hotspots by Conservation International (Wilson 2006).

Much of the Caucasus Region is mountainous, but there are also extensive lowlands and coastlines. Its major ecosystems are forests (broadleaf and coniferous), wetlands and swamps (lakes, rivers), high mountains, dry mountain shrublands, grassland steppes, semi-deserts, and cliff and rock communities (WWF International 2007). It may have up to 20% endemism in plants and harbors several critically endangered species.

The global Caucasus ecoregion is made up of terrestrial ecoregions which are Kopet Dag woodlands and forest steppe, Caucasus mixed forests, Euxine-Colchic deciduous forests, Northern Anatolian conifer and deciduous forests, Caspian Hyrcanian mixed forests and Elburz Range forest steppe (WWF International 2007).

Our study area falls within the Turkish part of the *Caucasus Mixed Forest Ecoregion*. This ecoregion extends further east into the Greater Caucasus mountain range at the Russia-Georgia border as well as south along the mountains on the Armenia-Azerbaijan border. In Turkey, the Caucasus Mixed Forests ecoregion covers all or parts of Erzurum, Artvin, Kars and Ardahan provinces (WWF Türkiye 2007). The exact boundaries of the study area follow those used by the Lesser Caucasus Gap Analysis project ("TEMA-METU Gap Analysis of Lesser Caucasus Forests Project").

2.1.2.1 Ecological Structure of Sub-ecoregions

The study area is classified into 4 sub-ecoregions according to climate, large soil groups and dominant vegetation type within the scope of "Gap Analysis of Lesser Caucasus Forests Project" (Figure 2.2).

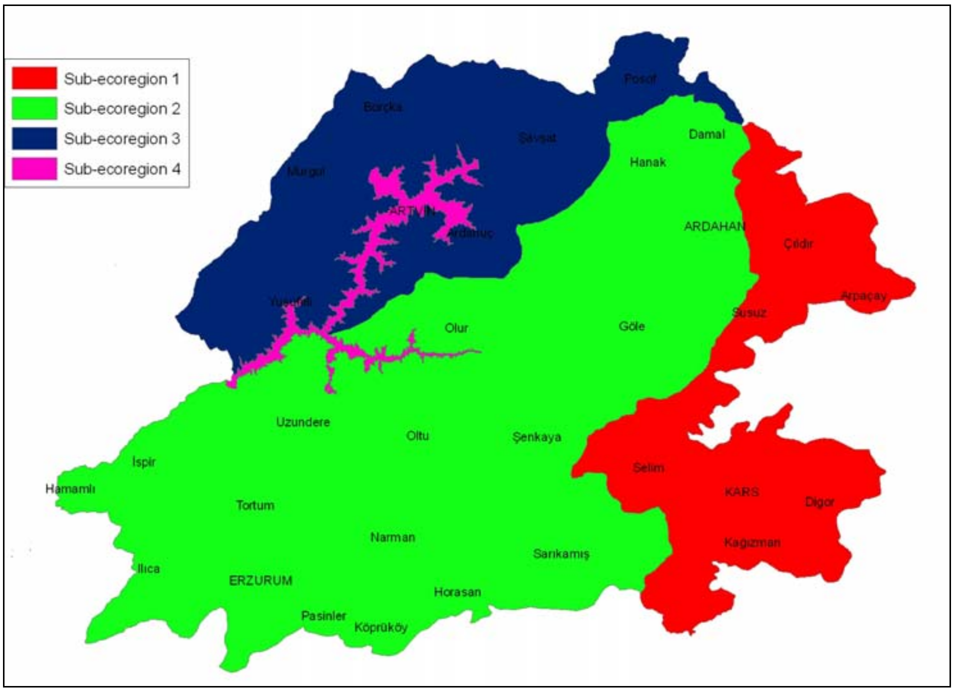

Figure 2.2. The sub-ecoregions in the area ("TEMA-METU Gap Analysis of Lesser Caucasus Forests Project")

1. **Kars-Ardahan High Plateau Sub-ecoregion (Sub-ecoregion 1)**

This sub-ecoregion is characterized by high plateaus and a dry climate. Forests consist of mainly Scots pine. These forests are also covered by aspen and birch species and sometimes these species form small pure stands.

2. **Erzurum Dry High Mountain Steppe-Alpine Meadows Sub-ecoregion (Sub-ecoregion 2)**

Euro-Siberian Phytogeographic region is mostly replaced by Irano-Turanian Phytogeographic region in this sub-ecoregion. It has a drier climate than other regions. Continental climate is dominant in the area where summers are cool and dry, while winters are cold and dry. The major vegetation type is high mountain steppe. Beside this Scots pine and oak communities are distributed at the lower altitudes.

3. **Humid Temperate Forests Sub-ecoregion (Sub-ecoregion 3)**

The *broadleaf forests* of the region are highly diverse and are dispersed according to elevation, soil conditions, and climate. The precipitation is high in this sub-ecoregion. Forests consist mainly of beech. Forests of chestnut, hornbeam, maple, elm and linden are distributed at the lower altitudes while beech is present with fir and spruce in higher altitudes. Besides, fir and spruce are found in areas with lower precipitation.

4. **Çoruh and Tortum Valleys Sub-ecoregion (Sub-ecoregion 4)**

This sub-ecoregion is predominantly dry; even the Çoruh valley in otherwise humid Artvin basin shows a drier character. Mediterranean vegetation is found between Yusufeli and Borçka. The maquis formation is widespread within the region and has high biological diversity.

2.1.3 Biological Diversity

The Caucasus-Anatolian-Hyrcanian Temperate Forests Ecoregion is a biological crossroad between Europe, Central Asia and the Middle East, and this explains the high number of endemic species found here. The global 200 ecoregion has unique geology, geomorphology, climate and evolutionary history and these result in different ecosystems, in consequence diverse and rich biological communities. 6,300 species of vascular plants are found with 1300 of them endemic - the high level of endemism in the temperate world (National Geographic 2007).

The Lesser Caucasus has a rich fauna and flora. 3650 plant species are found in the study area and 376 species are endemic to the region (Kaya 2006). The study area provides home for many large mammals like Brown Bear (*Ursus arctos*), Eurasian Lynx (*Lynx lynx*), Wolf (*Canis lupus*), Wild Cat (*Felis silvestris*), Jackal (*Canis aureus*), Wild Goat (*Capra aegagrus*), Chamois (*Rupicapra rupicapra*), Roe Deer (*Caproelus caproelus*), Wild Boar (*Sus scrofa*), Leopard (*Panthera pardu*s), Red Deer (*Cervus elaphus*) and also smaller mammals like Red Fox (*Vulpes vulpes*), Eurasian badger (*Meles meles*), Pine Marten (*Martes martes*) and Otter (*Lutra lutra*). One of the most important bird migratory routes on Earth passes over the Lesser Caucasus Ecoregion. The Caucasian black grouse (*Tetrao mlokosiewiczi*) is endemic to the Caucasus Ecoregion. The study area also includes many endangered, rare or endemic reptile, amphibian, butterfly and fish species. Caucasian rock lizards (*Lacerta clarkorum*), Caucasian viper (*Vipera kaznakowi*) and Caucasian salamander (*Mertensiella caucasica*) are some of those.

2.1.3.1 Breeding Bird Species

The regional pool of breeding bird species are listed in Table A.1 (Appendix A). The species are listed in taxonomic order with both scientific and English common names. Throughout the text and in other tables, only English common names of the birds are used. The list was prepared according to data provided by "TEMA-METU Analysis of Lesser Caucasus Forests Project" and expertise of C.C. Bilgin. For English, Turkish and scientific names and taxonomic order, "Türkiye ve Avrupa'nın Kuşları" (Heinzel et al. 1995) and Collins Bird Guide (Svensson and Grant 2001) were used as references.

2.2 Study Period-effect of season, time of day and weather on detection probabilities of birds

Many factors affect bird activity and behaviour. Among these the season, time of day, and the weather are the most important (Bibby et al. 1998). These in turn affect the observer's ability of detecting birds by sight and sound. The best time for point counts is when the detection rates of the species being studied are most stable (Ralph et al. 1995). The bird surveys should be implemented at the beginning of breeding season when identification of species is easier due to vocal or visual displays. Therefore, the study was carried out between 3rd of July and 1st of August when a great majority of birds in the area belong to a breeding population. Actually, it is not the beginning of the breeding season but the field observations of courtship behavior of particular species and nest findings indicate that the breeding season is later and/or extended at the higher altitudes of the study region. The period of study for the breeding season may differ, depending upon the species, the latitude, rainfall pattern, temperature and elevation. By taking consideration all of these factors, the study was designed according to the resources and opportunities available.

Time of the day is also an important consideration for such studies. The rate of calling and singing varies with time of day. Birds are more active in the mornings shortly after dawn and activity declines significantly by some time in mid-morning (Ralph et al. 1993; Ralph et al. 1995; Bibby et al. 2000). It is best to start counting at sunrise rather than first light and complete it until after about 5 hours (i.e. 10 a.m.). Therefore, field observations were started after dawn and completed at about 10:00 a.m. At higher elevations or latitudes the period of diurnal activity extends further (Huff et al. 2000).

Adverse weather conditions affect bird activity and observer's ability of detection birds by sight and sound (Bibby et al. 2000). Weather conditions unsuitable for counting include high wind, heavy rain, low cloud, heavy fog and even high temperatures (Ralph et al. 1995; Bibby et al. 1998; Huff et al. 2000). The degree to which these conditions affect counts depends upon the species and habitats surveyed. In this study, weather conditions were recorded and counts were conducted only under suitable weather conditions.

2.3 Field Methods

Field work was carried out between 3rd of July and 1st of August 2004 within the scope of "TEMA-METU Gap Analysis of Lesser Caucasus Forests Project" funded by Baku-Tbilisi-Ceyhan (BTC) Pipeline Environmental Investment Programme. The aim of the study was to document distribution of occurrence of bird species in the area. Totally 20 days of fieldwork were carried out by Turkish and Dutch experts. Three teams were formed by 3 or 4 observers in each, except for a small number of localities covered only by C. Bilgin. Kuş Araştırmaları Derneği implemented the fieldwork for TEMA-METU. Observers were selected to have at least a moderate level of competence in detecting birds by sight and sound.

A map projection of UTM North Zones 37 and 38 was used for study area. The study area is composed of 349 of 10km*10km UTM grids but only 49 of these grids were selected for sampling as allowed by available resources. The map shows the pre-selected grid squares for sampling (Figure 2.3). They were selected semi-randomly, constrained by the road accessibility, but they were revised in the field. Teams followed different routes in the study area and visited different UTM grids. A point count method was used to tally the birds observed in the predefined UTM grids. Each species were recorded in the standard field form provided.

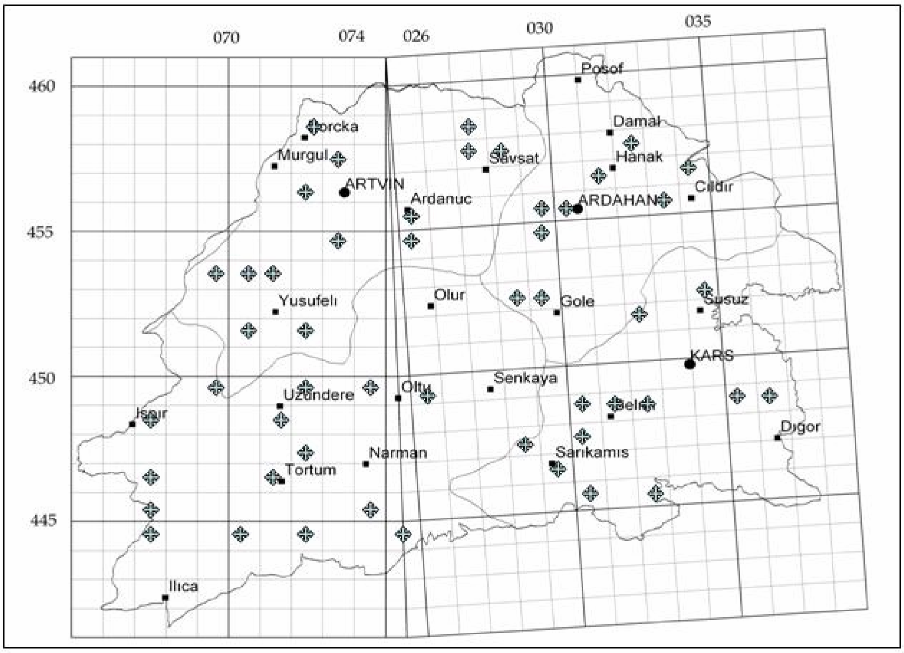

Figure 2.3. Pre-selected UTM grids ("TEMA-METU Gap Analysis of Lesser Caucasus Forests Project")

2.3.1 Point Count Method

The method of the study based on a habitat-based protocol developed especially for breeding season by Huff et al. (2000). The method is basically tallying all birds observed (sight or sound) for 5 minutes interval at each station.

2.3.1.1 Establishing the Point-Count Stations

In this study, counts were conducted at two locations within 100 km^2 UTM grids and two count stations (acting as replications) within each location. The locations were selected to be at least 2 km away from one another and be representative habitats larger than about 10 hectares (100,000 m^2). The size limit aims to ensure that the relationship between species recorded and their habitats is reliable.

The first station was randomly selected and the second one was spaced by walking away from the first station (by staying within the sampled habitat). The distance between point count stations should be at least 250 m (Ralph et al. 1995). This distance is determined according to a study which found out that more than 99 percent of individuals are detected within 125 m of the observer nearly in all habitats (Scott et al. 1981). According to Wolf and others (1995) the maximum detection of almost all individuals of most species is less than 250 m. However, this minimum distance should be increased because of the greater detectability of birds in open environments.

At each location point count stations were placed:

- At least 125 m (preferably 200 m) from the edge of the location boundary.
- At least 150 m (preferably 200-250 m) apart from each other to lower the possibility of double counting individual birds.
- At least 50 m (preferably 150 m) away from the edge of secondary roads, and water (small stream or wetland).
- At least 75 m (preferably 150 m) from a sharp break in the vegetation structure and composition.

2.3.1.2 Conducting the Point-Counts and Defining the Detections

Field observations started after dawn and were completed at about 10:00 a.m. Each team visited two point count stations at each location. At each station, the counts were conducted in a 5-minute span. 5 minute span is the most widely used interval in the literature and is the European standard (Koskmies and Vaisane 1991). According to Ralph and others (1995) duration for each count should be 5 minutes if travel time between stations is less than 15 minutes (for greater efficiency) and 10 minutes if travel time is greater than 15 minutes. Therefore, this study was designed to spend less than 10 minutes walk between stations. Birds detected (by sight or sound) within the first 3 minutes of a count period and during the last 2 minutes were noted separately.

Bird detections at each point count station were classified as typical detection or flyover. A typical detection includes those birds heard or seen from ground to the top of surrounding vegetation within defined horizontal boundary. For typical detections two distance bands, 0- to 50-m and >50 m, and two-time periods, 0 to 3 minutes and 3 to 5 minutes, were used. Two distance bands are defined as:

- 0 to 50 m: birds up to top of vegetation, ≤50 m from the station center point.
- >50 m: birds up to top of vegetation, >50 m from the station center point.

A flyover detection is defined as a bird detected above the highest surrounding vegetation which is the area above the typical detection within a 50 m diameter. However, the birds detected during very short flights from plant to plant, above and close to the highest vegetation are recorded as typical detection. Flyover detections were classified as either associated or independent. "Flyover associated" includes birds above top of vegetation associated with local habitat. "Flyover independent" is a bird detected flying away to or from some unknown location, distant and unassociated with local habitat. Two time periods, 0 to 3 minutes and 3 to 5 minutes, were also used for flyover detections.

Juvenile birds and birds detected before and after a point count were recorded separately.

2.3.1.3 Recording the Data

The bird detections for each station were written separately on the field form provided (Figure B.1 in Appendix B). The standard field form has two parts, a visit description and bird detection. Visit description part includes date, observer name, county name, GPS coordinates, habitat, altitude, wind and weather conditions. Bird detection information part has station code, station count start time, species detections (typical detection, flyover detection, juvenile count, flush detection and field notes) and number of individuals for each species. For identification of bird species, Collins Bird Guide (Svensson and Grant 2001) and "Türkiye ve Avrupa'nın Kuşları" (Heinzel et al. 1995) were used.

