FACTORS AFFECTING STEPPE BIODIVERSITY IN CENTRAL PART OF THE ANATOLIAN DIAGONAL AND THEIR USE IN CONSERVATION

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ABSTRACT

FACTORS AFFECTING STEPPE BIODIVERSITY IN CENTRAL PART OF THE ANATOLIAN DIAGONAL AND THEIR USE IN CONSERVATION

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This study aims to find out major factors acting on steppe biodiversity of Inner Anatolia by focusing on one million hectares of mountainous land. Quantitative data on common plants, breeding birds and butterflies as well as environmental and land use data were collected at 33 sites determined by environmental stratification. Data has been analyzed with Spearman's rank correlation, canonical correspondence analysis, detrended correspondence analysis, two-way indicator species analysis and hierarchical partitioning.

Results show that elevation, current grazing intensity, distance to woodlands and arable lands are the main determinants of richness and diversity. Other important factors are soil Magnesium and organic matter for plants; local heterogeneity and shrub/tree density for birds; plant richness and mud-puddling sites or wind shelters attracting butterflies. Altitude and grazing intensity have negative effects on biodiversity whereas soil Magnesium and proximity to other vegetation types have positive effects. In sites with more than 90% herbaceous coverage, shrub/tree density is a good indicator for the richness patterns of all groups. The richest sites are low mountain shrubby steppes close to woodlands

and arable lands, ploughed 30-100 years ago but then abandoned and experienced light or no grazing afterwards.

Six major plant communities are distinguished by gypsum bedrock, altitude and years since land abandonment. Four main bird assemblages are differentiated with landscape and local heterogeneity and composition and wood density of the sites.

Various factors act on richness and diversity patterns on steppes, differing for species groups and assemblages. Conservation actions should encompass conservation priority species, represent different species assemblages, consider all major factors mentioned above especially landscape and local heterogeneity including different seral stages and sustaining conservation through nature-friendly land use. Planning afforestation in the way not to destroy rich steppes and building awareness on steppes as a value are important conservation actions.

Keywords: steppe, biodiversity, land use, environmental parameters, multivariate techniques.

ÖZ

ANADOLU ÇAPRAZI'NIN ORTA BÖLÜMÜNDEKİ BOZKIRLARIN BİYOLOJİK ÇEŞİTLİLİĞİNİ ETKİLEYEN FAKTÖRLER VE BUNLARIN DOĞA KORUMADA KULLANIMI

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Bu çalışmanın amacı Anadolu'nun iç kesimindeki bozkırların biyolojik çeşitliliğini etkileyen temel etkenleri belirlemektir. Bu amaçla yaklaşık bir milyon hektarlık dağlık bir bölgede çevresel sınıflandırma ile belirlenen 33 alanda bitkiler, üreyen kuşlar, kelebekler, çevresel değişkenler ve arazi kullanımı ile ilgili sayısal veriler toplanmış; bu veriler Spearman sıralı korelasyonu, kanonik uyum analizi, doğrultulmuş uyum analizi, iki yönlü indikatör tür analizi ve hiyerarşik bölme teknikleri ile analiz edilmiştir.

Elde edilen sonuçlara göre yükseklik, mevcut otlatma düzeyi, ağaçlıklara ve tarlalara uzaklık değişkenleri tür zenginliği ve çeşitliliği üzerinde en etkili faktörlerdir. Diğer önemli faktörler ise bitkiler için topraktaki magnezyum ve organik madde, kuşlar için alansal ve lokal habitat çeşitliliği ve ağaç/çalı yoğunluğudur. Bir alanda gözlenen kelebek sayısında bitki zenginliği ve mineral toplama ya da rüzgar sığınağı alanlar etkilidir. Yükseklik ve mevcut otlatma düzeyi biyolojik çeşitliliği olumsuz yönde etkilerken topraktaki magnezyum ve ağaçlık ile tarlalara yakınlığın olumlu etkisi vardır. Otsu bitki örtüşünün %90'dan fazla olduğu alanlarda ağaç/çalı yoğunluğu, araştırılan tür gruplarının tamamının tür zenginliği için iyi bir göstergedir. Tür zenginliği en fazla olan alanlar alçak dağ katında, ağaçlık ve tarım alanlarına yakın, genellikle 30-100 yıl öncesine kadar ekilen fakat daha sonra terkedilmiş, hafif ya da hiç otlatma yapılmayan çalılı bozkırlardır.

Alanda belirlenen altı bitki yaşambirliği jipsli anakaya, yükseklik, geçmişte tarımsal faaliyetin olması ve ne zaman bırakıldığı etkenleri ile belirlenmektedir. Dört kuş komunitesi ise alansal ve yerel habitat çeşitliliği ile ağaç/çalı yoğunluğu etkenleri ile ayrılmaktadır.

Bozkırların tür zenginliği ve çeşitlilği ile tür kompoziyonunu etkileyen önemli etkenler çok sayıda olup; tür grupları ve komuniteler arasında değişkenlik göstermektedir. Koruma çalışmaları yapılırken korumada öncelikli türlerin hedeflenmesi, farklı komunitelerin koruma ağında temsil edilmesi, yukarıda değinilen temel değişkenler özellikle alansal ve yerel habitat çeşitliliği ile süksesyonun farklı evrelerinin göz önünde bulundurulması ve bozkır koruma çalışmalarına doğa dostu arazi kullanım faaliyetlerinin dahil edilmesi önemlidir. Ağaçlandırma çalışmalarının zengin bozkırları tahrip etmeyecek şekilde planlanması, bozkırların bir "değer" ve koruma hedefi olarak algılanması için farkındalık çalışmaları başlatmak önemli koruma çalışmaları arasında görülmelidir.

Anahtar kelimeler: bozkır, biyolojik çeşitlilik, arazi kullanımı, çevresel değişkenler, çokdeğişkenli analizler.

To my beatiful family

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ABBREVATIONS

(-)	Negative indicator species in TWINSPAN results
(+)	Positive indicator species in TWINSPAN results
BC	before Christ
BIOCLIM 1	Annual Mean Temperature
BIOCLIM 7	Temperature Annual Range
BIOCLIM 10	Mean Temperature of Warmest Quarter
BIOCLIM 11	Mean Temperature of Coldest Quarter
BIOCLIM 12	Annual Precipitation
BIOCLIM 17	Precipitation of Driest Quarter
CCA	Canonical Correspondence Analysis
Cont'd	Continued
CORINE	Land cover map of the European environmental landscape
CR	Critically Endangered
DCA	Detrended Correspondance Analysis
DD	Data Deficient
DKM	Nature Conservation Centre
dS/m	deciSiemens per meter
EN	Endangered
E (direction)	East coordinate
f	Frequency
FAO	Food and Agriculture Organization
GIS	Geographical Information Systems
ILEMOD	"Modernization of Provincial Inventories Project" of Ministry of Internal Affairs

IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Areas
LR	Low Risk
METU	Middle East Technical University
Mt.	Mountain
N (direction)	North coordinate
NA	Not Applicable
NDVI	Normalized Difference Vegetation Index
NPP	Net Primary Productivity
p	Significance level of a statistical test
PCA	Principal Component Analysis
ppm	Parts per million
r	correlation coefficient
RS	Remote sensing
S_{obs}	Observed Species Richness
S	South
sp	Species
Sqrt	Square root
ssp	subspecies
TEMA	The Turkish Foundation for Combating Soil Erosion, for Restoration and Protection of Natural Habitats
TGCI	Temperate Grassland Conservation Initiative of IUCN
TUIK	Turkish Statistical Institute
TWINSPAN	Two-Way Indicator Species Analysis
UNESCO	United Nations Educational, Scientific and Cultural Organization
VU	Vulnerable
W	West
ya	Years ago

CHAPTER I

INTRODUCTION

2.1. Anatolian Steppes

2.1.1. Definition, Distribution and Vegetation

The term "Grassland" is a self-explanatory word describing a land dominated by grasses. IUCN's Temperate Grasslands Conservation Initiative (2009) defines grasslands as "land covered with herbaceous plants with less than 10 percent tree and shrub cover". UNESCO (1973) classification limits grasslands to temperate zones characterized by seasonal change. Getting different names in different continents (Molles 2002; Smith and Smith 2006); the word "steppe" is mostly used for Eurasia (Walter 1985). Originated from Russian language (Walter 1985), the term "steppe" is defined by Forage and Grazing Terminology Committee (1992) as "semi-arid grassland characterized by short grasses occurring in scattered bunches with other herbaceous vegetation and occasional woody species".

In terms of geography, vegetation and floristic composition, Anatolian steppes are closer to western Eurasian steppes classified under the Pontic-Kazakh Steppe Subregion by Smelansky and Simonov (2008) and Irano-Turanian phytogeographical region by Zohary (1971). It is characterized by continentality, low precipitation and reduced plant growth in hot summers and cold winters (Zohary 1973).

A discontinuous distribution is accepted by authorities (Zohary 1973; Olson *et al.* 2001; Atalay 2002) with a Central Anatolian region and east Anatolian part with a gap filled by forest-steppe mosaic reflecting the potential vegetation. A recent map showing vegetation of Turkey (Eken *et al.* 2007) shows steppic areas as widespread and continuous in the Inner Anatolia with patchy distribution of forests without any patch of arable lands which is actually replaced most of the steppes (Figure 1.1). CORINE land cover map dating 2006 (European Environmental Agency 2011) shows that grasslands are replaced mostly by arable lands and now they cover so small area that it is difficult to locate them on the map (Figure 1.2). This leads to think that land abandonment is not considered in mapping. The real picture should be an intermediate of all.

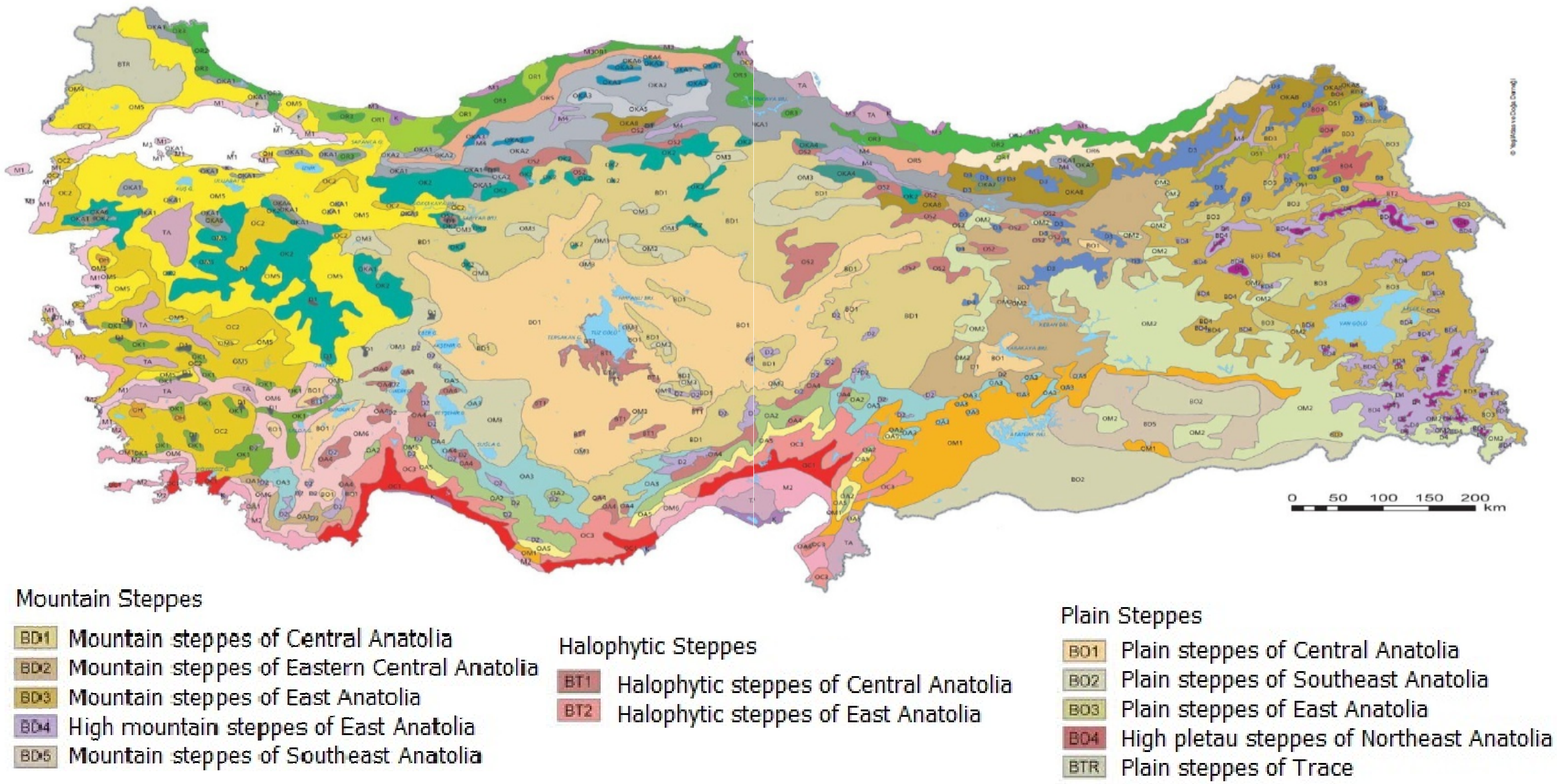
The steppes of Anatolia are dominated by hemicryptophyte and chamaephyte life forms. Many of the common genera are perennials unpalatable to grazers which are selected as a response to overgrazing (Davis 1965).

The plain steppes found in relatively low elevation are dominated by *Artemisia santonicum, A. fragrans* (Zohary 1973; White 1985; Atalay 2002) or *A. spicata* in some areas (Davis 1965). The most abundant species are *Salvia cryptantha, Stipa lagascae, Festuca valesiaca, Bromus tomentellus, Koeleria cristata, Poa bulbosa, Thymus* sp. especially *T.spyleus* and *Astragalus* sp. (Çetik 1985). Walter (1985) claims that the natural steppes of Central Anatolia were once grass-dominated mainly by *Stipa* spp, *Bromus tomentellus*, *Festuca valesiaca* but degraded and replaced by overgrazing in many places, and the widespread *Artemisia fragrans-Poa bulbosa* semidesert with many spring therophytes and geophytes is the outcome.