2.4 Analysis

For analysis, typical and fly over associated detections were taken into consideration. Other detections were not considered since they are less likely to be breeding or associated with the habitat surrounding. Records were checked by an expert for possible misidentification with the help of available information on the regional avifauna and details of habitat and other clues. Merlin (*Falco columbarius*) and Yellow-legged Gull (*Larus cachinnans*) were considered to be misidentifications and therefore removed from the analysis. Aquatic birds were also removed since they are not in the scope of this study. Since it is difficult to detect habitat association, the absolutely arboreal Swift (*Apus apus*) was excluded, too.

GPS coordinates for each station were converted to UTM zones and represented on a map. The coordinates were checked by help of the map and field forms. The distance between stations was calculated using simple trigonometric computations. Two of the stations at two locations located very close to each other (e.g. 11 m and 13 m) were excluded from the analysis because of probability of counting same individuals. The maximum distance between the stations in a location was accepted to be 1000 m and two stations in same location violating this assumption were evaluated as sampled at different locations. Besides, 15 stations were excluded since 3 of them do not have GPS coordinates, 3 of them were empty, 1 of them was recorded at 1.30 p.m. and 8 of them were not filled correctly. In total, 215 stations were used for the analysis (Figure 2.4). The 215 stations located in the Lesser Caucasus were composed of pair of stations at the same location. Since these stations were sampled within the same habitat, data from these stations were combined for species diversity measures and multivariate analysis for the study area except the species diversity measures for sub-ecoregions. In total 111 stations were obtained. They were letter- and color-coded to represent each of the sub-ecoregions (K: Sub-ecoregion 1, E: Sub-ecoregion 2, H: Sub-ecoregion 3 and C: Sub-ecoregion 4) in the tables and in the graphs of multivariate analysis.

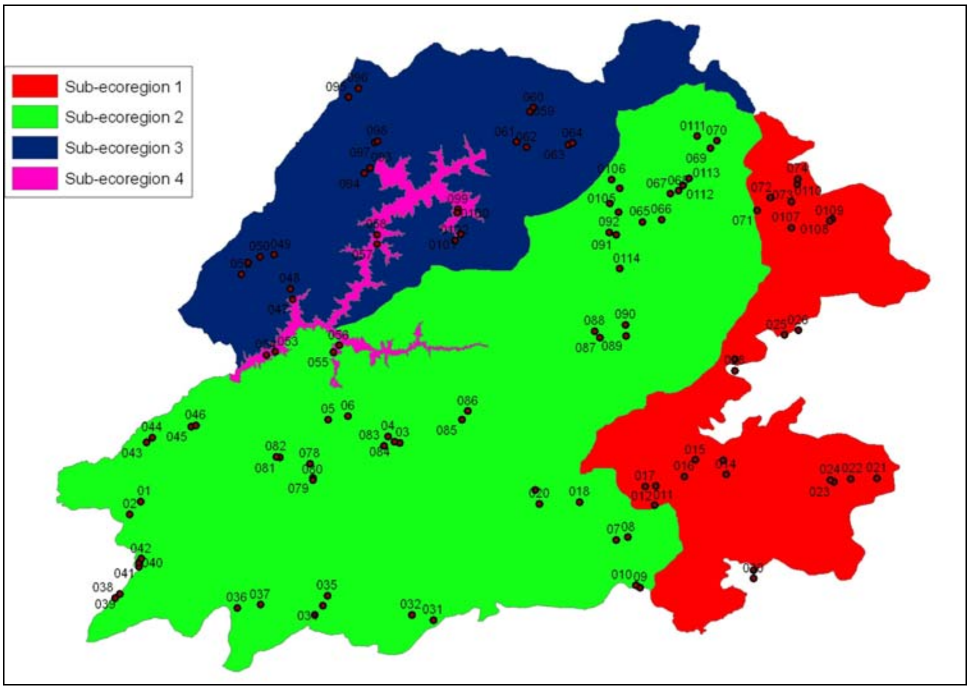

Figure 2.4. The location of stations in the Lesser Caucasus

Vegetation cover categories were prepared in the "TEMA-METU Gap Analysis of Lesser Caucasus Forests Project" for birds by using satellite image (Table C.1 in Appendix C). The vegetation map prepared in the scope of the project is shown in Figure 2.5. The vegetation layer of the project was used to extract vegetation cover categories and their proportions for 111 combined stations. This was performed by using a buffer zone of 75 m around of multiple stations and 106 m around of single stations in the same locations to obtain comparable areas. The vegetation cover categories as pixels in the buffer zones were extracted by using IDRISI software. The coordinates of stations were imported in Google Earth Software. The vegetation cover categories extracted from IDRISI were checked by the help of Google Earth and the habitat information written in the field forms. Some of the categories extracted from IDRISI were corrected and additional categories were added such as orchards and groves, rocky and stony, valley flat up and bottom and presence of running water. All point count stations were coded according to the sub-ecoregions they were sampled. The environmental parameters for 111 stations were given in Table C.2 of Appendix C.

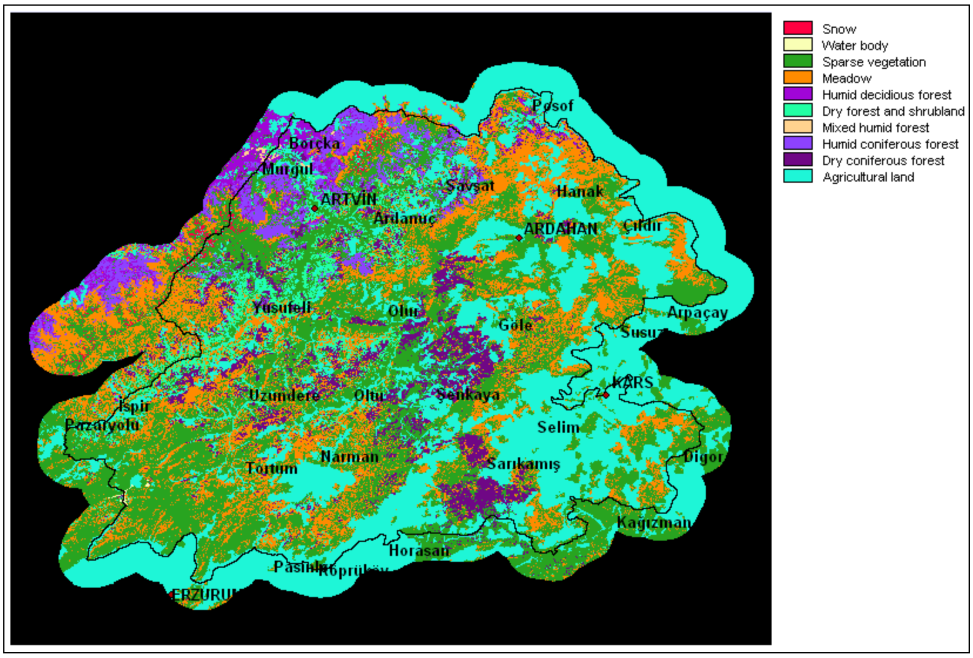

Figure 2.5. Vegetation layer of the Lesser Caucasus ("TEMA-METU Gap Analysis of Lesser Caucasus Forests Project")

2.4.1 Species Diversity Measures

In this study, species accumulation curves-rarefaction, non-parametric species richness measures and non-parametric species diversity indices were used.

The species accumulation curves plot the cumulative number of species, S(n), collected against a measure of the sampling effort (n). Species accumulation curves rise repeatedly at first, then much more slowly in later samples as increasingly rare taxa is added. These curves are distinguished according to the sampling efforts as sample-based or individual based species accumulation curves. In this study, sample-based rarefaction curves were computed by using the program EstimateS (Colwell 2000). The order that samples are added to the species–accumulation curve affects the shape of the curve produced because of sampling error and heterogeneity among the species in the samples (Colwell & Coddington 1994). To overcome this problem various sample randomization procedures have been developed. However the number of random selections was set to 1 since they are computed analytically and does not need resampling in EstimateS (Colwell et al. 2004). Rarefaction is a method for interpolating to smaller samples and estimating species richness in the rising part of the species accumulation curve (Gotelli and Colwell 2001).

Non-parametric indices such as Chao1, Chao2, first order Jackknife and second order Jackknife are used to estimate species richness in the study. The Chao1 estimator is developed by Chao (1984) based on the concept that rare species carry the most information about the number of missing ones. They are designed as a lower bound for species richness. The estimator relies on the distribution of individuals among species and requires abundance data, and is based on the number of species represented by a single individual (singletons) and the number of species represented by two individuals (doubletons). The Chao2 estimator developed by Chao (1984) is based on the distributions of species among samples and requires only incidence (presence-absence) data. The estimator is based on the number of species that only occur in one sample (unique) and the number of species that occur in only two samples (duplicate). Jackknife estimators are developed to reduce bias of estimates and are based on incidence data. First order Jackknife is developed independently by Heltshe and Forrester (1983) and Burnham and Overton (1978). The estimator is based on the number of species only found in one sample (unique). Burnham and Overton (1978) developed the second-order jackknife estimator which is based on the number of species only found in one sample (unique) and the number of species only found in two samples (duplicate) by using incidence data. Non-parametric diversity indices make no assumptions about the shape of underlying species abundance and give no additional insight (Southwood and Henderson 2000).

In this study, also the widely used Shannon-Wiener and Simpson's indices were used. Shannon-Wiener index is an information index of measuring order or disorder in the community (Krebs 1999); it assumes that individuals are randomly sampled from an "indefinitely large" population and all species are represented in the sample (Magurran 1988). The Shannon-Wiener index generally ranges between 1.5 and 3.5 (Magurran 1988). Simpon's index is based on the probability of any two individuals drawn at random from an infinitely large community belonging to the different species (Krebs 1999). Shannon-Wiener is insensitive to the character of species number and abundance relationship, weighes rare species more, and thus inclines towards species richness whereas Simpson's index is strongly affected by the underlying species abundance distribution, weighes common species more, and thus leans towards evenness (Magurran 1988; Southwood and Henderson 2000). Magurran (1988) states that the choice of an diversity index depends on the objective of the study: indices weighing towards species richness are more useful for detecting differences between different sites. Southwood and Henderson (2000) reviewed that Shannon-Wiener index is found unsatisfactory in many studies in spite of popularity. Shannon-Wiener index is more sensitive to sample size than Simpson index and Simpson's index is preferable in small samples sizes (Magurran 2004). Exponential of Shannon-Wiener index which is the number of equally common species required to produce the value of Shannon index given by the sample and Simpson inverse

(1/D) which is the number of equally common species required to produce the observed heterogeneity of the sample were also used.

Non-parametric indices of species richness and species diversity were computed by using the program EstimateS for each sub-ecoregion (Colwell 2000). The indices estimate total species richness, including species not present in any sample. Number of random selections was set to 100 to remove the sample order. By this way, samples were selected 100 times at random from the complete set of samples and the mean estimate was calculated. Sampling without replacement and “Chao 1 and Chao 2 classic formula” were selected in diversity settings of EstimateS. PC-ORD was also used to compute the Shannon-Wiener and Simpson diversity indices for each station.

2.4.2 Multivariate Analyses

Multivariate analysis is used to search for relationships between objects or to classify objects that are defined by a number of attributes. If the objective is to assign the objects into a number of discrete groups, cluster analysis is used. Ordination can be used to investigate the overall similarity of sites and to pick out major groupings. In the study multivariate analysis was computed by using PC-ORD software (McCune and Mefford 1999).

Cluster analysis was used to identify groups of stations that are similar in their species composition. There are many types of cluster analysis. In this study UPGMA (Unweighted Pair Group Method Using Arithmetic Averages) which is agglomerative based on fusion of clusters into larger groups, was used. The result is a hierarchical dendogram where objects are assigned to groups, which are arranged further into larger groupings. UPGMA uses average clustering algorithm and give weight to each point in each cluster. The algorithm maximizes the correlation between the original (dis)similarities and the (dis)similarities between samples

(Jongman et al. 1995). Relative Sorenson distance measure was used to measure similarities between objects.

Ordination is the collective term for multivariate techniques that arrange sites along axes on the basis of data on species composition. The result of ordination in two dimensions (two axes) is a diagram in which sites are represented by points in two dimensional space. The aim of ordination is to arrange the points such that points that are closer together correspond to sites that are similar in species composition and points that are far apart correspond to sites that are dissimilar in species composition. The method does not provide a classification of community types but recognize the pattern present in the community.

Detrended Correspondence Analysis (DCA) was used as an indirect gradient analysis to determine species composition because species are usually clearly distinguishable entities. DCA is an eigenanalysis ordination technique based on reciprocal averaging. It is used to overcome the major problems in correspondence analysis which are arch effect (caused by the unimodal species response curves) and compression of the ends of the gradient (OSU Ecology 2007). The first problem is solved by dividing the first axis into segments, then setting the average score on the second axis within each segment to zero. The second is done by rescaling the axis to equalize as much as possible the within-sample variance of species scores along the sample ordination axis.

Canonical Correspondence Analysis (CCA) was carried out to understand how environmental factors affected bird composition. CCA is a direct gradient analysis in which species are directly related to measured environmental factors. CCA maximizes the correlation between species scores and sample scores and find the best dispersion of species scores. The ordination of samples and species is constrained by their relationships to environmental variables (Jongman et al. 1995). The analysis ordinates stations according to their bird composition and shows environmental factors as vectors. Quantative variables including sparse vegetation, grassland, humid deciduous forest, dry woodland and shrubland, mixed humid forest, humid coniferous forest, orchards and groves, crop fields and altitude were used in the analysis. The categorical variables such as rock and stony, valley flat up and bottom and presence of running water were also included as dummy variables.

CHAPTER 3

RESULTS AND DISCUSSION

3.1 Community Parameters

3.1.1 Regional Species Pool of the Study Area

2845 individuals of 101 bird species were observed (using typical and fly-over associated detections) for a 5 minutes-long interval at 215 stations located in the study area. The observed bird species and their relative abundance are listed in taxonomic order in Table C.3 (Appendix C).

The regional species pool of the Lesser Caucasus (Table A.1 in Appendix A) consists of 186 species. In this study, aquatic birds, including grebes, pelicans, herons, geese, ducks, rails and crakes, waders, gulls and terns, as well as completely aerial birds such as swifts were excluded from the analysis since the methodology was not based on counting wetland birds and it was difficult to associate swifts with the habitat. Only, White Stork, Black Stork, Ruddy Shelduck, Lapwing and Common Sandpiper were included since these species nest in terrestrial habitats some distance from the water (Svensson and Grant 2001).

Table C.3 showed that the most abundant species were in order of decreasing rank Starling (353 individuals), Skylark (300), Ruddy Shelduck (204) and Hooded Crow (177). Quail (77 times), Skylark (63), Corn Bunting (58), Chaffinch (41), Blackbird

(41) and Hooded Crow (41) were the most frequent species observed at different point count stations (Table C.3). The log number of individuals of each species was plotted against their rank (Figure 3.1). There were 15 species represented by only a single individual.

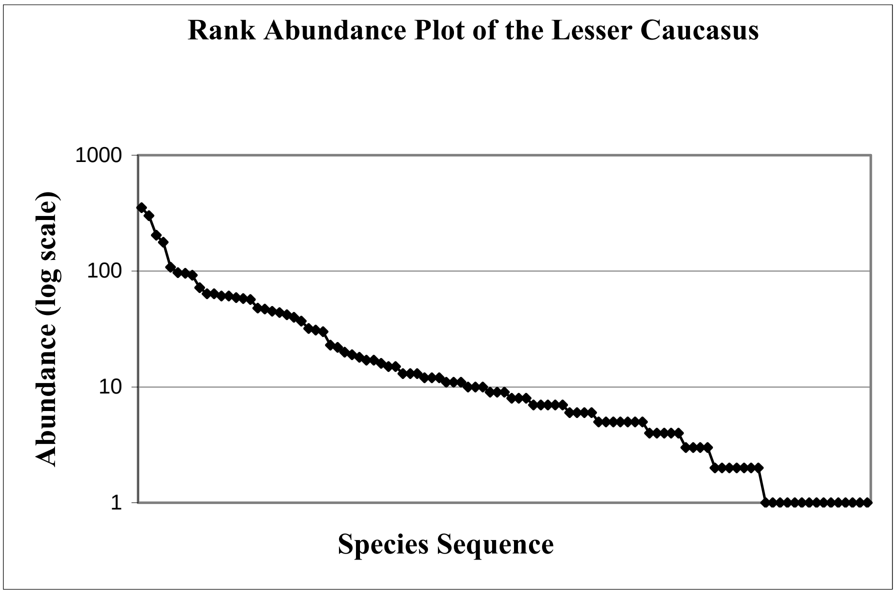

Figure 3.1. Rank abundance graph of the study area

In total, 64 percent of bird species were observed compared to regional species pool, excluding aquatic birds. The percentage of species observed changed among different taxa. Particularly, 77 percent of passerines in the regional pool were observed. Moreover, an additional 16 percent of passerine species were recorded before or after the point counts and during visits between the stations. Bluethroat, Rock Thrush, Ring Ouzel, Garden Warbler, Orphean Warbler, Sedge Warbler, Great Reed-Warbler, Semi-collared Flycatcher, Long-tailed Tit, Penduline Tit, Wallcreeper, Treecreeper, Woodchat Shrike, Lesser Grey Shrike and Red-fronted Serin were not recorded during point counts. However, only 33 percent of raptors from the regional species pool were observed. Again, 63 percent of raptors in the regional species pool were observed before or after the point count and visits between the stations. Nocturnal species such as owls and nightjars were not recorded at all during 5 minutes intervals. Only 50 percent of previously recorded woodpecker species were observed.

Some species such as Caspian Snowcock, Caucasian Black Grouse, Corncrake and Great Bustard were not observed since they are rare species and it is difficult to detect them. Grey Partridge and Stock Dove are not really rare but still were not recorded since they are shy and difficult to detect.

These results are consistent with the assumption that detection probabilities differ among bird species (Ralph et al. 1993; Ralph et al. 1995; Bibby et al. 2000; Huff et al. 2000). This is probably due to some species being noisier and mobile whereas others being quiet and shy or some being cryptic or nocturnal like the owls. The owls were not recorded at all in this study. Usually more than 90 percent of birds in the field are detected by sound rather than sight (Hamel et al. 1996). Sound is very important for the detection of the small birds in dense vegetation which is mostly the case for passerines since those species were detected by sound rather than sight. On the other hand, detection of the much rarer raptor species is dependent on sight and they were generally observed as flying-over, which usually meant there was no dependence on the particular habitat. The observed frequency of raptors was found low in the study.

The duration of a point count is also important for detection of birds. A 5 minute-long span was used in the study since it is the most widely used interval in the literature and is the European standard (Koskmies and Vaisane 1991). In the study of Howe et al. (1995) birds recorded in 0-3, 3-5 and 5-10 minute intervals were compared and they found that 64 and 63 percent of the bird species were recorded in forest habitats and in open habitats, respectively, during the first 3 minutes. They showed that 79 percent and 76 percent of birds recorded within the first 5 minutes in forest and open habitats, respectively. They detected some species like woodpeckers in the 5-10 minute interval. This study supported the fact that another important consideration is that the detectability of birds changes from one habitat to another (Bibby et al. 2000). Bibby and Buckland (1987) showed that birds are more detectable in open habitats in comparison to woodland. Another study by Lynch (1995) showed that 55 percent and 82 percent of all initial species detections occurred within the first 5 and 10 minute intervals, respectively. These studies also showed that different count periods are also appropriate for different groups of species. For this reason, the time should be long enough to detect all the birds in that station especially for rare and cryptic species. The longer the duration, the finer a resolution of bird communities will a count provide. However, this increases the chance of detecting the same birds and of movement of birds into the station site (Bibby et al. 2000). There are also tradeoffs between count duration and travel time since a longer duration will cause a smaller number of points sampled. In this study, some of the raptors, woodpeckers and passerines were recorded before or after the count duration.

Variation in detection of birds is important components of bird surveys which did not gain enough importance. The detectability also changes for each species with time of the day and time of the year (Hamel et al. 1996; Bibby et al. 2000; Huff et al. 2000; Sutherland et al. 2004). In this study, it was assumed that all species have equal detection probabilities during the whole month of sampling or at any time of day between dawn and 10 a.m. Unfortunately all factors can not be controlled. The diversity measures and bird-habitat association can be influenced from the variable detection probabilities. There are several tools for estimation of detectability of birds during counts such as distance sampling. Overall we recommend future point count surveys to record additional information necessary to apply these existing and emerging statistical models. These are mainly dividing period into three or more time-intervals of equal length and record the distance to each bird detected or by using several distance categories.

The point count method does not provide reliable data on waterfowl, except on rails and waders and on some land birds of particularly quiet, loud, nocturnal, or flocking

(Ralph et al. 1993). In this study, highly visible and vocal species especially passerines are well-documented as stated by Sutherland (1996).

3.1.2 Community Composition and Avifaunal Patterns in the Lesser Caucasus

Cluster analysis of 111 stations by bird species composition revealed two main groups separated by blue lines in Figure 3.2, which were further divided into many groups. The first group represented mostly crop field and grasslands and the second group represented tree cover. The first group was composed of Sub-ecoregion 1 and Sub-ecoregion 2 while the second group was composed of Sub-ecoregion 2, Sub-ecoregion 3 and Sub-ecoregion 4. Each of the outliers, C58, E35 and K30, were composed of two species which are dissimilar to other stations. However, there are probably many different variables that underlie the construction of the groups.

The cluster analysis did not give a very clear picture of community classification. Since it is also difficult to interpret the groups, DCA was used as an indirect gradient analysis to determine pattern present in species compositions because species are usually clearly distinguishable entities. The analysis was computed by using species abundance data and shows the pure community patterns without environmental variables (Figure 3.3). The eigenvalues for Axis 1, Axis 2 and Axis 3 were computed as 0.61, 0.72 and 0.55 respectively. The first two axes explained the variance in the community better. Axis 2 reflected the presence of a vertical vegetation layer where stations in crop fields and grasslands grouped at the bottom shown by a red ellipse and stations in dry coniferous forest were at the top of the axis shown by a green ellipse. Also the stations of valley bottom characteristic grouped together are shown by a blue ellipse. The relationship of sub-ecoregions was detected along Axis 2. Sub-ecoregion 1 and Sub-ecoregion 2 are more similar to one another while Sub-ecoregion 3 and Sub-ecoregion 4 are more similar each other. This shows that the region can be divided into two sub-ecoregions where first sub-ecoregion was composed of Sub-ecoregion 1 and 2 while the second sub-ecoregion was composed of Sub-ecoregion 3 and 4. Sub-ecoregion 2 showed broad variability along Axis 2 and some of stations therein grouped with Sub-ecoregion 3 and Sub-ecoregion 4. Some of the stations at the left side of the first axis correspond to sites that are dissimilar in species composition mostly in rocky and stony habitats. The DCA showed similar pattern with cluster analysis which is the result of presence of tree cover.

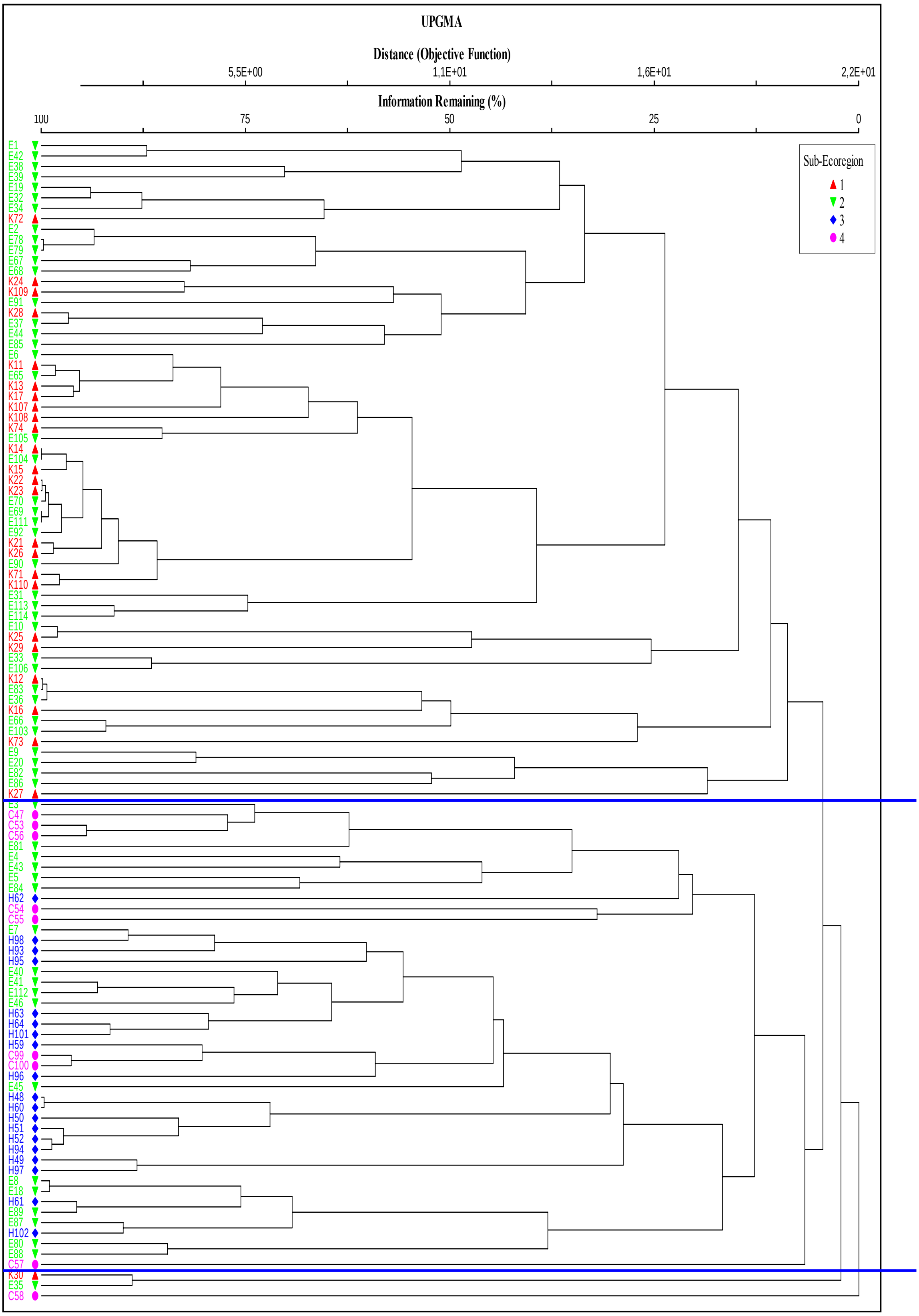

Figure 3.2. Dendogram of stations based on compositional similarity

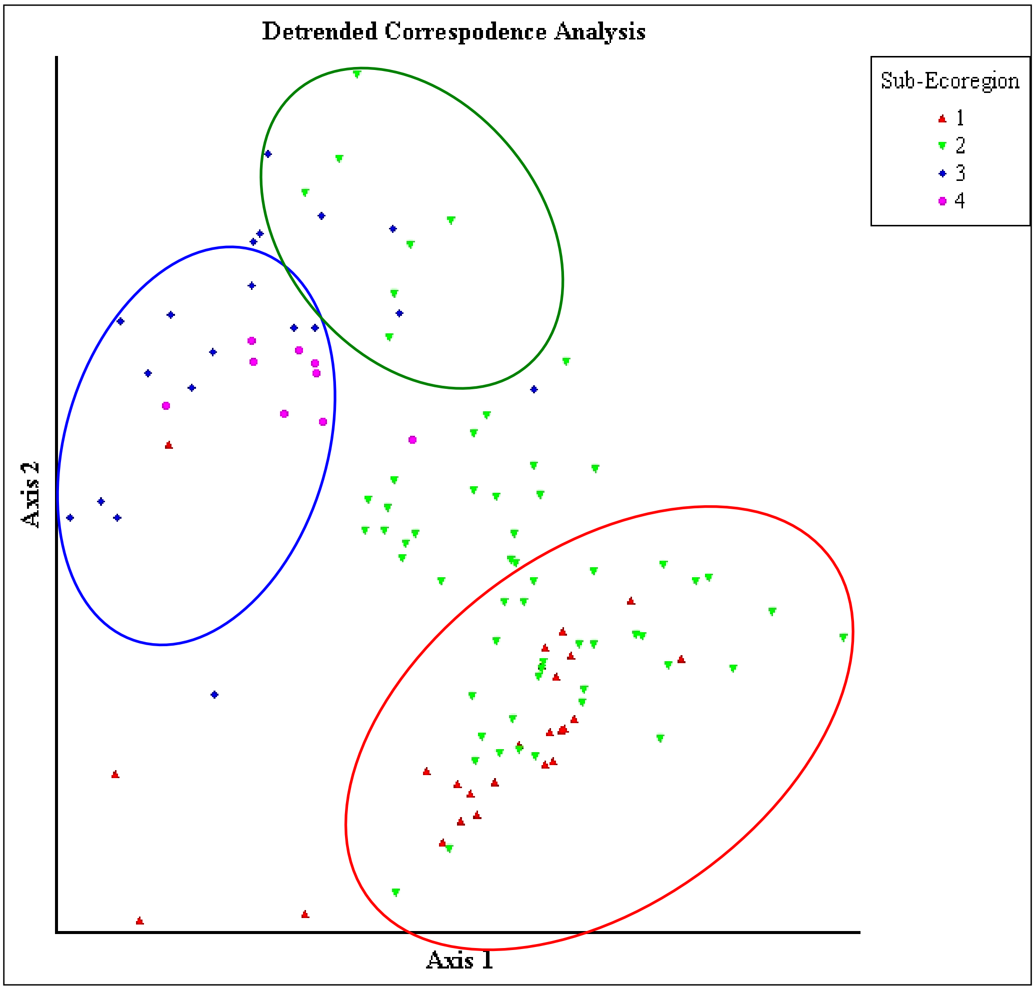

Figure 3.3. Detrended Correspondence Analysis of bird composition in each station (see text for more explanation)

3.1.3 Bird Composition of the Sub-ecoregions

Sampled point count stations were unequally distributed in four of these sub-ecoregions (Table 3.1). However when compared to size of the sub-ecoregions, the first three sub-ecoregions seem to be sampled at a similar moderate intensity while the fourth sub-ecoregion were sampled densely. Table C.4 (Appendix C) shows the distribution of species and their relative abundance among the sub-ecoregions in taxonomic order.

Table 3.1: Sampling parameters of sub-ecoregions

Sub-ecoregions	Size (km^2)	Number of stations	Stations per 1000 km^2
1	4869.46	50	10.27
2	15231.42	111	7.29
3	5819.11	37	6.36
4	612.13	17	27.77
Total	**26532.11**	**215**	**8.10**

Rock Bunting, Red-backed Shrike and Corn Bunting were recorded from all of the sub-ecoregions (Table C.4).

Rudy Shelduck, Marsh Harrier, Hobby, Lapwing, Sand Martin, Black Redstart, Isabelline Wheatear, Pied Wheatear and Twite were recorded only in the Kars-Ardahan High Plateau Sub-ecoregion (Sub-ecoregion 1). The most abundant species was Ruddy Shelduck which were actually observed as single flocks at 3 count stations. The others were mostly passerines which breed in farmland and woodland. The most frequently observed species at different count stations were Quail, Skylark and Corn Bunting, which are all farmland birds.

Erzurum Dry High Mountain Steppe-Alpine Meadows Sub-ecoregion (Sub-ecoregion 2) is the largest, most visited and most species recorded site (Table 3.1). Black Stork, White Stork, Lesser Spotted Eagle, Short-toed Eagle, Booted Eagle, Black Kite, Chukar, Woodpigeon, Turtle Dove, Hoopoe, Crested Lark, Woodlark, Water Pipit, Dunnock, Mistle Thrush, Cetti's Warbler, Chiffchaff, Caucasian Chiffchaff, Sombre Tit, Nuthatch, Siskin, Serin, Bullfinch and Crossbill were only recorded in this sub-ecoregion. These species require open and/or forested habitat for breeding. Mostly passerines (Starling, Skylark and Hooded Crow) were found to be abundant which breed in woodland and farmland. Quail, Skylark, Hooded Crow and

Corn Bunting, which were found to be the most frequently observed species at different count stations, also breed in farmland.