Halophytic herbaceous vegetation occurs around inland saline lake shores. Members of Chenopodiaceae and Plumbaginaceae such as *Salsola*, *Limunium, Frankenia hirsuta, Halocenum strobilaceum* are common with very few or no representation of common forbs of montane steppes (Kurt *et al.* 2006).

Gypsiferous steppes are classified as a distinct vegetation alliance on gypsum bedrocks of Inner Anatolia, especially between Çankırı-Sivas and Sivas-Erzincan (Akpulat and Çelik 2005) with characteristic species of *Gypsohila parva, G. eriocalyx, Silene supina* subsp. *pruinosa, Allium flavum, Salvia cryptantha, Ziziphora tenuior* and *Lappula barbata* (Ketenoğlu *et al.* 2000).

Figure 1.1: Vegetation map of Turkey (Güven *et al.* 2007, ©Yeşil Atlas and Doğa Derneği)



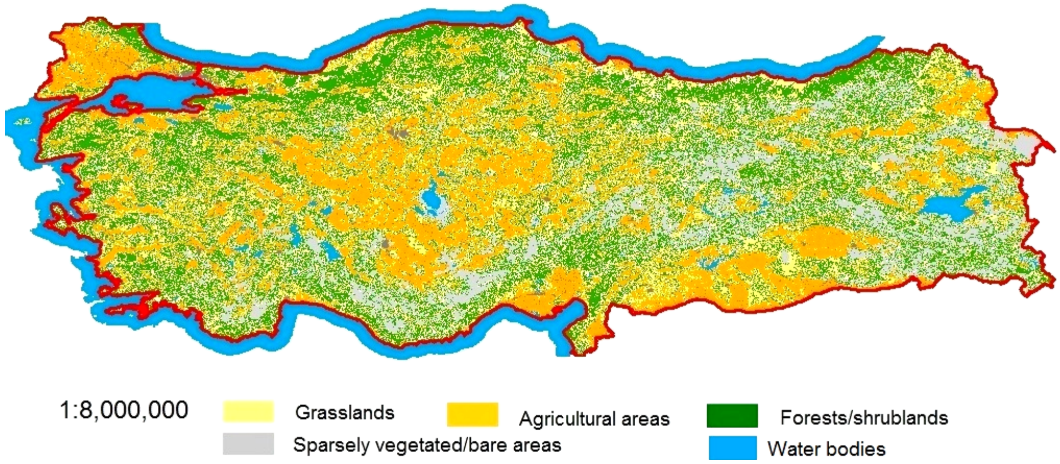


Figure 1.2: Vegetation map of Turkey based on CORINE 2006 Landcover Map (European Environmental Agency 2011) (Pastures, natural grasslands, "Land principally occupied by agriculture, with significant areas of natural vegetation" and "complex cultivation patterns" are included in grasslands. Other land cover types are colored in accordance with level 1 classification of CORINE)

The steppes of southeast Anatolia belong to Mesopotamian sector and are covered mostly with forest-steppes in the mountains and Mesopotamian steppe of the northern Syrian Desert on the plain (Zohary 1973). Steppes at Urfa-Mardin low plateau are made up of chamaephytes and hemicryptophytes such as *Artemisia herba-alba, Phlomis bruguieri, Cousinia stenocephala, Capparis ovata var. sicula, Teucium polium, Scrophularia xanthoglossa, Phlomis curdica, Onosma echinatum, Astragalus platyraphis, Centaurea myriocephala,* etc (Zohary 1973).

As indicated before, most of the steppes of the past are replaced by arable lands which are also currently being replaced by different successional stages due to land abandonment. In addition, pine forests or oak-juniper shrublands occur with patchy distribution in between the montane steppes, which are named as forest-steppe due to this reason. Common woody members of the steppes are species of *Quercus, Amygdalus, Juniperus, Crataegus* genera; *Pyrgus elaeagnifolia*, *Rosa canina* etc (Zohary 1973).

2.1.2. Disturbance and Succession

World-wide expansion of grasslands was associated with increasing abundance of grasses using the C4 photosynthetic pathway due to increased aridity, a decline in woodlands due to fires, and coevolution of mammals adapted to grazing and open habitats (Anderson 2006). Those enabled grassland to replace once-forest covered habitats. Onwards, grasslands and woodlands or forests interact continuously, replacing one another due to climatic oscillations and other driving forces: In glacial periods North Europe was covered with ice caps and tundra south of it. The southern Europe experienced Anatolian steppe-like vegetation with forest island scattered in it Lévêque (2003). In a study on sediments in Lake Van (Wick *et al.* 2003) evidence has been found for steppe vegetation in lateglacial period, then semi-desert *Artemisia*-chenopod steppe in drier period, grassy steppe and Pistachio scrub with increase in moisture, oak forest-steppes with more increase in moisture.

The factors enabling grassland evolution i.e. aridity, fire and grazing are major disturbances shaping grasslands, initiating "secondary succession " which is the change in the community after a disturbance (or removal of disturbance) like fire, altered grazing, nutrient inputs or agricultural land abandonment (Gibson 2009). The disturbance regime defined by its size, frequency, intensity and timing, determines the response of components of the community to the overall result (Hobbs and Huenneke 1992). Interactions between different disturbances or modifications of disturbance regime can have substantial effect of the ecosystem. The grassland succession is difficult to predict except perhaps at the phsiognomically level with the life forms related to climate, and to the time, frequency and intensity of the last disturbance (Gibson 2009). For example a study on relationship of plant life history attributes and disturbances; McIntyre and colleagues (1995) found that life-form is a very useful attribute to characterize community response to disturbances such as there are more therophytes and versatile/flat rosettes in soil-disturbed sites and heavily-grazed sites; more geophytes, chamaephytes, phanerophytes and proto-hemicryptophytes in disturbance-free sites of temperate grasslands of Australia. Kahmen and Pschlod (2004) found that species with regular distribution of leaves on stem, ability of vegetative spread more than 1m, longer than 0.6m, flowering later than May and flowering longer than 1 month tend to increase in proportion during 25 years of succession in Germany.

Soil disturbance creates space for establishment of new plants most of which are weedy, ruderal species (Hobbs and Huenneke 1992). McLendon and Redente found that (1990) different types of soil disturbance in terms of vegetation removal and soil processing result in different seral communities. Late in succession, fluctuations in composition may occur without a clear directional trend in the vegetation (Collins and Adams 1983). Transient dynamics can be observed as one species then another becomes dominant temporarily as Fynn and O'Connor (2005) show in South African grasslands by switches in dominance among four species in 50 years after addition of fertilizers.