Krüper's Nuthatch, Song Thrush, Spotted Flycatcher, Grey Wagtail, Stonechat, and Green Warbler were only recorded in the Humid Temperate Forests Sub-ecoregion (Sub-ecoregion 3). Most of those species breed in forests and other wooded habitats. Most abundant species included Hooded Crow, Crag Martin, Chaffinch, Coal Tit and Crag Martin. The most frequently observed species were Blackbird, Chaffinch, Crag Martin and Coal Tit. Breeding habitats of the most abundant and most frequently observed species are open woodlands, orchards and groves, rocky and forested areas.

Black-eared Wheatear, Olivaceous Warbler, Chough and Tree Sparrow were only detected in the Çoruh and Tortum Valleys Sub-ecoregion (Sub-ecoregion 4). These species breed in orchards and groves and rocky areas. The most abundant species were Golden Oriole, Tree Sparrow, House Martin, Great Tit, Crag Martin and Linnet which breed in orchards and groves and rocky areas. Golden Oriole, Great Tit and Blackbird were widely distributed which require orchards and groves.

The majority of recorded species were present in two or more sub-ecoregions, but there was a significant number of species only found at a single sub-ecoregion. Although some of those species may simply be present but unrecorded elsewhere, others can be considered as indicator species for each sub-ecoregion that helps clustering and ordination separate species assemblages at the sub-ecoregion level (see section 3.1.2).

3.1.4 Species Diversity

Species diversity indices (Shannon-Wiener and Simpson) computed for 111 stations were given in Table C.5 (see Appendix C). Figure 3.4 shows the species richness of the 111 stations. There is no apparent influence of any gradient on the species richness.

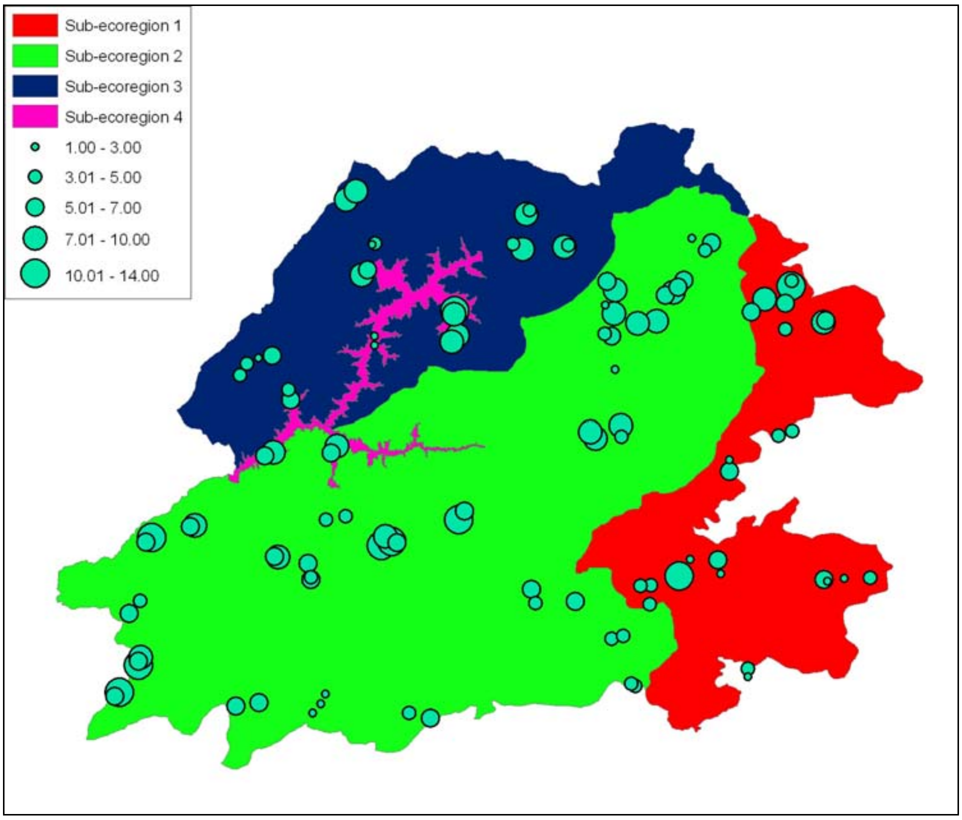

Figure 3.4. The species richness of the stations in the Lesser Caucasus

Universally in all of the taxonomic groups, a few species are represented with a lot of individuals and a large number of species with few individuals. To investigate this pattern, the log number of individuals of each species was plotted against their rank (Figure 3.5). This graph demonstrated that the relationship between species number and abundance of individuals had two features, namely species richness and evenness (Southwood and Henderson 2000).

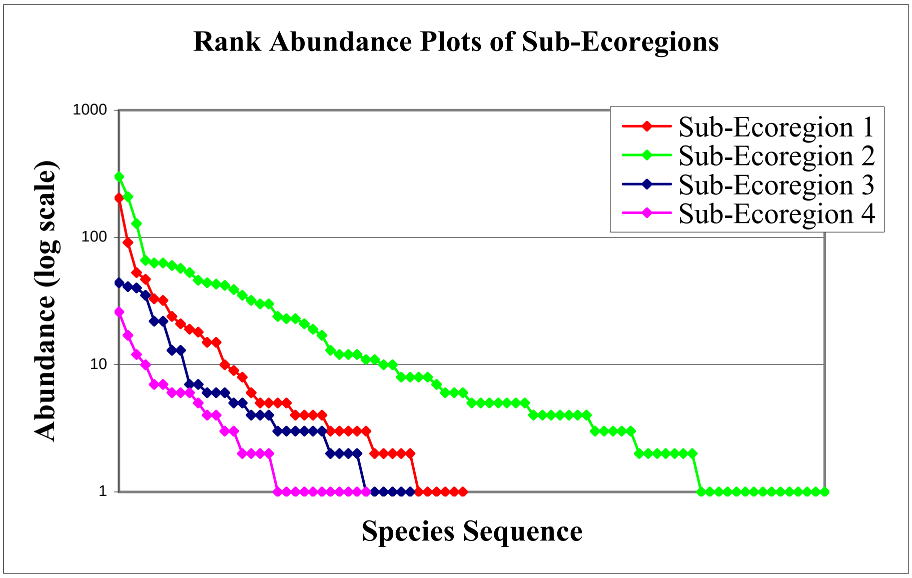

Figure 3.5. Rank abundance graph of the sub-ecoregions

The sample-based rarefaction curves plotted for each of sub-ecoregions were shown in Figure 3.6. The curves plot the cumulative number of species (actual species observed) collected against a measure of the sampling effort which is the number of stations.

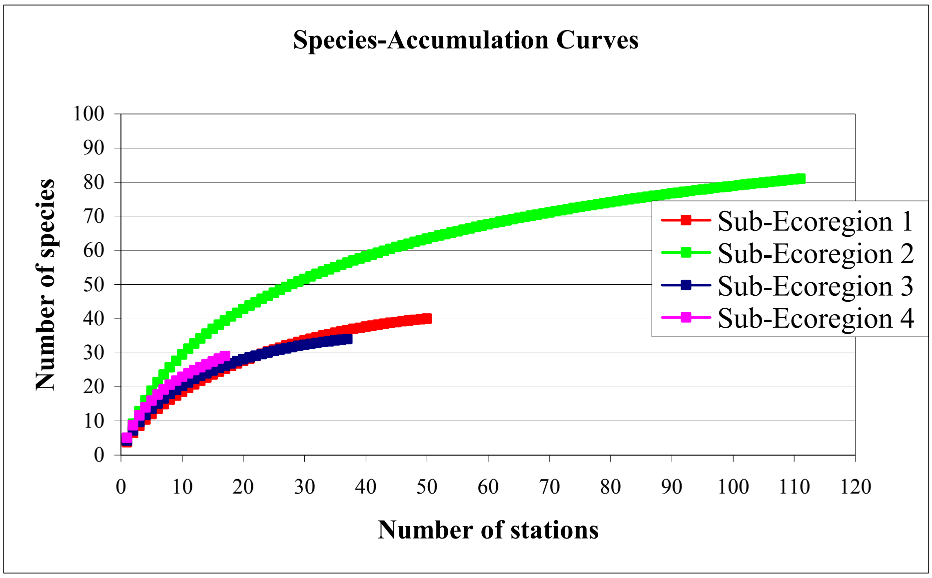

Figure 3.6. Sample-based rarefaction curves for sub-ecoregions

As shown in Figure 3.6, the species accumulation curves rise steeply at first, and then much more slowly in later samples as increasingly rare taxa were added. Sampling effort was not sufficient since the curves for each sub-ecoregions did not show a clear horizontal asymptote. Sub-ecoregions 1, 2 and 3 showed a pattern of nearing asymptote whereas Sub-ecoregion 4 tended to increase with increasing sampling effort. The increase in curvature meant that there were singletons (single observations of species) in the data set, so there is a probability of finding new species and the total species richness was not reached. Raw species data can be compared when species accumulation curves reach an asymptote when increased effort will not increase the recorded species (Gotelli and Colwell 2001). According to Walther and Moore (2005) S_{obs} is almost always the worst estimator and any estimator is preferable to the simple species count unless sampling has been exhaustive. Because of this reason another approach was to use non-parametric indices to estimate total species richness.

Total species richness and diversity indices estimated for each sub-ecoregion were shown in Table 3.2.

Table 3.2: Species richness and diversity indices computed for sub-ecoregions

	Sub-ecoregions			
	1	**2**	**3**	**4**
Observed Species Richness	40	81	34	31
Chao1	43.6	97.07	38.5	44.13
Chao2	42.7	94.33	36.23	57.17
Jack1	48.82	100.82	40.81	41.24
Jack2	43.35	105.86	37.32	50.22
Shannon-Wiener	2.66	3.37	2.87	2.86
Shannon-Wiener (exp)	14.3	29.08	17.64	17.46
Evenness	0.72	0.77	0.82	0.85
Simpson	0.87	0.94	0.919	0.917
Simpson (inverse)	7.64	15.76	12.74	13.09

Since the number of stations for each sub-ecoregion was not equal, the estimated species richness was plotted by using "lower bound" estimator Chao1 and "bias reduction" estimator Jackknife1 (Figure 3.7 and Figure 3.8).

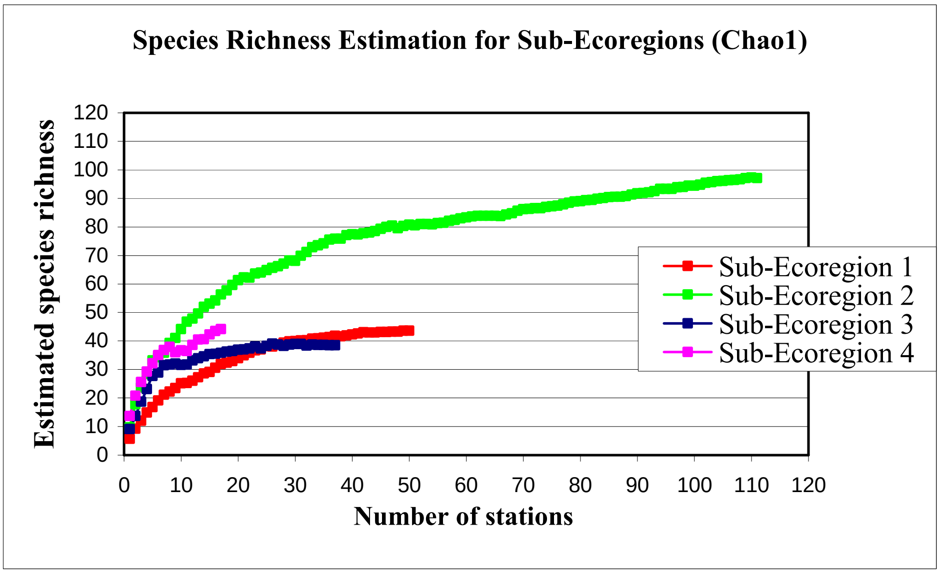

Figure 3.7. Species richness estimation for each sub-ecoregion by using Chao1

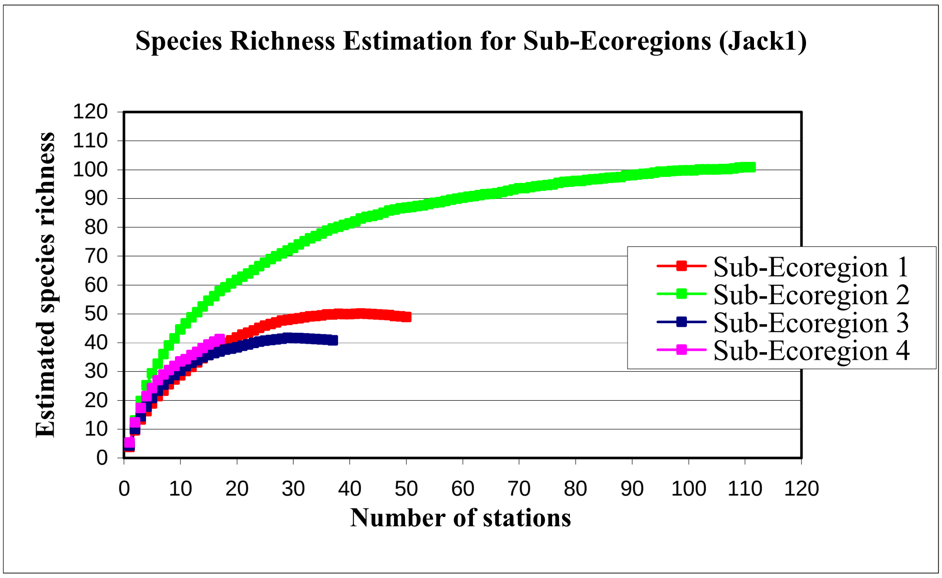

Figure 3.8. Species richness estimation for each sub-ecoregion by using Jack1

The species accumulation curve itself is a strongly (negatively) biased estimator of species richness. These indices reduce this bias to different degrees. As the samples accumulate, more and more information is included in the analysis and the richness estimates generally become more accurate. As understood from the progressive changes in estimates, sufficient samples were not taken to stabilize the estimate for Sub-ecoregion 4. The curves of estimated species richness showed that Sub-ecoregion 2 has almost twice the species richness compared to others. Both estimated and observed species richness values declined as one goes from Sub-ecoregion 4 or Sub-ecoregion 1 to Sub-ecoregion 3.

Exponential of Shannon-Wiener index showed that Sub-ecoregion 2 is the most diverse and nearly twice that of Sub-ecoregion 1. In contrast to species richness estimators, Sub-ecoregion 1 is the least diverse and Sub-ecoregion 3 is more diverse than the Sub-ecoregion 4 according to the Shannon-Wiener and Simpson indices. Simpson inverse (1/D) showed the same pattern with exponential Shannon-Wiener index except for the Sub-ecoregion 3 and Sub-ecoregion 4. Sub-ecoregion 4 was found to be more diverse than the Sub-ecoregion 3. Actually Sub-ecoregion 3 and Sub-ecoregion 4 were not found to be very different in mean diversity.

The evaluation of species rarefaction curves, species richness and species diversity indices showed in common that Sub-ecoregion 2 is the most diverse. However, there is no common rank for Sub-ecoregion 1, Sub-ecoregion 3 and Sub-ecoregion 4. One of the difficulties was insufficient sampling effort, particularly for Sub-ecoregion 4. The diversity indices are sensitive to sample size and this should be considered. Chao and jackknife estimators sometimes perform badly and the reasons are mainly total species richness, sample size and the variables that change the aggregation of individuals within samples like species abundance distribution or the sampling effort (Walther and Moore 2005). The species-abundance distribution and the sampling protocol determine how individuals are distributed within the individual samples and this in return influences estimator performance (Gotelli and Colwell 2001).

Walther and Moore (2005) summarized the results of 14 studies that compared the estimator performance and his study confirms that with most data sets non-parametric estimators mostly Chao and Jackknife estimators perform better than other estimators. They ranked the estimators according to the overall bias and accuracy respectively Chao2, Jackknife2, Jackknife1 and Chao1. Colwell and Coddington (1994) reviewed the Chao1, Chao2, first-order Jackknife and second-order Jackknife estimators and their study with seed-bank data showed that all the estimators provide adequate bias reduction for large samples and Chao2 and second-order Jackknife estimators for small samples. Comparative studies are still needed to test the overall performance of estimators.

There is strong evidence that species richness increased with the increasing sample area (the species-area relationship). The higher species richness of Sub-ecoregion 2 can be explained as such. However, there are several mechanisms underlying this and among these the most obvious, although not exclusive, explanation is that higher species richness is due to the higher habitat heterogeneity of larger areas (Baldi

2007). The study of Baldi (2007) on nature reserves of Hungary indicated that habitat heterogeneity rather than area per se is the most important predictor of species richness in the studied system.

MacArthur and MacArthur (1961) found that the structural diversity, the number of vertical layers present and the abundance of vegetation within them was a much better predictor of bird species diversity than floristic diversity in temperate woodlands of North America. To test this prediction, habitat diversity for each of the sub-ecoregions was computed by using proportions of vegetation cover categories (Table C.6 in Appendix C). According to Table 3.3 the order of habitat diversity from highest to lowest is Sub-ecoregion 3, Sub-ecoregion 2, Sub-ecoregion 4 and Sub-ecoregion 1 according to Shannon-Wiener diversity index. Actually there is not much difference between Sub-ecoregion 2 and Sub-ecoregion 3. However, the almost twice as much higher species diversity of Sub-ecoregion 2 can not be easily explained by the slightly more diverse habitats therein. However, not all compared pairs of habitats are equally distant (i.e. different) from each other. For example, the degree of ecological difference between grassland and crop fields is certainly less than that between grassland and dry coniferous forest. Nevertheless, the habitat diversity measure used here treats all such pairs as if they are equally distant.

Table 3.3: Habitat diversity of sub-ecoregions according to the stations sampled

Sub-ecoregions	Evenness	Shannon Wiener	Simpson	Exponential Shannon Wiener
Sub-ecoregion 1	0,96	1,05	0,64	2,86
Sub-ecoregion 2	0,89	1,58	0,77	4,85
Sub-ecoregion 3	0,75	1,64	0,75	5,16
Sub-ecoregion 4	0,81	1,31	0,67	3,71

3.1.5 Habitat-Bird Community Relations

Canonical Correspondence Analysis (CCA) was carried out to understand how environmental factors affected bird composition. The eigenvalues for Axis 1, Axis 2 and Axis 3 were computed respectively 0.669, 0.439 and 0.337. The first two axes represented the variance in the community matrix better. Pearson correlation coefficient which is the proportion of variance in the species matrix that is explained by the environmental matrix was computed as 0.887 for Axis 1, 0.901 for Axis 2 and 0.832 for Axis 3.

Table 3.4: Correlation scores for environmental variables

	Variable	Abbreviation in the graphs	Axis 1	Axis 2	Axis 3
1	Sparse vegetation		0.208	-0.017	-0.423
2	Grassland		-0.474	-0.021	0.288
3	Humid Deciduous Forest	h_d_f	0.228	-0.044	**0.584**
4	Dry Woodland & Shrubland		0.436	0.090	-0.107
5	Mixed Humid Forest		0.120	0.066	0.053
6	Humid Coniferous Forest		0.350	0.059	0.072
7	Dry Coniferous Forest	d_c_f	0.378	**0.707**	0.059
8	Crop fields	crp-f	**-0.605**	-0.154	0.364
9	Orchards and groves	orc-gr	0.281	**-0.571**	-0.278
10	Altitude	Altt	**-0.718**	**0.540**	-0.160
11	Running water	wtr	0.481	-0.270	-0.209
12	Valley flat up and bottom	v_bttm	**0.641**	-0.383	-0.121
13	Rocky and stony	rck	0.453	-0.035	**-0.475**

Correlation of environmental variables with ordination axes was given in Table 3.4. Altitude variable is the most important variable to structure first axis with negative correlation while dry coniferous forest variable is the most important in the second axis with positive correlation. Actually altitude variable showed a strong correlation with both axes. Crop fields and grassland showed negative correlation with the first axis. In the first axis valley flat up and bottom variable represented strongest positive correlation. Orchard and groves variable showed a strong negative correlation with the second axis. Running water and valley flat up showed a high positive correlation. The ordination graph was shown in Figure 3.9.

Stations from Sub-ecoregion 1 present a clustered group on the left side of the first axis where their open character (and use for crop agriculture) determines the nature of its bird community composition. Higher altitude showed positive correlation with crop fields; however, altitude may not have an effect on species distributions per se, but rather reflect the fact that agricultural land used for growing cereal crops lies at the higher Kars-Ardahan plateau. The bird species in these stations are typical of the farmland rather than altitude. Three stations were distinct at the right side of the second axis. This was explained by their rock and stony character in the third axis (Figure 3.10). There is a high overlap of Sub-ecoregion 1 stations with most Sub-ecoregion 2 stations. This is not unexpected as these two sub-ecoregions differ mainly in one being slightly drier. Beside these clumped stations were geographically close with open habitat character and similar species compositions. However, Sub-ecoregion 2 stations were dispersed over the ordination space, with some being aligned with stations from Sub-ecoregion 3 and 4 along the first axis. These stations have habitats that are wooded in contrast with other stations of that same sub-ecoregion. Therefore, the first axis mainly partitions the bird communities as recorded in this study by the presence of tree cover.

Sub-ecoregions 3 and 4 were aligned similarly along the first axis and the relatively few Sub-ecoregion 3 stations overlap with part of the Sub-ecoregion 4 stations. This may indicate that orchards & groves (of Sub-ecoregion 3) simulate broadleaved forests (of Sub-ecoregion 4) in terms of bird assemblages. However, certain stations of Sub-ecoregion 3 were aligned uniquely distinct at the right side of the first axis due to humid-forest specific taxa. Some of the stations of Sub-ecoregion 3 aligned with Sub-ecoregion 4 at the bottom of second axis where their valley bottom character determines the bird composition.

The wooded stations of Sub-ecoregion 2 were clearly separated along the second axis at its either end. The 6 stations at the top and right side of the second axis have the dry coniferous forest habitat. This distinction may be a result of the needle leaved-broad leaved dichotomy, which have their specific bird fauna. The stations at the bottom of the second axis were a characteristic of valley bottom.

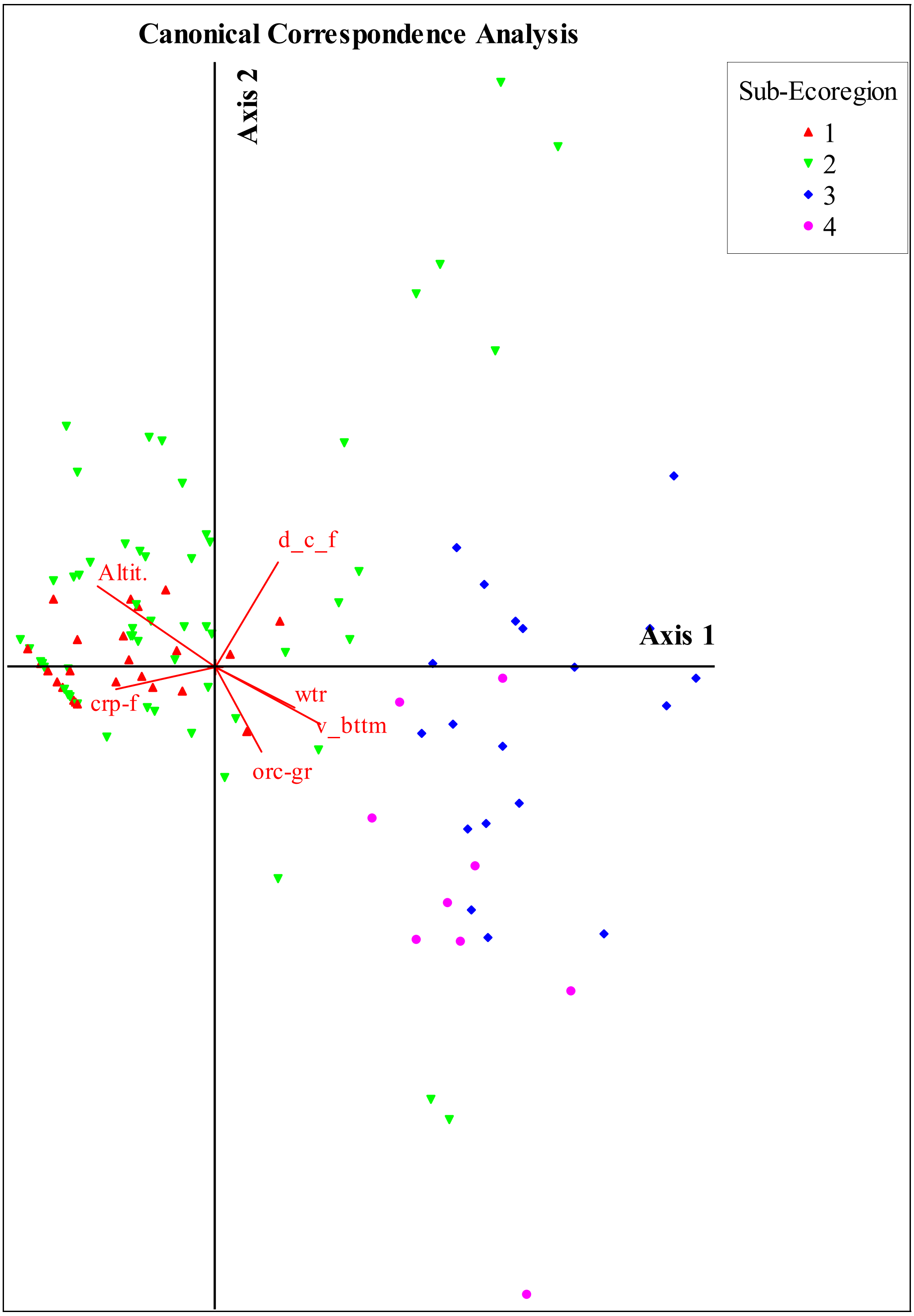

Figure 3.9. Canonical Correspondence Analysis for stations Axis 1 versus Axis 2

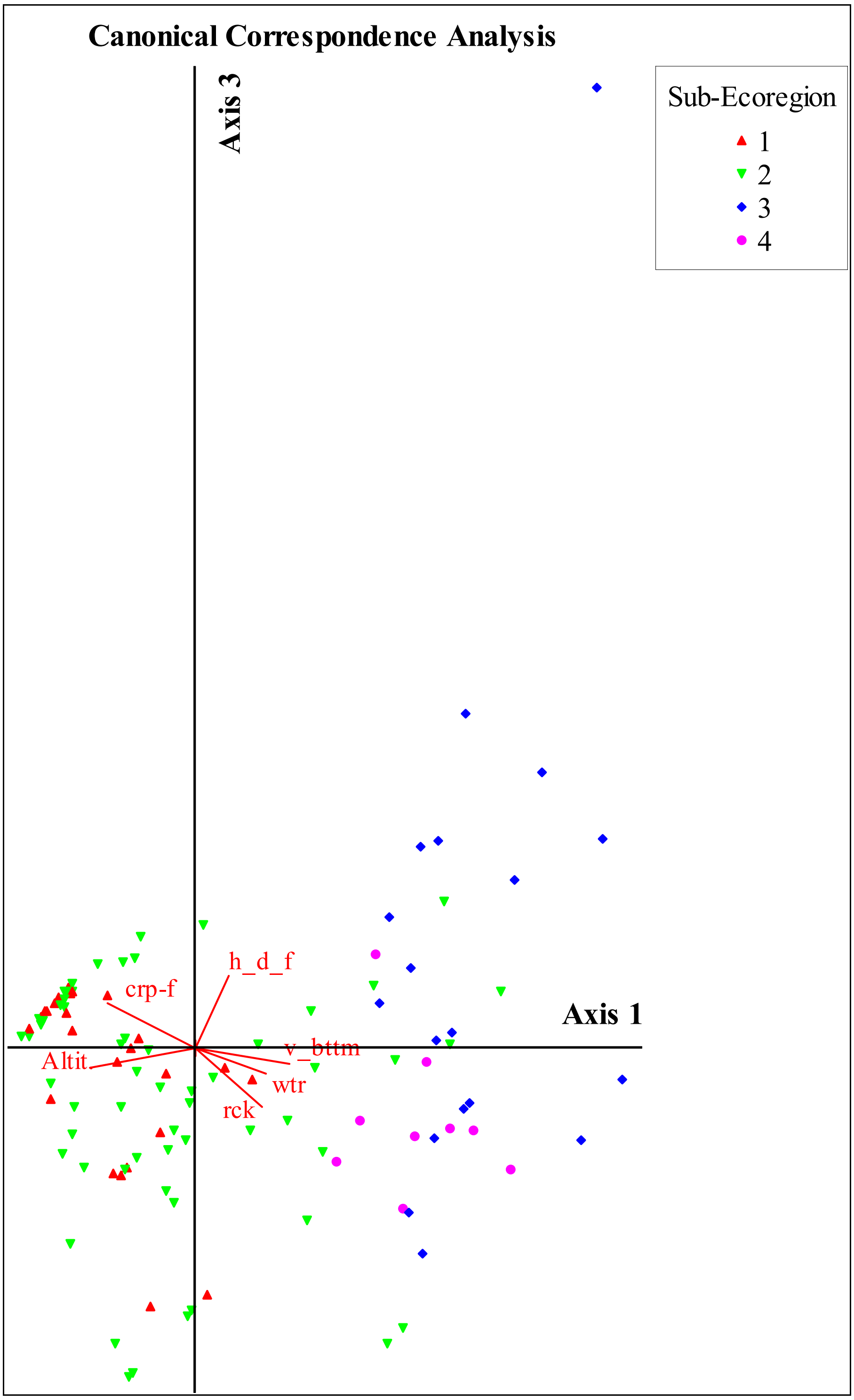

Figure 3.10. Canonical Correspondence Analysis for stations Axis 1 versus Axis 3

CHAPTER 4

CONCLUSIONS

This is the first study using point count methodology for community characterization and analysis in Turkey. The study revealed that point count is a useful method for terrestrial birds, especially passerines. It works at both open highland and wooded valley conditions in the Lesser Caucasus.

The most frequent and abundant bird species occur in crop fields or other open habitats. Each sub-ecoregion has its own group of bird taxa which are probably not shared with other sub-ecoregions. Bird compositions of sub-ecoregions revealed the characteristic habitat types of each sub-ecoregion.

Species richness and diversity change significantly within parts of the study area. The most diverse Sub-ecoregion 2 seems to be also more diverse in habitat types but this does not explain the observed differences. However, the ranges of different non-parametric species richness and diversity indices did not show a common order for Sub-ecoregion 1, Sub-ecoregion 3 and Sub-ecoregion 4. One of the difficulties was insufficient sampling effort, particularly for Sub-ecoregion 4.

The differences in bird species composition across stations were reflected by the different habitat type and structure of stations. This study supported that habitat is likely to be an important determinant of the distribution and number of birds. The composition of terrestrial bird assemblages is mainly determined by the presence or absence of woody vegetation, especially trees, and then whether it is needle-leaved or broad-leaved. Anthropogenic habitats like crop fields or orchards seem to simulate similar natural habitats, i.e. grassland and broad-leaved woodland, respectively, as revealed by similar bird communities.

Division of the Lesser Caucasus region into sub-ecoregions may not be straightforward when using bird assemblages as indicators. Although there seem to certain clear boundaries at some places, several stations from different sub-ecoregions had very similar species composition while several nearby stations within the same sub-ecoregion fell distant in the ordination space. Local habitat seems to be more important than dominant regional habitat in determining the bird composition. The region can be best divided into two parts where the first part is composed of Sub-ecoregions 1 and 2 while the second part is composed of Sub-ecoregions 3 and 4.

Determining diversity of birds present is important to assess conservation of the region and relative values of different habitats. The study provides baseline conservation data on the community composition of the region and of different habitats. The bird and habitat associations can provide valuable information on the factors which affect bird occurrence or abundance. This is useful to predict bird population changes as habitat in area changes through climate change, management or other human activities.

REFERENCES

Baldi, A., 2007, “Habitat Heterogeneity Overrides the Species-Area Relationship”, Journal of Biogeography, 1-7.

Bibby, C.J., Jones, M. and Marsden, S., 1998, “Expedition Field Techniques: Bird Surveys”, Expedition Advisory Centre, London.