The relationship between disturbance and biodiversity is explained by intermediate disturbance theory (Grime 1973 in Wilkinson 1999; Horn 1975 in Wilkinson 1999; Connell 1978) indicating that highest levels of diversity occur in intermediate levels of disturbance on a community (Petraitis *et al.* 1989). Otherwise only stress-tolerators will persist in high disturbance or superior-competitors in low levels of disturbance both of which result with low diversity (Grime 1973 in Wilkinson 1999). But applicability of the theory to rangelands is questioned as researches found positive monotonic, negative monotonic, unimodal and no significant relationship between diversity and disturbance such as fire and grazing in grasslands (Sasaki *et al.* 2009). The effect of specific disturbance agents on grasslands will be discussed in the following pages.

2.1.3. Land Use

Anatolian steppes are not considered to be in natural state (Asouti and Hather 2001) since Turkey's vegetation has been under continuous human use starting with first settlements and domestication of livestock dating back to around 8000 B.C. (Akurgal 1999; Vigne 2011). Miller (2002) states that by the end of Pre-Pottery Neolithic B (10700-8000 years before present), evidence of environmental degradation in the immediate vicinity of some sites indicate people had at least a local impact on environment through gathering fire wood and maintenance of grazing herds. Wick and colleagues (2003) claim that the human effect on environment started 3800 years ago around van Lake with appearance of *Plantago lanceolata* pollens in sediments indicating livestock grazing. It intensified during the last 600 years as the clearing of the woodlands.

Çetik (1985) claims that since at least 3000 BC with the era of Prohitites and Hitites the vegetation degradation has started and still continues by destruction of forests for fuel, construction material, mining, fires, wars; opening arable land and overgrazing. Added to the climatic changes throughout the last 10.000 years, those activities resulted in formation of anthropogenic steppes, expansion of natural steppes of plains well above the natural lowest limit of forests and degradation of steppes (Çetik 1985).

Through many civilizations, the main income source of Anatolia was agriculture. The Anatolian land was used actively in traditional ways by villagers and nomads making use of natural resources of steppes. A short summary of animal and plant production in Anatolian steppe region is given below:

- The arable lands are cultivated with dryland cereals and pulses. In addition, cotton is cultivated with irrigation in southeast Anatolia and forage legumes are cultivated in Central Anatolia locally. (SIS 1994 *In* Redman and Hemmami 2008).
- Sheep and goat are usually grazed extensively. In central part, dairy cattle husbandry was intensive in the past. In the highlands of East Anatolia, which is quite cold, extensive livestock production takes place together with cereal production for the household (SIS 1994 *In* Redman and Hemmami 2008).
- The majority of farms are typically small-scale and over 83% of the farmlands are smaller than 10 hectares for Turkey, based on 2001 Agricultural Census (Karagöz 2006, in Redman and Hemmami 2008). Mostly, the plant and animal production are practiced together in farms. Low productivity enables subsistence or semi-subsistence for most of the farmers (Karagöz 2006 *In* Redman and Hemmami 2008).

The "recent" large-scale destruction and degradation of steppes took place between 1950-1980 with subvention of agricultural mechanization, allocation of governmental land for agriculture, opening of marginal lands and rangelands for crop production (Kazgan 2003). As seen from Figure 1.3, the arable lands increased and the livestock numbers increased in 1965. This resulted in shrunk and overgrazing of rangelands: the total rangeland area was reduced from 44.2 million hectares to 12.4 million hectares between 1940 and 2000, over 70% (Karagöz, 2006 In Redman and Hemmami 2008). Overgrazing in existing rangelands was the result (Fırıncıoğlu *et al*. 2007) causing erosion, decreased productivity, and desertification. Redman and Hemmami (2008) state that until

1950s, arable lands form a mosaic of small plots with complex patterns of land ownership and tenure, surrounded by vast grasslands where livestock of the farms grazed.

With the increase in rural population and mechanization of agriculture, surplus laborers and non-agrarian workers started to migrate internally in 1950s then to western European countries since 1960 (Akgündüz 2008) which initiated large scale land abandonment.

After 1980's, the agriculture sector is left outside state protection and control under the effect of world economy (Kazgan 2003). Increase in total arable land size has decreased as seen in Figure 1.3 and animal husbandry started to decline (Kazgan 2003). In 2000s, the world economy forced Turkey to become a consumer rather than a supplier so the agriculture has deteriorated and animal husbandry has crushed (Kazgan 2003). Land abandonment continues today as expected from trend represented in Figure 1.3 as decrease of arable lands between 1994 and 2010.

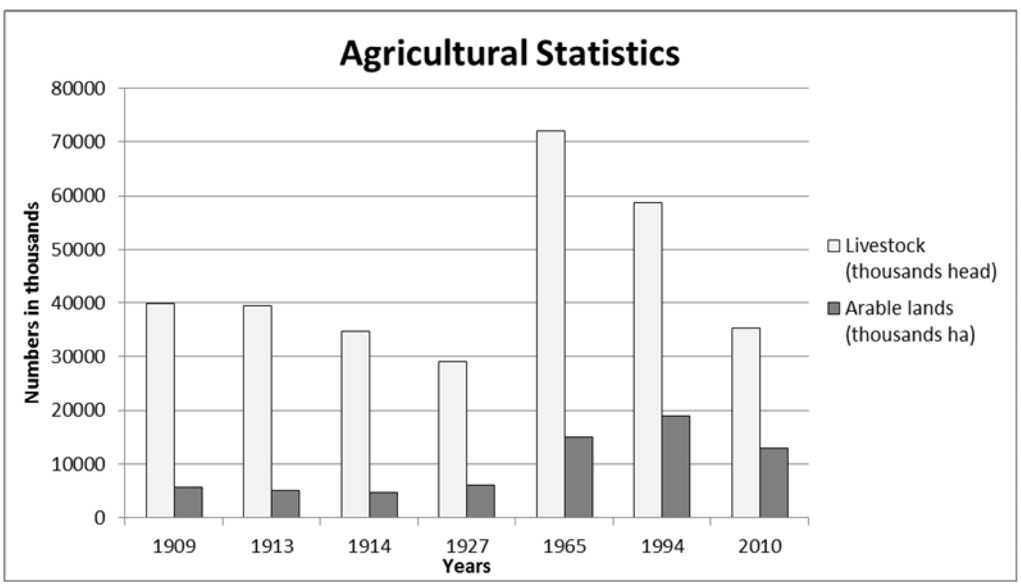


Figure 1.3: Statistics for livestock numbers and total arable land in Turkey through in different periods (TUİK 2012).

2.1.4. Biodiversity, Threats and Conservation

3.1.1.1 Biodiversity

Grasslands of the world are huge pools of biodiversity (Gibson 2009). Below short information on species groups are given with global and Anatolian examples emphasizing importance of steppes for biodiversity.

Grasslands are quite important for plant diversity. Plant species diversity in grasslands can be high compared with most forests (Whittaker 1975). Plant species richness of grasslands varies between 18-50 in 10-30m^2 to 23-68 in 101-1000m^2 with the highest numbers belonging to temperate grassland, meadow and shrublands (Faber-Langendoen and Josse 2010). According to Özhatay and colleagues (2003), Turkey is the richest country in terms of plant biodiversity in the temperate zone of Northern Hemisphere. Among the more than 9000 vascular plant species that exist in Turkey, more than 3000 are endemics, and half of those endemics live on the Anatolian steppes (Vural and Adıgüzel 2007).