Bibby, C.J., Burgess, N.D., Hill, D.A. and Mustoe, H.S., 2000, “Bird Census Techniques”, Academic Press, San Diego.

Bibby, C.J., 2004, “Bird diversity survey methods”, In: Sutherland, W.J, Newton, I. and Green, R. S., tech. eds., “Bird Ecology and Conservation: A Handbook of Techniques”, Oxford University Press, New York, 1-15.

Burnham, K.P. and Overton, W.S., 1978, “Estimation of the size of a closed population when capture probabilities vary among animals”, Biometrika 65, 623-633. Cited in: Colwell, R. K. and Coddington, J. A., 1994, “Estimating Terrestrial Biodiversity through Extrapolation”, Philosophical Transactions of the Royal Society (Series B) 345, 101-118.

Chao, A., 1984, “Non-Parametric Estimation of the Number of Classes in a Population”, Scandinavian Journal of Statistics, Vol. 11, 265-270.

Chao, A., 1987, “Estimating the Population Size for Capture-Recapture Data with Unequal Catchability”, Biometrics, Vol. 43, 783-791.

Colwell, R. K. and Coddington, J.A., 1994, “Estimating Terrestrial Biodiversity Through Extrapolation”, Philosophical Transactions of the Royal Society (Series B) 345, 101-118.

Colwell, R. K., 2000, EstimateS: Statistical Estimation of Species Richness and Shared Species from Samples, http://viceroy.eeb.uconn.edu/EstimateS.

Colwell, R. K., Mao, C. X. and Chang, J., 2004, “Interpolating, Extrapolating and Comparing Incidence-Based Species Accumulation Curves”, Ecology, 85, 2717-2727.

Gotelli, N., and Colwell, R. K., 2001, “Quantifying Biodiversity: Procedures and Pitfalls in the Measurement and Comparison of Species Richness”, Ecology Letters, 4, 379-391.

Gregory, R. D., Gibbons, D. W. and Donald, P. F., 2004, "Bird Census and Survey Techniques", In: Sutherland, W.J., Newton, I. and Green, R. S., tech. eds., "Bird Ecology and Conservation: A Handbook of Techniques", Oxford University Press, New York, 17-55.

Hamel, P.B., Smith, W.P., Twedt, D.J., 1996, "A Land Manager's Guide to Point Counts of Birds in the Southeast", Gen. Tech. Rep. SO-120, U.S. Department of Agriculture, Forest Service, Southern Research Station, New Orleans, LA.

Heinzel, H., Fitter R. and Parslow, J., 1995, "Türkiye ve Avrupa'nın Kuşları", Türkiye Doğal Hayatı Koruma Derneği Yayınları.

Heltshe, J. and Forrester, N.E., 1983, "Estimating Species Richness Using the Jackknife Procedure", Biometrics 39, 1-1 1. Cited in: Colwell, R. K., and Coddington, J. A., 1994, "Estimating Terrestrial Biodiversity through Extrapolation", Philosophical Transactions of the Royal Society (Series B) 345, 101-118.

Howe, R.W., Wolf, A.T. and Rinaldi, T., 1995, "Monitoring Birds in a Regional Landscape: Lessons from the Nicolet National Forest Bird Survey", In: Ralph, C.J., Sauer, J.R. and Droege, S., tech. eds., "Monitoring Bird Populations by Point Counts", Gen. Tech. Rep. PSWGTR- 149, U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA, 83-92.

Huff, M. H., Brown, M. J., 1998, "Four Years of Bird Point-Count Monitoring in Late Successional Conifer Forests and Riparian Areas From Pacific Northwest National Forests Interim Results", U.S. Department of Agriculture, Forest Service, Mount Hood National Forest, Sandy, OR.

Huff, M. H., Bettenger, K. A., Ferguson, H. L., Brown, M. J. and Altman, B., 2000, "A Habitat Based Point Count Protocol for Terrestrial Birds, Estimating Washington and Oregon", Gen. Tech. Rep. PNW-GTR-501, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Jongman, R. H. G., Braak, C. J. F. and Van Tongeren, O. F. R., 1995, "Data Analysis in Community and Landscape Ecology", Cambridge University Press, Cambridge, UK.

Karaçetin, E. 2002, "Bird and Butterfly Composition and Abundance at Two Different Habitats in Kayseri Turkey", Master Thesis, METU.

Kaya, B., 2006, Thesis Proposal: "Protected Area Site Selection Based on Abiotic Data: How Reliable is it?"

Koskimies, P. and Vaisanen, R. A., 1991, "Monitoring Bird Populations", Zoological Museum, Finnish Museum of Natural History, University of Helsinki, Helsinki. Cited in: Ralph, C.J., Sauer, J.R. and Droege, S., 1995, "Managing and Monitoring

Birds Using Point Counts: Standards and Applications", In: Ralph, C.J., Sauer, J.R. and Droege, S., tech. eds., "Monitoring Bird Populations by Point Counts", Gen. Tech. Rep. PSWGTR- 149, U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA, 161-175.

Krebs, C.J., 1999, "Ecological Methodology", Benjamin Cummings, California.

Lee, P. and Rotenberry, J. T., 2005, "Relationships between Bird Species and Tree Species Assemblages in Forested Habitats of Eastern North America", Journal of Biogeography, 32, 1139-1150.

Lynch, J. F., 1995, "Effects of Point Count Duration, Time of Day and Aural Stimulu on Detectability of Migratory and Resident Bird Species in Quintana Roo, Mexico.", In: Ralph, C.J., Sauer, J.R. and Droege, S., tech. eds., "Monitoring Bird Populations by Point Counts", Gen. Tech. Rep. PSWGTR- 149, U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA, 1-6.

MacArthur, R.H. and MacArthur, J.W., 1961, "On Bird Species Diversity", Ecology, 42, 594-598.

Magurran, A. E., 1988, "Ecological Diversity and Its Measurement", Princeton University Press, New Jersey.

Magurran, A. E., 2004, "Measuring Biological Diversity", Blackwell Publishing, UK.

Morin, P. J., 1999, "Community Ecology", Blackwell Science, USA.

OSU Ecology, Ordination Methods for Ecologist, http://ordination.okstate.edu/overview.htm, Last visited on December 2007.

McCune, B. and M. J. Mefford, 1999, "PC-ORD. Multivariate Analysis of Ecological Data." Version 4.39, MjM Software, Gleneden Beach, Oregon, U.S.A. http://home.centurytel.net/~mjm/index.htm.

National Geographic, Caucasus – Anatolian – Hyrcanian Temperate Forests, http://www.nationalgeographic.com/wildworld/profiles/g200_index.html, Last visited on December 2007.

Ralph, C.J., Geupel, G.R. and Pyle, P., 1993, "Handbook of Field Methods for Monitoring Landbirds", Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA, U.S.

Ralph, C.J., Sauer, J.R. and Droege, S., 1995, "Managing and Monitoring Birds Using Point Counts: Standards and Applications", In: Ralph, C.J., Sauer, J.R. and Droege, S., tech. eds., "Monitoring Bird Populations by Point Counts", Gen. Tech.

Rep. PSWGTR- 149, U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA, 161-175.

Ralph, C.J., Sauer, J.R. and Droege, S., tech. eds., “Monitoring Bird Populations by Point Counts”, Gen. Tech. Rep. PSWGTR- 149, U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Rotenberry, J. T. and Wiens, J. A., “Habitat Structure, Patchiness and Avian Communities in North American steppe vegetation: A Multivariate Analysis”, Ecology, 61, 1228-1250.

Scott, J. M., Ramsey, F. L. and Kepler, C. B., 1981, “Distance Estimation as a Variable in Estimating Bird Numbers from Vocalizations”, In: Ralph, C. J. and Scott, J. M., editors, “Estimating numbers of terrestrial birds”, Studies in Avian Biology 6: 334-340. Cited in: Ralph, C.J., Sauer, J.R. and Droege, S., 1995. “Managing and monitoring birds using point counts: standards and applications” In: Ralph, C.J., Sauer, J.R., Droege, S., tech. eds. “Monitoring bird populations by point counts”. Gen. Tech. Rep. PSWGTR- 149. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA, 161-175.

Smith, R. L. and Smith, T. M., 2000, “Elements of Ecology”, Benjamin Cummings, San Francisco.

Sutherland, W.J., 1996, “Ecological Census Techniques”, Cambridge University Press, New York.

Sutherland, W.J., Newton, I. and Green, R. S., 2004, “Bird Ecology and Conservation: A Handbook of Techniques”, Oxford University Press, New York.

Svensson, L. and Grant, P. J., 2001, “Collins Bird Guide: The Most Complete Guide to the Birds of Britain and Europe”, HarperCollins Publishers, UK.

TEMA-METU Gap Analysis of Lesser Caucasus Forests Project Final Report in prep.

Walther, B. A. and Moore, J. L., 2005, “The Concepts of Bias, Precision and Accuracy, and Their Use in Testing the Performance of Species Richness Estimators, with a Literature Review of Estimator Performance”, Ecography, 28, 815-829.

Wilson, A., 2006, “An Ecoregional Conservation Plan for the Caucasus”, WWF Caucasus Programme Office, Tbilisi, Georgia.

Wolf, A. T., Howe, R. W. and Davis, G. J., “Detectability of Forest Birds from Stationary Points in Northern Wisconsin”, In: Ralph, C.J., Sauer, J.R. and Droege, S., tech. eds., “Monitoring Bird Populations by Point Counts”, Gen. Tech. Rep.

PSWGTR- 149, U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA, 83-92.

Wright , R. G., Murray, M. P.and Merrill, T., 1998, “Ecoregions as a Level of Ecological Analysis”, Biological Conservation, 86, 207-213.

WWF Türkiye, Kafkasya Ekolojik Bölgesi, http://www.wwf.org.tr/wwf-tuerkiye-hakkinda/nerede-calisiyoruz/kafkasya-ekolojik-boelgesi/, Last visited on October 2007.

WWF International, Caucasus-Anatolian-Hyrcanian Temperate Forests - A Global Ecoregion,http://www.panda.org/about_wwf/where_we_work/ecoregions/caucasus_temperate_forests.cfm, Last visited on December 2007.

WWF International, What is an Ecoregion, http://www.panda.org/about_wwf/where_we_work/ecoregions/about/what_is_an_ecoregion/index.cfm, Last visited on December 2007.

APPENDIX A

BIRDS OF THE LESSER CAUCASUS

Table A.1: Regional Breeding Species Pool of the Lesser Caucasus

	Latin Name	**English Name**
1	*Tachybaptus ruficollis*	Little Grebe
2	*Podiceps cristatus*	Great Crested Grebe
3	*Podiceps grisegena*	Red-necked Grebe
4	*Podiceps nigricollis*	Black Necked Grebe
5	*Pelecanus onocrotalus*	White Pelican
6	*Pelecanus crispus*	Dalmatian Pelican
7	*Nycticorax nycticorax*	Night-Heron
8	*Egretta garzetta*	Little Egret
9	*Ardea cinerea*	Gray Heron
10	*Ciconia nigra*	Black Stork
11	*Ciconia ciconia*	White Stork
12	*Anser anser*	Greylang Goose
13	*Tadorna ferruginea*	Ruddy Shelduck
14	*Anas strepera*	Gadwall
15	*Anas platyrhynchos*	Mallard
16	*Anas querquedula*	Garganey
17	*Aythya ferina*	Pochard
18	*Aythya nyroca*	Ferruginous Duck
19	*Aythya fuligula*	Tufted Duck
20	*Oxyura leucocephala*	White-headed Duck
21	*Gypaetus barbatus*	Lammergeier
22	*Gyps fulvus*	Griffon Vulture
23	*Aegypius monachus*	Black Vulture
24	*Neophron percnopterus*	Egyptian Vulture
25	*Aquila chrysaetos*	Golden Eagle
26	*Aquila heliaca*	Imperial Eagle
27	*Aquila pomarina*	Lesser Spotted Eagle
28	*Circaetus gallicus*	Short-toed Eagle
29	*Hieraaetus pennatus*	Booted Eagle
30	*Milvus migrans*	Black Kite

Table A.1 (continued)

	Latin Name	English Name
31	*Circus aeruginosus*	Marsh Harrier
32	*Circus pygargus*	Montagu's Harrier
33	*Buteo rufinus*	Long-legged Buzzard
34	*Buteo buteo*	Common Buzzard
35	*Pernis apivorus*	Honey Buzzard
36	*Accipiter nisus*	Sparrowhawk
37	*Accipiter brevipes*	Levant Sparrowhawk
38	*Accipiter gentilis*	Goshawk
39	*Falco tinnunculus*	Common Kestrel
40	*Falco naumanni*	Lesser Kestrel
41	*Falco subbuteo*	Hobby
42	*Falco peregrinus*	Peregrine Falcon
43	*Falco cherrug*	Saker Falcon
44	*Falco biarmicus*	Lanner Falcon
45	*Tetrao tetrix*	Black Grouse
46	*Tetraogallus caspius*	Caspian Snowcock
47	*Alectoris chukar*	Chukar
48	*Perdix perdix*	Grey Partridge
49	*Coturnix coturnix*	Quail
50	*Crex crex*	Corncrake
51	*Rallus aquaticus*	Water Rail
52	*Gallinula chloropus*	Moorhen
53	*Fulica atra*	Coot
54	*Grus grus*	Crane
55	*Otis tarda*	Great Bustard
56	*Haematopus ostralegus*	Oystercatcher
57	*Himantopus himantopus*	Black-winged Stilt
58	*Glareola pratincola*	Collared Pratincole
59	*Charadrius dubius*	Little Ringed Plover
60	*Vanellus vanellus*	Lapwing
61	*Actitis hypoleucos*	Common Sandpiper
62	*Tringa totanus*	Redshank
63	*Larus ridibundus*	Black-headed Gull
64	*Larus armenicus*	Armenian Gull
65	*Sterna hirundo*	Common Tern
66	*Chlidonias hybridus*	Whiskered Tern
67	*Columba livia*	Rock Dove
68	*Columba oenas*	Stock Dove
69	*Columba palumbus*	Woodpigeon
70	*Streptopelia turtur*	Turtle Dove
71	*Cuculus canorus*	Cuckoo
72	*Strix aluco*	Tawny Owl
73	*Bubo bubo*	Eagle Owl
74	*Asio otus*	Long-eared Owl
75	*Athena noctua*	Little Owl

Table A.1 (continued)

	Latin Name	English Name
76	*Otus scops*	Scops Owl
77	*Caprimulgus europaeus*	Nightjar
78	*Apus apus*	Swift
79	*Apus melba*	Alpine Swift
80	*Upupa epops*	Hoopoe
81	*Merops apiaster*	Bee-eater
82	*Coracias garrulus*	Roller
83	*Dryocopus martius*	Black Woodpecker
84	*Picus viridis*	Green Woodpecker
85	*Picus canus*	Grey-headed Woodpecker
86	*Dendrocopos major*	Great-Spotted Woodpecker
87	*Dendrocopos syriacus*	Syrian Woodpecker
88	*Dendrocopos leucotos*	White-backed Woodpecker
89	*Alauda arvensis*	Skylark
90	*Galerida cristata*	Crested Lark
91	*Lullula arborea*	Woodlark
92	*Calandrella brachydactyla*	Short-toed Lark
93	*Melanocorypha bimaculata*	Bimaculated Lark
94	*Eremophila alpestris*	Shore Lark
95	*Riparia riparia*	Sand Martin
96	*Ptyonoprogne rupestris*	Crag Martin
97	*Hirundo rustica*	Swallow
98	*Delichon urbica*	House Martin
99	*Anthus campestris*	Tawny Pipit
100	*Anthus spinoletta*	Water Pipit
101	*Anthus trivialis*	Tree Pipit
102	*Motacilla alba*	Pied Wagtail
103	*Motacilla flava*	Yellow Wagtail
104	*Motacilla citreola*	Citrine Wagtail
105	*Motacilla cinerea*	Grey Wagtail
106	*Troglodytes troglodytes*	Wren
107	*Cinclus cinclus*	Dipper
108	*Prunella modularis*	Dunnock
109	*Erithacus rubecula*	Robin
110	*Luscinia megarhynchos*	Nightingale
111	*Luscinia svecica*	Bluethroat
112	*Phoenicurus phoenicurus*	Redstart
113	*Phoenicurus ochruros*	Black Redstart
114	*Oenanthe oenanthe*	Northern Wheatear
115	*Oenanthe isabellina*	Isabellina Wheatear
116	*Oenanthe hispanica*	Black-eared Wheatear
117	*Oenanthe pleschenka*	Pied Wheatear
118	*Oenanthe finschii*	Finsch's Wheatear
119	*Saxicola rubetra*	Whinchat
120	*Saxicola torquata*	Stonechat

Table A.1 (continued)

	Latin Name	English Name
121	*Monticola solitarius*	Blue Rock Thrush
122	*Monticola saxatilis*	Rock Thrush
123	*Turdus philomelos*	Song Thrush
124	*Turdus viscivorus*	Mistle Thursh
125	*Turdus merula*	Blackbird
126	*Turdus torquatus*	Ring ouzel
127	*Sylvia borin*	Garden Warbler
128	*Sylvia atricapilla*	Blackcap
129	*Sylvia hortensis*	Orphean Warbler
130	*Sylvia curruca*	Lesser Whitethroat
131	*Sylvia communis*	Whitethroat
132	*Acrocephalus schoenobaenus*	Sedge Warbler
133	*Cettia cetti*	Cetti's Warbler
134	*Acrocephalus arundinaceus*	Great Reed-Warbler
135	*Hippolais languida*	Upcher's Warbler
136	*Hippolais pallida*	Olivaceous Warbler
137	*Phylloscopus collybita*	Chiffchaff
138	*Phylloscopus sindianus*	Caucasian Chiffchaff
139	*Phylloscopus (trochiloides) nitidus*	Green Warbler
140	*Muscicapa striata*	Spotted Flycatcher
141	*Ficedula semitorquata*	Semi-collared Flycatcher
142	*Parus major*	Great Tit
143	*Parus ater*	Coal Tit
144	*Parus caeruleus*	Blue Tit
145	*Parus lugubris*	Sombre Tit
146	*Aegithalos caudatus*	Long-tailed Tit
147	*Remiz pendulinus*	Penduline Tit
148	*Sitta europaea*	Nuthatch
149	*Sitta krueperi*	Krüper's Nuthatch
150	*Sitta neumayer*	Rock Nuthatch
151	*Tichodroma muraria*	Wallcreeper
152	*Certhia familiaris*	Treecreeper
153	*Lanius collurio*	Red-backed Shrike
154	*Lanius senator*	Woodchat Shrike
155	*Lanius minor*	Lesser Grey Shrike
156	*Pica pica*	Magpie
157	*Garrulus glandarius*	Jay
158	*Corvus monedula*	Jackdaw
159	*Pyrrhocorax pyrrhocorax*	Chough
160	*Pyrrhocorax graculus*	Alpine Chough
161	*Corvus frugilegus*	Rook
162	*Corvus cornix*	Hooded Crow
163	*Corvus corax*	Raven
164	*Sturnus vulgaris*	Starling
165	*Oriolus oriolus*	Golden Oriole

Table A.1 (continued)

	Latin Name	English Name
166	*Passer domesticus*	House Sparrow
167	*Passer montanus*	Tree Sparrow
168	*Petronia petronia*	Rock Sparrow
169	*Carpospiza brachydactyla*	Pale Rock Sparrow
170	*Montifringilla nivalis*	Snow Finch
171	*Fringilla coelebs*	Chaffinch
172	*Carduelis cannabina*	Linnet
173	*Carduelis flavirostris*	Twite
174	*Carduelis carduelis*	Goldfinch
175	*Carduelis chloris*	Greenfinch
176	*Carduelis spinus*	Siskin
177	*Serinus serinus*	Serin
178	*Serinus pusillus*	Red-fronted Serin
179	*Pyrrhula pyrrhula*	Bullfinch
180	*Loxia curvirostra*	Crosbill
181	*Carpodacus erythrinus*	Common Rosefinch
182	*Rhodopechys sanguinea*	Crimson-winged Finch
183	*Emberiza hortulana*	Ortolan Bunting
184	*Emberiza melanocephala*	Black-headed Bunting
185	*Miliaria calandra*	Corn Bunting
186	*Emberiza cia*	Rock Bunting

APPENDIX B

FIELD FORM

Point Count Data Form

DATE:	OBSERVER:	WEATHER:	FIELD NOTES:
COUNTY:	HABITAT:		
UTM GRID:			
WIND:			

				TYPICAL DETECTION				**FLYOVERS**				**JUV**	**FLH**	
				0 to 50 m		>50 m		ASSOC.		IND.		#	#	**FIELD NOTES**
STN #	GPS WAY POINT	START TIME	SPECIES	0-3 MIN	3-5 MIN	0-3 MIN	3-5 MIN	0-3 MIN	3-5 MIN	0-3 MIN	3-5 MIN			

ASSOC.: Associated with the local habitat **IND**.: unassociated with the local habitat **JUV**.: Juvenile **FLH.**: species only detected before or after the point count

Figure B.1. "TEMA-METU Gap Analysis of Lesser Caucasus Forests Project" Field Form

APPENDIX C

TABLES

Table C.1: Vegetation cover categories

In "TEMA-METU Gap Analysis of Lesser Caucasus Forests Project"	In this study	Definition and Range
meadow	grassland	All kinds of dense grass or forb covered vegetation, including subalpine grasslands, pastures and meadows
sparse vegetation	sparse vegetation	All kinds of sparse herbaceous vegetation, including dry steppes, rangelands and barren land
agricultural land	crop fields	Dry cereal agriculture, mainly of wheat and barley
garden	orchards and groves	Fruit orchards as well as walnut and poplar groves
dry forest and shrubland	dry woodland and shrubland	Woodlands or shrubland, dominated mostly by oak, alem and/or juniper, but also including maquis
dry coniferous forest	dry coniferous forest	Scots pine dominated needle-leaved forest under a dry climate
humid coniferous forest	humid coniferous forest	Spruce (and/or fir) dominated needle-leaved forest under a humid climate
humid deciduous forest	humid deciduous forest	Broad-leaved forest mostly of beech, but also other humidity-loving broad-leaved species
mixed humid forest	mixed humid forest	Humid forests composed of both broad-leaved and needle-leaved trees, mostly beech and fir

Table C.2: Environmental parameters for stations

	Sparse Vegetation	Grassland	Humid Deciduous Forest	Dry Woodland & Shrubland	Mixed Humid Forest	Humid Coniferous Forest	Dry Coniferous Forest	Crop Fields	Orchards and Groves	Altitude	Running Water	Valley flat up and bottom	Rocky
E1	0,64	0,36	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2393,0	0	0	0
E2	0,49	0,51	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2186,0	1	0	0
E3	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	1415,0	1	1	0
E4	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1826,0	0	0	1
E5	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	1313,0	1	1	0
E6	0,76	0,00	0,00	0,24	0,00	0,00	0,00	0,00	0,00	1625,0	0	0	0
E7	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	2330,5	0	0	0
E8	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,50	0,00	2081,0	0	0	0
E9	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	1621,0	1	1	1
E10	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1712,0	0	0	0
K11	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	1941,5	0	0	0
K12	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	1915,0	0	0	0
K13	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,50	0,00	1814,5	0	0	0
K14	0,76	0,00	0,00	0,00	0,00	0,00	0,00	0,24	0,00	1779,5	0	0	0
K15	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1896,5	0	0	0
K16	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	1848,0	0	0	0
K17	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	2034,5	0	0	0
E18	0,79	0,07	0,00	0,00	0,00	0,00	0,14	0,00	0,00	2392,0	0	0	0
E19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	1868,0	0	0	0
E20	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,81	0,00	2402,0	0	0	0
K21	0,43	0,58	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2253,0	0	0	0
K22	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	2109,0	0	0	0
K23	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2113,5	0	0	0
K24	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2157,0	0	0	0
K25	0,50	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,00	1952,5	0	0	0
K26	0,57	0,10	0,00	0,00	0,00	0,00	0,00	0,33	0,00	1906,5	1	0	0
K27	0,68	0,32	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2094,0	0	0	1
K28	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1893,0	0	0	0
K29	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1726,0	0	0	1
K30	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1490,5	0	0	0
E31	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	1826,0	0	0	0
E32	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2236,0	0	0	1
E33	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2265,0	0	0	1
E34	0,73	0,27	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2324,0	0	0	1
E35	0,24	0,43	0,00	0,33	0,00	0,00	0,00	0,00	0,00	2468,0	0	0	0
E36	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,50	0,00	1839,5	1	0	0
E37	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2122,5	0	0	0

Table C.2 (continued)

	Sparse Vegetation	Grassland	Humid Deciduous Forest	Dry Woodland & Shrubland	Mixed Humid Forest	Humid Coniferous Forest	Dry Coniferous Forest	Crop Fields	Orchards and Groves	Altitude	Running Water	Valley flat up and bottom	Rocky
E38	0,25	0,00	0,00	0,25	0,00	0,00	0,00	0,50	0,00	1949,5	1	0	0
E39	0,75	0,03	0,00	0,00	0,00	0,00	0,00	0,22	0,00	2087,0	0	0	0
E40	0,00	0,43	0,00	0,46	0,00	0,00	0,11	0,00	0,00	2228,0	0	0	0
E41	0,00	0,32	0,00	0,65	0,00	0,00	0,03	0,00	0,00	2171,0	0	0	0
E42	0,59	0,41	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2171,0	1	1	0
E43	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,81	0,00	1424,5	0	0	0
E44	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,50	0,00	1638,0	0	0	0
E45	0,17	0,31	0,00	0,19	0,00	0,00	0,33	0,00	0,00	1992,0	0	0	0
E46	0,05	0,00	0,00	0,14	0,00	0,00	0,60	0,21	0,00	1772,0	0	0	0
C47	0,26	0,10	0,00	0,00	0,00	0,00	0,00	0,50	0,14	720,5	1	1	1
H48	0,05	0,00	0,00	0,59	0,00	0,00	0,00	0,35	0,00	740,0	1	1	1
H49	0,48	0,00	0,00	0,02	0,00	0,05	0,00	0,14	0,31	1015,5	1	1	1
H50	0,52	0,00	0,00	0,00	0,00	0,48	0,00	0,00	0,00	1138,5	1	1	1
H51	0,45	0,00	0,00	0,00	0,00	0,55	0,00	0,00	0,00	1226,5	1	1	1
H52	0,00	0,48	0,00	0,00	0,00	0,52	0,00	0,00	0,00	1348,5	1	1	0
C53	0,00	0,24	0,00	0,27	0,00	0,00	0,00	0,27	0,22	673,0	1	1	0
C54	0,55	0,00	0,00	0,45	0,00	0,00	0,00	0,00	0,00	932,5	0	0	1
C55	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	906,0	0	0	1
C56	0,00	0,07	0,00	0,00	0,00	0,00	0,00	0,00	0,93	659,0	0	1	0
C57	0,50	0,00	0,00	0,50	0,00	0,00	0,00	0,00	0,00	432,5	0	1	1
C58	0,50	0,00	0,00	0,50	0,00	0,00	0,00	0,00	0,00	722,0	1	0	1
H59	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	936,0	1	1	1
H60	0,51	0,00	0,00	0,49	0,00	0,00	0,00	0,00	0,00	981,0	1	1	0
H61	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	712,5	1	1	1
H62	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	752,0	1	1	1
H63	0,38	0,29	0,00	0,00	0,00	0,00	0,29	0,05	0,00	1270,5	0	0	0
H64	0,19	0,00	0,00	0,00	0,00	0,50	0,31	0,00	0,00	1344,5	0	0	0
E65	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,50	0,00	1802,0	0	0	0
E66	0,00	0,67	0,00	0,00	0,00	0,00	0,00	0,33	0,00	1840,5	0	0	0
E67	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1861,0	0	0	1
E68	0,07	0,86	0,00	0,00	0,00	0,00	0,07	0,00	0,00	1969,5	0	0	0
E69	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	2041,5	0	0	0
E70	0,00	0,07	0,00	0,00	0,00	0,00	0,00	0,93	0,00	2035,5	0	0	0
K71	0,00	0,36	0,00	0,00	0,00	0,00	0,00	0,64	0,00	1975,0	0	0	0
K72	0,50	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,00	1813,5	0	0	0
K73	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,50	0,00	1808,5	0	0	0
K74	0,50	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,00	1871,5	0	0	0
E78	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	2007,0	0	0	0

Table C.2 (continued)

	Sparse Vegetation	Grassland	Humid Deciduous Forest	Dry Woodland & Shrubland	Mixed Humid Forest	Humid Coniferous Forest	Dry Coniferous Forest	Crop Fields	Orchards and Groves	Altitude	Running Water	Valley flat up and bottom	Rocky
E79	0,00	0,32	0,00	0,00	0,00	0,00	0,00	0,68	0,00	2151,0	1	0	0
E80	0,00	0,34	0,00	0,00	0,00	0,00	0,34	0,31	0,00	2201,0	0	0	0
E81	0,41	0,51	0,00	0,08	0,00	0,00	0,00	0,00	0,00	1220,0	0	0	1
E82	0,45	0,00	0,00	0,55	0,00	0,00	0,00	0,00	0,00	1271,5	0	0	1
E83	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1557,5	0	0	0
E84	0,18	0,00	0,00	0,05	0,00	0,00	0,00	0,40	0,38	1454,0	1	1	0
E85	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	1277,0	0	1	1
E86	0,00	0,12	0,00	0,19	0,00	0,00	0,19	0,50	0,00	1172,0	0	0	1
E87	0,31	0,00	0,00	0,00	0,00	0,00	0,69	0,00	0,00	2150,5	0	0	0
E88	0,78	0,03	0,00	0,00	0,00	0,00	0,19	0,00	0,00	2085,0	0	0	0
E89	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,50	0,00	2005,5	0	0	0
E90	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,50	0,00	1989,0	0	0	0
E91	0,76	0,24	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1902,5	0	0	0
E92	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	1874,0	0	0	0
H93	0,50	0,00	0,00	0,50	0,00	0,00	0,00	0,00	0,00	405,0	0	0	0
H94	0,64	0,00	0,00	0,33	0,00	0,00	0,02	0,00	0,00	434,5	0	0	1
H95	0,88	0,00	0,12	0,00	0,00	0,00	0,00	0,00	0,00	114,0	1	1	0
H96	0,29	0,00	0,48	0,00	0,00	0,00	0,00	0,24	0,00	351,0	0	1	0
H97	0,50	0,00	0,00	0,50	0,00	0,00	0,00	0,00	0,00	231,5	0	1	0
H98	0,00	0,00	0,00	0,67	0,00	0,00	0,00	0,33	0,00	464,0	0	0	0
C99	0,81	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,19	537,0	1	1	1
C100	0,98	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	550,0	1	1	1
H101	0,67	0,00	0,00	0,33	0,00	0,00	0,00	0,00	0,00	1110,0	1	1	1
H102	0,12	0,48	0,00	0,24	0,17	0,00	0,00	0,00	0,00	1126,5	0	0	1
E103	0,00	0,33	0,00	0,00	0,00	0,00	0,00	0,67	0,00	1804,5	0	0	0
E104	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,50	0,00	1855,5	0	0	0
E105	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,50	0,00	1872,0	1	0	0
E106	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2212,5	0	0	1
K107	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	1998,0	0	0	0
K108	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	1992,0	0	0	0
K109	0,00	0,69	0,00	0,00	0,00	0,00	0,00	0,31	0,00	2042,5	0	0	1
K110	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2110,5	0	0	0
E111	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	2154,5	0	0	0
E112	0,00	0,31	0,00	0,02	0,00	0,00	0,67	0,00	0,00	2115,5	0	0	0
E113	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,50	0,00	1881,5	0	0	0
E114	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2048,0	0	0	0

Table C.3: Birds observed in the study area during point counts

No	Species (English Name)	Number of individuals	Frequency
1	Black Stork	4	1
2	White Stork	8	2
3	Ruddy Shelduck	204	3
4	Lesser Spotted Eagle	30	4
5	Short-toed Eagle	1	1
6	Booted Eagle	1	1
7	Black Kite	1	1
8	Marsh Harrier	1	1
9	Common Buzzard	4	3
10	Common Kestrel	10	10
11	Hobby	1	1
12	Chukar	1	1
13	Quail	108	77
14	Lapwing	3	2
15	Common Sandpiper	7	3
16	Rock Dove	31	6
17	Woodpigeon	19	10
18	Turtle Dove	2	2
19	Cuckoo	11	10
20	Hoopoe	1	1
21	Bee-eater	18	5
22	Roller	9	4
23	Green Woodpecker	12	7
24	Great-Spotted Woodpecker	8	7
25	Syrian Woodpecker	5	5
26	Skylark	300	63
27	Crested Lark	11	2
28	Woodlark	1	1