The term "grassland bird" is used for birds with affinities or physiological and behavioral adaptations to grasslands (Brennan *et al.* 2005; de Juana 2005). Sharp declines in grassland bird populations have been observed due to grassland destruction and degradation (Herkert and Knopf 1998). As a result 81% of breeding bird populations of steppe birds in Europe has unfavorable status (Burfield 2005). 97% of breeding bird populations in European steppes are localized in Russia, Turkey and Spain, which makes Turkey a very important country in terms of steppe birds (Burfield 2005). Some of those species are threatened worldwide. Two well-known examples are Little Bustard (*Tetrax tetrax*) and Great Bustard (*Otis tarda*).

Grazing mammals are linked to grasslands worldwide through evolutionary history. Most of the vast natural grasslands have their own grazers moving in herds and shaping the grassland such as bison, various antelopes, zebras, elephants, wild horses, wild asses and sheep and gazelles (Woodward 2008). The populations of some those animals have decreased in many places and some are on the verge of extinction, living only in captivity. Once harboring very different grazers ranging from wild horse (*Equus ferus*) and onager (*E. hemionus*) to wild ox (*Bos primigenius*), now only the Turkish Mouflon (*Ovis* *gmelini anatolica*) and Goitered Gazelles (*Gazella subgutturosa*) survive on steppes of Konya and Ankara, plains of Urfa, respectively (Durmuş 2010; Özüt 2010).

Grasslands are quite rich in different insect groups such as Diptera, Hymenoptera and Hemiptera (Biedermann *et al.* 2005). For example more than forty species of grasshoppers in densities of 1000-8500 individuals per m^2 can be observed (Biedermann *et al.* 2005). High butterfly richness in the temperate zone is exemplified in Europe's calcareous grasslands as the richest habitats for butterflies, with 274 (48%) of 576 species recorded in Europe (Van Swaay 2006). Turkey is richest country terms of butterflies in Europe and the northern temperate zone with 381 species and 45 endemics (Karaçetin and Welch 2011). The richest sites are grazed or mowed meadows at high mountains in East and Northeast Anatolia where butterflies are dependent on grassland management (Karaçetin *et al.* 2011). Of the 93 Prime Butterfly Areas identified in Turkey, 30 of them are located in Inner Anatolia, all of which have considerable area of steppes (Karaçetin *et al.* 2011).

3.1.1.2 Threats and Conservation

In spite of the richness indicated above, grasslands are experiencing the tragedy of commons, being one of the most ignored and under-protected ecosystems of the world. Grassland is the biome most threatened according to the Conservation Risk Index (Hoekstra *et al.* 2005). Only 7.6% of the grasslands (White *et al.* 2000) and only 0.69% of the temperate grasslands are under protection (Davis *et al.* 1994-1995 in White *et al.* 2000). The actors on loss of habitat and biodiversity, fragmentation, degradation and desertification of temperate grasslands are as follows (Peart 2008):

1. Unsustainable and inappropriate grazing,
2. Conversion/clearing of the landscape for forest plantations and crop production,
3. Landscape change for mining and energy production (coal, oil/gas, electricity),
4. Urban encroachment with the associated infrastructure, especially roads,
5. Inappropriate fire regimes,
6. Excessive water extraction/aquifer depletion, inadequate irrigation management, existing/potential water basin transfers,

7. Current protected areas too small, too few, poorly managed and lacking balanced ecosystem representation,
8. Other - over collection for fuel and medicinal plants, illegal hunting/poaching.
9. Climate change is a factor interacting with all the items listed above.

Intensive agriculture is the strongest actor replacing 41 percent of the world's temperate grasslands while another 13.5 percent have been converted to urban, industrial and other uses (Heidenreich 2009). Cultivation or ecosystem conversion took place on 42 million hectares in Eurasian steppe belt (Frühauf and Meinel 2006).

The situation is similar for steppes of Anatolia. Agricultural mechanization, overgrazing, removal of chamaephytes resulted in the recent destruction and degradation of steppes. Although the recent Rangeland Law provided a legal basis for sustainability of rangelands, problems in implementation prevented solutions for rangeland issues (Tarım ve Köyişleri Bakanlığı 2004).

Grasslands had a dual condition due to changes in agricultural practices starting in 1960s: overgrazing on highlands, and around villages of lowlands but under-grazing on mountainous sites that are far from the villages (Karabak 2009). Overgrazing and agricultural intensification are no more valid threats for steppes in many parts of Anatolia, due to land abandonment. The possible effects of land abandonment on steppes of Anatolia are not documented, but seen as succession to forests and change in diversity.

There are now novel threats on natural habitats: afforestation, unplanned urbanization, mining and energy production, road and energy constructions, climate change and pollution. Although some of such threats may have only local impacts, the inconceivable number and magnitude of such activities may give considerable harm to steppes.

Among the threats, a large-scale afforestation campaign started in 2007 to control soil erosion with a target of 2.300.000 ha (equal to Trace), planted 1.990.470 ha so far (Ağaçlandırma ve Erozyon Kontrolü Genel Müdürlüğü 2009; 2011). Although it is forbidden to do afforestation on rangelands (Ağaçlandırma ve Erozyon Kontrolü Genel Müdürlüğü 2009) ; we witness destruction of steppes all over Turkey. Çolak and Can (2011) indicate that steppes close to natural state should not be afforested not to lose rich biodiversity.

Yet there is not a single protected area in Turkey that is specifically assigned to protect steppe diversity. There are protected areas with considerable steppe in them established to protect cultural heritage, geomorphologically unique areas (Şekercioğlu *et al.* 2011) and wildlife management. The only exception is Salt Lake (Tuz Gölü) Special Environmental Protection Area (Şekercioğlu *et al.* 2011) which is assigned for its biodiversity as a whole.

2.2. Driving Forces of Grassland Biodiversity

Noss (1990) lists the community-level biodiversity indicator variables for terrestrial life as "substrate and soil variables, slope and aspect, vegetation biomass and physiognomy, foilage density and layering, horizontal patchiness, coverage and distribution of key features (cliffs, outcrops, sinks), structural elements (snags, downlogs) water and resource availability, snow cover". Faber-Langendoen and Josse (2010) list the ecological drivers of grassland biodiversity as site factors such as topography, climate (including fire) and soil properties, land management activities such as grazing, moving and fertilization; successional dynamics and global parameters such as biome, latitude and evolutionary gradients. Landscape features are used commonly to explain grassland such as habitat area (patch size), isolation/connectivity, heterogeneity/landscape diversity (Krauss *et al.* 2004). The effects of such major drivers on grassland biodiversity will be the focus of following pages.

2.2.1. Climate

Climate determines temperature range and water availability for organisms which in turn restricts species composition, community structure and ecosystem functions (Molles 2005). The mean annual temperature of the grassland zone is between 3-18°C (Whittaker 1975) and the amount of rainfall is between that of desert lands and forest lands (Odum and Barrett 2005) with 250-1000 mm of mean annual precipitation (Molles 2002; Woodward 2008).

Climate of an area is determined largely by latitude, altitude, topography, the position in relation to seas and land masses, rainshadows, aspect and exposure to regional circulations (Cox and Moore 1993; Whiteman, 2000). The last three conditions are requisites of aridity supporting grassland vegetation all over the world (White *et al.* 2000). Aridity can simply be defined as evapotranspiration exceeding precipitation resulting in drought; it expresses moisture availability as a result of precipitation and evapotranspiration, seasonal variation in precipitation effectiveness, temperature efficiency and concentration of precipitation in hot season (Nicholson 2011). Vegetation of grassland and savannah change along aridity and related climatic gradients all over the world:

- In South Argentina distributions of semi-desert, grass-steppe, shrub-steppe, and forest vegetation types are determined by precipitation gradient and matches with phytogeographical regions (Mancini 1993).
- Five major vegetation types of the Mongolian Plateau as meadow steppe, typical steppe, desert steppe, steppe desert and typical desert are determined by climatic factors and defined by latitude, elevation and climatic ranges. (ECGRIM 1990 in Fan *et al.* 2009; DAHV 1996 in Fan *et al.* 2009).
- The Russian steppe is first divided into dryland and floodplain then classified based on topography and moisture by Ramenskii to more than 50 types (Boonman and Mikhalev 2005).
- A study on East Kazakhstan showed that four different steppe communities are differentiated with temperature and rainfall variables, land abandonment history and grazing (Cheng and Nakamura 2007).
- In semi-arid grasslands of Hungary, plant richness and diversity decreases with increasing aridity (Kovács-Láng *et al*. 2000).

Whitlock and Bartlein (1997) state that climatic variations are the primary causes of regional vegetation change on millennial time scales in the forest-steppe zone of northwest America. 100-130 year drought cycles during middle Holocene decreased grasses and increased forbs whereas humid decades increased grass production in north America (Clark *et al.* 2002).

It is known that steppe birds are sensitive to drought and total precipitation in which populations show oscillations (George *et al.* 1992; Delgado *et al.* 2009) but their habitat selection is based more on vegetation and altitude which are determined by climate, topography, water sources and distance to human-modified environments (Suárez-Seoane *et al.* 2002a). The climate is important at macrogeographical scale for bird species richness and distribution (Cueto and Casenave 1999).

Butterflies are strongly depend to climate and weather conditions since most of them are ectothermic so activity and resource use dependent on air temperature, wind speed and solar radiation (Wickman 2009). The factors effective on local climate or microclimate are important for butterflies such as topography, shelters and vegetation (Wickman 2009). Butterfly populations in Britain are strongly related to weather, fluctuating with local weather conditions, high numbers are related with high summer temperatures, low rainfall (Roy *et al.* 2001). Butterfly species richness in Europe varies with latitude, altitude, climate and also reflects historical and current ecological processes in the sites (Gutierrez 2009).

Fire is a major determinant of the grasslands (Anderson 2006) to the degree that the current distribution of C4 grasslands in the tropical and subtropical region would mostly be replaced mostly by angiosperm trees in the absence of fire (Bond *et al.* 2005). Based on its effects of consuming dead and living material and suppressing forest growth, Bond and Keeley (2005) treat fire as a “global herbivore” and “fire and herbivores” as alternative consumers of vegetation. Fire suppression in countries with a long history of fire like USA and South Africa can cause complete biome switches, such as from savannas to forests as fire both enhances grass productivity and constrains the establishment and expansion of native woody vegetation (Heisler *et al.* 2003). Although there is not any study on the historical or theoretical effect of fire on Anatolian steppes, it is known that high steppe-fire frequency was observed in east Anatolia in early Holocene (Wick *et al.* 2003).

Biodiversity and productivity are in continuous interaction. Primary productivity can be defined as the rate at which energy is stored in the organic matter of plants per unit area of earth’s surface and net primary productivity (NPP) is the amount left after respiration. Key determinants of NPP in grasslands are soil moisture as the major determinant, annual precipitation, nutrients and light to lesser extend and disturbances like fire and grazing (Knapp *et al.* 2007). The widely accepted original view is humped-back model for the relationship between net primary productivity and plant richness (Grime 1973; Fridley *et al.* 2012) increasing richness at a certain level then decreasing with increase in productivity. But a major study on grasslands reveals that productivity and plant biodiversity are positively correlated (Tilman *et al.* 1996). Adler and colleagues (2011) claim no clear relationship between productivity and fine-scale richness in herbaceous communities within sites, within regions, or across the globe. So debate goes on for relationship between productivity and plant richness. A work on grassland biodiversity in North America and Europe (Bakker *et al.* 2006) found that the effect of herbivory on grassland plant biodiversity depends on productivity of the site and herbivore size i.e. large herbivores consistently increase diversity in productive sites.

Global climate change by means of change in precipitation regimes especially the variability, warming, CO_2 fertilization and responses of fire and herbivory to those variables will have strong impacts on grasslands (Fischlin *et al.* 2007). A review about how European grasslands will change based on climate change scenarios indicates that (Alcamo *et al.* 2007) a decrease in area, structural change and increase in productivity especially on early-stage, immature, disturbed but fertile stages of grassland succession (Grime *et al.* 2000) will be likely. The same study indicates that physiology, phenology and distribution of European plant and animal species will be affected. The species will shift from south-west to north-east (Berry *et al.* 2006; Harrison *et al.* 2006). The plants and animals will have higher risks of extinction if they can not disperse (Thuiller *et al.* 2005). Generalist butterfly species of Europe known to disperse to higher latitudes, expanding north (Hill *et al.* 2009). As an example of how detrimental the effect can be, according to Climatic Risk Atlas of European Butterflies, one of the commonest species *Issora lathonia* Queen of Spain Fritillary will disappear in most of west Turkey and east Europe by 2080 according to two climate change scenarios (Settele *et al.* 2008).

2.2.2. Soil and Bedrock

Soil is one of the major determinants of the grassland communities limiting the plant composition and productivity which in turn affect biodiversity. The most common soil attributes used to understand grassland diversity are soil pH, soil N, NO_3, soil P, extractable P, soil depth, organic matter and aggregate stability (Pärtel *et al.* 2007; Janssens *et al.* 1998; Gardi *et al.* 2002).

The major limiting resource in arid environments is water. Soil water is determined by precipitation regime, soil texture and soil depth, the latter two determining the water holding capacity (Singh *et al*. 1998). Lane and colleagues (1998) found that soil texture is an important determinant of plant community in terms of plant functional types across a precipitation gradient. A study in African tropical grasslands revealed that the plant communities are diverged in the ordination axes shaped by mean annual grazing intensity and soil texture (McNaughton 1983). A study in Rocky Mountain grasslands show that 59.4% variation in plant richness is explained by percent silt, elevation and foliar cover (Stohlgren *et al.* 1999). Supporting the inverse-texture hypothesis, it is found that vegetation on sandy soils with low water holding capacity have higher annual net primary production than vegetation on loamy (fine-textured) soils if mean annual precipitation is below 370 mm and the reverse is true for higher precipitation amounts (Sala *et al.* 1988).