Table C.3 (continued)

No	Species (English Name)	Number of Individuals	Frequency
29	Bimaculated Lark	8	3
30	Shore Lark	22	8
31	Sand Martin	15	4
32	Crag Martin	42	13
33	Swallow	13	3
34	House Martin	23	3
35	Tawny Pipit	32	24
36	Water Pipit	1	1
37	Tree Pipit	11	8
38	Pied Wagtail	5	4
39	Yellow Wagtail	48	14
40	Grey Wagtail	2	2
41	Wren	9	8
42	Dunnock	2	2
43	Robin	13	13
44	Nightingale	6	5
45	Redstart	2	2
46	Black Redstart	3	2
47	Northern Wheatear	64	29
48	Isabellina Wheatear	5	3
49	Black-eared Wheatear	6	2
50	Pied Wheatear	1	1
51	Finsch's Wheatear	5	4
52	Whinchat	5	5
53	Stonechat	4	1
54	Blue Rock Thrush	4	3
55	Song Thrush	1	1
56	Mistle Thrush	5	2
57	Blackbird	58	41

Table C.3 (continued)

No	Species (English Name)	Number of Individuals	Frequency
58	Blackcap	12	8
59	Lesser Whitethroat	7	6
60	Whitethroat	16	7
61	Cetti's Warbler	3	3
62	Upcher's Warbler	2	2
63	Olivaceous Warbler	1	1
64	Chiffchaff	5	2
65	Caucasian Chiffchaff	12	6
66	Green Warbler	6	3
67	Spotted Flycatcher	2	2
68	Great Tit	37	25
69	Coal Tit	57	20
70	Blue Tit	7	5
71	Sombre Tit	10	4
72	Nuthatch	3	2
73	Krüper's Nuthatch	1	1
74	Rock Nuthatch	20	13
75	Red-backed Shrike	13	11
76	Magpie	61	26
77	Jay	7	7
78	Jackdaw	96	17
79	Chough	1	1
80	Rook	72	6
81	Hooded Crow	177	41
82	Raven	9	4
83	Starling	353	13
84	Golden Oriole	61	28
85	House Sparrow	64	5
86	Tree Sparrow	17	5

Table C.3 (continued)

No	Species (English Name)	Number of Individuals	Frequency
87	Rock Sparrow	7	4
88	Chaffinch	92	41
89	Linnet	59	31
90	Twite	10	1
91	Goldfinch	45	23
92	Greenfinch	17	13
93	Siskin	1	1
94	Serin	6	2
95	Bullfinch	2	2
96	Crossbill	4	3
97	Common Rosefinch	44	21
98	Ortolan Bunting	47	26
99	Black-headed Bunting	40	27
100	Corn Bunting	97	58
101	Rock Bunting	15	12
Total number of species		**101**	
Total number of individuals		**2845**	

Table C.4: Species composition of sub-ecoregions

	Species (English Name)	Sub-ecoregions							
		Numbers of individuals				Frequency			
		1	2	3	4	1	2	3	4
1	Black Stork	0	4	0	0	0	1	0	0
2	White Stork	0	8	0	0	0	2	0	0
3	Ruddy Shelduck	204	0	0	0	3	0	0	0
4	Lesser Spotted Eagle	0	30	0	0	0	4	0	0
5	Short-toed Eagle	0	1	0	0	0	1	0	0
6	Booted Eagle	0	1	0	0	0	1	0	0
7	Black Kite	0	1	0	0	0	1	0	0
8	Marsh Harrier	1	0	0	0	1	0	0	0
9	Common Buzzard	2	2	0	0	2	1	0	0
10	Common Kestrel	2	8	0	0	2	8	0	0
11	Hobby	1	0	0	0	1	0	0	0
12	Chukar	0	1	0	0	0	1	0	0
13	Quail	47	60	0	1	31	45	0	1
14	Lapwing	3	0	0	0	2	0	0	0
15	Common Sandpiper	5	2	0	0	1	2	0	0
16	Rock Dove	8	23	0	0	2	4	0	0
17	Woodpigeon	0	19	0	0	0	10	0	0
18	Turtle Dove	0	2	0	0	0	2	0	0
19	Cuckoo	0	8	3	0	0	8	2	0
20	Hoopoe	0	1	0	0	0	1	0	0
21	Bee-eater	0	5	13	0	0	3	2	0
22	Roller	0	4	5	0	0	2	2	0
23	Green Woodpecker	0	8	3	1	0	3	3	1
24	Great-Spotted Woodpecker	0	5	3	0	0	5	2	0
25	Syrian Woodpecker	0	4	0	1	0	4	0	1
26	Skylark	91	209	0	0	31	32	0	0
27	Crested Lark	0	11	0	0	0	2	0	0
28	Woodlark	0	1	0	0	0	1	0	0
29	Bimaculated Lark	5	3	0	0	2	1	0	0
30	Shore Lark	1	21	0	0	1	7	0	0
31	Sand Martin	15	0	0	0	4	0	0	0
32	Crag Martin	0	2	40	0	0	2	11	0
33	Swallow	3	10	0	0	2	1	0	0
34	House Martin	0	1	22	0	0	1	2	0
35	Tawny Pipit	15	17	0	0	11	13	0	0
36	Water Pipit	0	1	0	0	0	1	0	0
37	Tree Pipit	4	6	1	0	3	4	1	0
38	Pied Wagtail	0	4	1	0	0	3	1	0
39	Yellow Wagtail	24	23	1	0	7	6	1	0
40	Grey Wagtail	0	0	2	0	0	0	2	0

Table C.4 (continued)

	Species (English Name)	Sub-ecoregions							
		Numbers of individuals				Frequency			
		1	2	3	4	1	2	3	4
41	Wren	0	2	7	0	0	1	7	0
42	Dunnock	0	2	0	0	0	2	0	0
43	Robin	0	4	6	3	0	4	6	3
44	Nightingale	0	5	0	1	0	4	0	1
45	Redstart	0	1	0	1	0	1	0	1
46	Black Redstart	3	0	0	0	2	0	0	0
47	Northern Wheatear	18	46	0	0	8	21	0	0
48	Isabellina Wheatear	5	0	0	0	3	0	0	0
49	Black-eared Wheatear	0	0	0	6	0	0	0	2
50	Pied Wheatear	0	1	0	0	0	1	0	0
51	Finsch's Wheatear	2	3	0	0	1	3	0	0
52	Whinchat	1	4	0	0	1	4	0	0
53	Stonechat	0	0	4	0	0	0	1	0
54	Blue Rock Thrush	0	0	3	1	0	0	2	1
55	Song Thrush	0	0	1	0	0	0	1	0
56	Mistle Thrush	0	5	0	0	0	2	0	0
57	Blackbird	0	11	41	6	0	9	26	6
58	Blackcap	0	0	6	6	0	0	4	4
59	Lesser Whitethroat	0	1	2	4	0	1	2	3
60	Whitethroat	3	13	0	0	2	5	0	0
61	Cetti's Warbler	0	3	0	0	0	3	0	0
62	Upcher's Warbler	0	1	0	1	0	1	0	1
63	Olivaceous Warbler	0	0	0	1	0	0	0	1
64	Chiffchaff	0	5	0	0	0	2	0	0
65	Caucasian Chiffchaff	0	12	0	0	0	6	0	0
66	Green Warbler	0	0	6	0	0	0	3	0
67	Spotted Flycatcher	0	0	2	0	0	0	2	0
68	Great Tit	0	12	13	12	0	6	8	11
69	Coal Tit	0	35	22	0	0	10	10	0
70	Blue Tit	0	1	4	2	0	1	3	1
71	Sombre Tit	0	10	0	0	0	4	0	0
72	Nuthatch	0	3	0	0	0	2	0	0
73	Krüper's Nuthatch	0	0	1	0	0	0	1	0
74	Rock Nuthatch	1	12	0	7	1	8	0	4
75	Red-backed Shrike	1	7	2	3	1	5	2	3
76	Magpie	2	57	0	2	2	23	0	1
77	Jay	0	1	5	1	0	1	5	1
78	Jackdaw	33	63	0	0	3	14	0	0
79	Chough	0	0	0	1	0	0	0	1
80	Rook	6	66	0	0	2	4	0	0
81	Hooded Crow	5	128	44	0	2	33	6	0
82	Raven	0	6	3	0	0	2	2	0

Table C.4 (continued)

	Species (English Name)	Sub-ecoregions							
		Numbers of individuals				Frequency			
		1	2	3	4	1	2	3	4
83	Starling	53	300	0	0	3	10	0	0
84	Golden Oriole	0	32	3	26	0	13	3	12
85	House Sparrow	21	43	0	0	3	2	0	0
86	Tree Sparrow	0	0	0	17	0	0	0	5
87	Rock Sparrow	4	3	0	0	2	2	0	0
88	Chaffinch	0	53	35	4	0	14	23	4
89	Linnet	19	30	0	10	11	16	0	4
90	Twite	10	0	0	0	1	0	0	0
91	Goldfinch	4	39	1	1	2	19	1	1
92	Greenfinch	0	5	7	5	0	5	5	3
93	Siskin	0	1	0	0	0	1	0	0
94	Serin	0	6	0	0	0	2	0	0
95	Bullfinch	0	2	0	0	0	2	0	0
96	Crosbill	0	4	0	0	0	3	0	0
97	Common Rosefinch	2	42	0	0	2	19	0	0
98	Ortolan Bunting	3	44	0	0	3	23	0	0
99	Black-headed Bunting	9	24	0	7	5	17	0	5
100	Corn Bunting	32	63	0	2	20	36	0	2
101	Rock Bunting	4	5	4	2	2	4	4	2
Total number of species		**40**	**81**	**34**	**31**				
Total number of individuals		**672**	**1722**	**316**	**135**				

Table C.5: Species richness and diversity indices computed for stations

Stations	Total number of individuals	Species richness	Evenness	Shannon-Wiener	Simpson
E1	9	4	0.876	1.215	0.6667
E2	19	7	0.937	1.822	0.8255
E3	18	7	0.837	1.629	0.7407
E4	21	10	0.899	2.07	0.8435
E5	21	5	0.834	1.342	0.6848
E6	10	5	0.967	1.557	0.78
E7	14	5	0.805	1.296	0.6735
E8	17	5	0.873	1.405	0.7197
E9	11	5	0.849	1.367	0.6942
E10	16	5	0.939	1.511	0.7656
K11	8	5	0.928	1.494	0.75
K12	25	4	0.498	0.69	0.3424
K13	19	6	0.888	1.59	0.7701
K14	7	1	0	0	0
K15	14	3	0.812	0.892	0.5204
K16	49	12	0.829	2.059	0.8322
K17	8	4	0.953	1.321	0.7188
E18	23	6	0.826	1.48	0.7259
E19	18	6	0.944	1.692	0.8025
E20	7	4	0.921	1.277	0.6939
K21	8	4	0.875	1.213	0.6562
K22	18	3	0.82	0.901	0.537
K23	13	3	0.756	0.831	0.4734
K24	27	7	0.866	1.685	0.7737
K25	12	4	0.98	1.358	0.7361
K26	16	4	0.825	1.143	0.6328
K27	8	3	0.887	0.974	0.5938
K28	13	6	0.992	1.778	0.8284
K29	11	4	0.968	1.342	0.7273
K30	2	2	1	0.693	0.5
E31	15	7	0.946	1.841	0.8267
E32	25	6	0.886	1.588	0.7552
E33	7	3	0.982	1.079	0.6531
E34	7	3	0.87	0.956	0.5714
E35	2	2	1	0.693	0.5
E36	39	6	0.605	1.084	0.4984
E37	15	7	0.908	1.767	0.8
E38	8	6	0.967	1.733	0.8125
E39	22	12	0.919	2.284	0.876
E40	26	11	0.932	2.235	0.8787
E41	15	7	0.878	1.709	0.7822
E42	13	8	0.885	1.839	0.7929

Table C.5 (continued)

Stations	Total number of individuals	Species richness	Evenness	Shannon-Wiener	Simpson
E43	21	7	0.892	1.736	0.7937
E44	22	12	0.935	2.323	0.8843
E45	21	7	0.873	1.699	0.7755
E46	15	9	0.938	2.061	0.8533
C47	10	6	0.898	1.609	0.76
H48	15	5	0.785	1.263	0.6578
H49	12	6	0.822	1.474	0.6944
H50	8	3	0.887	0.974	0.5938
H51	14	4	0.864	1.197	0.6633
H52	11	4	0.895	1.241	0.6777
C53	31	9	0.87	1.913	0.8158
C54	17	7	0.812	1.579	0.7197
C55	18	7	0.892	1.736	0.7963
C56	19	9	0.904	1.986	0.831
C57	1	1	0	0	0
C58	4	2	0.811	0.562	0.375
H59	25	8	0.931	1.936	0.8416
H60	27	4	0.78	1.081	0.6008
H61	34	4	0.285	0.395	0.1661
H62	26	9	0.734	1.613	0.6982
H63	26	10	0.916	2.109	0.858
H64	16	4	0.925	1.282	0.6953
E65	25	8	0.846	1.759	0.7936
E66	175	10	0.862	1.985	0.8383
E67	17	7	0.963	1.875	0.8374
E68	20	10	0.91	2.095	0.855
E69	21	5	0.748	1.204	0.6122
E70	25	6	0.763	1.366	0.6432
K71	21	6	0.849	1.522	0.7302
K72	50	9	0.813	1.786	0.7824
K73	269	14	0.423	1.115	0.4364
K74	22	5	0.864	1.39	0.7066
E78	20	6	0.884	1.584	0.77
E79	15	5	0.926	1.49	0.7556
E80	22	6	0.846	1.517	0.7231
E81	17	8	0.887	1.844	0.8028
E82	10	7	0.943	1.834	0.82
E83	237	12	0.306	0.76	0.2841
E84	25	12	0.88	2.186	0.8512
E85	41	12	0.907	2.253	0.8685
E86	11	7	0.908	1.768	0.7934
E87	70	10	0.721	1.659	0.7429
E88	40	8	0.842	1.751	0.795

Table C.5 (continued)

Stations	Total number of individuals	Species richness	Evenness	Shannon-Wiener	Simpson
E89	68	5	0.757	1.218	0.606
E90	65	8	0.688	1.431	0.6802
E91	15	6	0.886	1.587	0.7556
E92	30	5	0.914	1.471	0.74
H93	10	7	0.943	1.834	0.82
H94	21	8	0.798	1.659	0.7256
H95	12	8	0.952	1.979	0.8472
H96	15	8	0.911	1.894	0.8178
H97	2	1	0	0	0
H98	8	5	0.861	1.386	0.6875
C99	24	12	0.902	2.242	0.8611
C100	11	8	0.971	2.02	0.8595
H101	15	9	0.904	1.987	0.8267
H102	19	8	0.841	1.749	0.7645
E103	92	9	0.733	1.611	0.7453
E104	111	3	0.322	0.353	0.1802
E105	17	8	0.965	2.007	0.8581
E106	21	6	0.693	1.241	0.6077
K107	13	4	0.835	1.157	0.6272
K108	11	6	0.96	1.72	0.8099
K109	13	8	0.958	1.992	0.8521
K110	15	7	0.878	1.709	0.7822
E111	6	3	0.79	0.868	0.5
E112	13	6	0.885	1.586	0.7574
E113	10	7	0.97	1.887	0.84
E114	6	3	0.79	0.868	0.5
Averages	25.63	6.4	0.829	1.481	0.6937

Table C.6: Vegetation cover categories and their proportions in sub-ecoregions

Sub-ecoregions	Sparse vegetation	Grassland	Humid deciduous forest	Dry woodland and shrubland	Mixed humid forest	Humid coniferous forest	Dry coniferous forest	Orchards and groves	Crop fields
1	0,357	0,2	0	0	0	0	0	0	0,441
2	0,289	0,21	0	0,072	0	0	0,092	0,041	0,291
3	0,326	0,07	0,031	0,351	0,009	0,11	0,033	0,016	0,059
4	0,511	0,05	0	0,191	0	0	0	0,167	0,086