In general, grasslands with high plant diversity occur on soils with low nutrient status (Critchley *et al.* 2002b). Nitrogen is the primary soil nutrient affecting grassland biomass production, species composition and diversity (Critchley *et al.* 2002a,b). British temperate grasslands had highest plant species richness at pH>6 and Phosphorus is 4-15mg/L (Critchley *et al.* 2002b). Other nutrients can have substantial effects on specific soil types as well (Critchley *et al.* 2002 a,b). Highest plant richness has been found in soils with Phosphorus levels below optimum for plant growth (5-8 mm /100 g) and Potassium levels at optimum (20 mg/100) for plant nutrition (Janssens *et al.* 1998). Same study shows no relationship of richness and pH, organic matter, total nitrogen and calcium.

Soil organic matter has a key role in productivity (Tiessen *et al.* 1994) both as a source and sink through its function in providing nutrients and sustaining physiochemical properties (Campbell 1989). Affected from climate and vegetation, organic matter itself affects soil properties such as structure, cation exchange capacity, water infiltration, adsorption of organics therefore key for ecosystem function (Brady *et al.* 2008). Soil depth is a measure of potential soil resources for plant growth. It is found that aboveground biomass in herbaceous vegetation is strongly correlated with soil depth (Belcher *et al.* 1995). It is an important factor affecting vegetation composition of grazed or abandoned sites, creating grassland mosaic (Fuhlendorf and Smeins 1998). Many soil attributes change with land management and abandonment. For example soil organic carbon, silt content, potentially mineralizable N are lower in cultivated fields (Burke *et al.* 1995).

The typical grassland soil has been described by Acton (1992) as "surface layer dark in color (dark brown, black or dark grey), 15-30cm thick, friable with cloddy structure, high in bases and nutritive elements; underlying layer paler in colour, more yellow, grey or reddish brown, cloddy in structure, but could be more blocky, prismatic or columnar, sometimes platy". But grasslands can develop in a variety of soil types. The main soil groups underlying Eurasian temperate grasslands are the ones which the mineral soils whose formation is conditioned by climate in the east and the ones shaped by human influences in the west i.e. Eastern Europe (Gibson 2009). Chernozems (mollisols) cover large areas under temperate grasslands in Northern hemisphere. Chernozems are brown in color because of abundance of humus topsoil and soil (A and B horizons). Calcification is characteristic of soils of semi-arid and arid climates (Woodward 2008).

It is interesting that the major literature do not mention much about the bedrock underlying the grassland biomes although there are numerous works on effect of rock type on succession (Lesschen *et al.* 2008). The explanation can be found in the sentences of Kruckeberg (2004): "most of the higher plants do not show preferences for igneous, sedimentary or metamorphic rocks per se as habitats. It is mostly the weathered products of rocks-soils-that select certain species form a region's available flora. Yet soils do reflect quality of parent material, both in physical properties and in chemical content".

2.2.3. Grazing

Olf and Ritchie (1998) indicate that effect of herbivores on plant communities varies with their body size and state that among the herbivores, grazers (those eating grasses and grass-like plants, such as most ungulates) have the greatest effect on plants.

Herbivory by large grazers are accounted as a major disturbance for the grasslands (Noy-Meir 1995). Grazing animals play a major role in maintenance of some semi-natural grasslands both in temperate and tropical latitudes which would otherwise turn into woody vegetation. They utilize the vegetation selectively at different spatial and temporal scales to obtain high quality forage.

Herbivores affect the plant communities by consuming (grazing), trampling, digging and by leaving urine, feces and carcasses with the general effects summarized below (Hobbs 2006; Danell *et al.* 2006; Heitschmidt 1990):

- Defoliation: Grazing selectively removes part of the plant tissue. In this way it can affect the viability and reproduction of plants, and alter competitive interactions among them.
- Physical impacts: Trampling by large herbivores damages or breaks plant tissue. It may cause the death of that part or the whole plant, creating gaps for emergence of new plants. It also causes soil compaction and disturbance.
- Excretions and carcasses: They have positive effects on soil heterogeneity, nutrient cycling and dispersal of seeds.
- Digging or scraping: They can damage underground plant tissue but cause soil disturbance, hence help create gap openings and nutrient cycling.

The effect of herbivory on plant community depends on many internal and external parameters (Ward 2004; Olff and Ritchie 1998; Milchunas and Lauenroth 1993):

- **Abiotic factors:** As primary determinants of large scale patterns and constraints of biotic factors, major factors are precipitation, soil fertility, water availability or distance to water, season of herbivory, slope and microsite characteristics (affecting foraging behavior)
- **Herbivore parameters:** abundance and biomass of the herbivore, body size, the animal species (its selectivity and behavior)
- **Plant community parameters:** evolutionary history of grazing at the site, annual net primary production, forage quality, quantity and distribution (plant species composition, palatability, morphology), competitive abilities of plants

The response of plants to the herbivory occurs on an individual basis and can be generalized to species level but not the community level. Plant species tend to avoid the negative effects of herbivory by physical avoidance (location, visibility, defense structures) and chemical defenses or tolerance and compensation mechanisms (Hester *et al.* 2006). Plant and herbivore effect, response and biomass are in continuous interaction. Recent studies attempts to link ecosystem responses to grazing with plant functional traits like life form, plant stature, seed size and leaf toughness (Adler *et al.* 2004).

Herbivores affect the plant communities by creating heterogeneity, spatial variation in resource availability, by changing competitive abilities of species, through local colonization and regeneration from species pools, and by causing extinctions (Olff and Ritchie 1998). The outcome of herbivory can be observed as change in plant composition and successional shifts. The intermediate disturbance hypothesis (Milchunas *et al.* 1998,: Grime 1973; Horn 1975; Connell 1978;) has been long tested by many studies (McNaughton 1993) claim that intermediate grazing levels supported the highest level of diversity in grasslands. In one of the major works of grazer effect on grasslands (Olff and Ritchie 1998) it is indicated that herbivores often, but not always, increase plant diversity. Herbivory can enhance primary production through compensation mechanisms of plants (Heitschmidt 1990), but too much grazing may often lead to land degradation, erosion and the loss of biodiversity, while too little grazing may lead to succession from grassland to woodland and the loss of the grassland habitat (Watkinson and Ormerod 2001). Therefore, it is apparent that many factors interact, and the hypotheses put forward are each valid for a specific case but not for a generalization (Ward 2006).

2.2.4. Biotic Interactions

The well-known interactions among individuals or species are competition, allelopathy, exploitation such as predation, herbivory, parasitism and disease; various forms of symbiosis and interactions can be extended to community level through food webs (Molles 2005). Especially competition among plants for soil water, light (in upper canopy) and nutrients (subdominants) in the order of importance have profound importance in determining composition and structure of mature prairie (Clemens *et al.* 1929). All those interactions are difficult to consider here. One remark for fungi and microorganisms is needed: studies on fungi and microorganisms of grasslands have increased in recent years. It is shown by many studies that symbiotic like N-fixing and pathogenic microorganisms have considerable effect in vegetation composition (Klironomos 2002). Soil fauna strongly influence succession through altering the composition of natural vegetation by selective improvement or suppression of plant species (De Deyn *et al.* 2003). Arbuscular mycorrhizal fungi which is in symbiosis with more than 80% of terrestrial plant species are identified to be a major factor for plant diversity and ecosystem functioning in grasslands (van der Heijden *et al.*

1998). Although not covered in this study, the importance of such elements is emphasized in many studies.

2.2.5. Vegetation Structure

Vegetation structure is a popular subject of grassland research focusing on bird and butterfly diversity and composition. Vegetation structure is a key factor for habitat selection for grassland birds especially in the breeding season (Delgado and Moreira 2000). Birds have varying vegetation structure choices especially sward height, vegetation cover, percent of bare ground and shrub requirements due to prey or food choice and predator avoidance mechanisms (Benton *et al.* 2003; McCracken and Tallowin 2004; Chamberlain *et al.* 1999). Grassland-specialist birds favor variation in grass height and cover (Baldi and Batary 2011). Species that feed on soil-dwelling invertebrates selected short swards, while species that feed on sward-dwelling invertebrates or seeds selected taller swards with greater spatial heterogeneity (Atkinson *et al.* 2005; Buckingam *et al*. 2006).

Butterfly species differ in their preference in vegetation height and bare ground for thermoregulation and mating behavior (Shreeve *et al.* 2009; Vogel *et al.* 2007). Vegetation height is important for butterfly composition, commonness and rarity in a degree that conservation actions should sustain vegetation of different heights in a landscape to conserve whole community (Rosin *et al.* 2011). So those factors are important parameters for grassland biodiversity research.

2.2.6. Habitat and Landscape Heterogeneity

Habitat heterogeneity in a landscape determines which species to occur in a landscape (Brotons *et al.* 2005; Batary *et al.* 2007). Not only certain features but habitat combinations and gradients are important for certain species assemblages (Noss 1990). Landscape structure features such as patch size, heterogeneity, perimeter-area ratio, connectivity are well-known features affecting species abundance and composition at regional scale (Noss 1990). The landscape features used commonly in grassland biodiversity studies are habitat area (patch size), isolation/connectivity, and heterogeneity/landscape diversity (Krauss *et al.* 2004). The parameters are different expressions to define the target habitat in the matrix of the surrounding landscape which contributes to the survival of populations, especially if the species exist as a metapopulation (Krauss *et al.* 2003).

Bortons and colleagues (2005) found that quality of a steppe habitat is conditional to the nature of adjacent habitats for four steppe birds studied. Presence of other habitats in the surrounding landscape enhances the quality of natural steppe for birds like skylark and tawny pipit in accordance with habitat supplementation hypothesis. But according to the same study, nearby non-herbaceous habitats in has negative effects to skylarks and shore larks due to increased predation risk. Some bird species especially seed eating birds such as skylark, grey partridge and corn bunting benefit from occurrence of arable lands on grassland landscapes (Robinson *et al.* 2001). But some other species such as horned larks and corn buntings are not related with landscape features (Knick and Rottenbery 1995; Chamberlain and Fuller 2000) but vegetation structure.

Benton and colleagues (2003) state that farmland biodiversity is associated with landscape heterogeneity at various scales and field-scale mosaics favors many species groups including butterflies and breeding birds. But Baldi and Batary (2011) restate that landscape heterogeneity can be beneficial for some species but detrimental for others for example grassland specialist birds need large homogeneous grasslands. Butterflies benefit from on higher heterogeneity in farmed landscapes by increasing abundance and richness (Weibull *et al.* 2000). Arthropods are quite sensitive to grassland structure and different management methods (Morris 2000; Kruess and Tscharntke 2002).

A study on plant diversity in managed semi-natural grasslands of Sweden (Lindborg & Eriksson 2004) revealed that historical landscape structure, heterogeneity and connectivity can be an important determinant as they found that plant species diversity responds to changes with a 50-100 years lag.

Most of the grasslands are highly fragmented today in Europe and America and fragmentation is considered to be one of the major threats on biodiversity. Although detrimental effects of fragmentation are usually by reducing population sizes and diversity, the effect on each species varies (Steffan-Dewenter and Tscharntke 2000). Krauss *et al.* (2004) propose that habitat area and heterogeneity are the most important predictors of plant biodiversity. It has also been found that in calcareous grasslands butterfly diversity was positively related with the habitat area and plant diversity (Steffan-Dewenter and Tscharntke 2000). Especially habitat-generalist species benefit from landscape diversity (Krauss *et al.* 2003). Similarly, bird species richness was positively correlated with the area of grasslands (Herkert 1994). The effect of tree cover on grassland birds is negative at the proximate levels but it is variable at the landscape scale (Cunningham & Johnson 2006).

2.2.7. Land Use Activities

Different land use activities shape biodiversity of grasslands (Belsky 1992, Klimek *et al* 2007; Collins *et al.* 1998). Since the appearance of *Homo sapiens* on the grasslands of Africa, they are among the ecosystems that are used and shaped by humans most (Henwood 1998; White *et al.* 2000). Historically, grasslands at all latitudes have presented one of the most amenable environments for human settlement and have provided for human needs since early evolutionary times (Suttie *et al.* 2005) to a degree that little of it remains in natural state. In her study for TGCI, Heidenreich (2009) lists the direct and indirect uses of grasslands:

- Direct uses requiring grassland conversion are agriculture from food crops to plantation trees, mining and urban development. Those activities are listed as the major threat to grassland biodiversity which causes habitat destruction or fragmentation.
- Direct uses that do not need conversion are rangeland use for livestock production, subsistence of pastorals, bio-medical uses of vegetation, genetic resources, harvesting grass or grassland by-products for different purposes and recreation. Good practices and sustainable management can support grassland biodiversity whereas over-use can cause grassland degradation.
- In addition to direct uses, no-use or indirect use values are listed as social, cultural goods and services and ecosystem functions.

Studies on grasslands show that the history of a region, especially the historical land use dating back to prehistoric times can affect its community and biodiversity (Lindborg and Eriksson 2004; Pärtel *et al.* 2007). The effect is profound on the grasslands determined not by abiotic factors but by human use (e.g. European mesic grasslands). Pärtel and colleagues (2007) found that vascular plant richness in semi-natural calcareous grasslands in Estonia are positively correlated with the density of settlements in Late Iron Age, with mechanisms of extension of grasslands and species dispersal, whereas richness was highest at intermediate densities of current human population.

The management and age are two factors of population densities and species richness of butterflies in grasslands (Krauss *et al.* 2003). The age of the site and the stage of succession are important factors for butterflies (Balmer & Erhardt 2011). The presence of urban features and urban gradients are other important factors (Collinge *et al.* 2003).

In a 2100 global biodiversity scenario (Sala *et al.* 2000) it is estimated that land use change will have the largest effect on global biodiversity. At local and regional scales, land-use changes are among the most immediate drivers of species diversity. Intensification of land use, especially the conversion of natural ecosystems into agro-ecosystems is supposed to both change the composition and reduce the diversity of biological communities (Van Der Putten *et al.* 2000). Below given are general information about effect of different land uses on grasslands.

2.2.8. Managing Grasslands

3.1.1.3 Livestock Grazing

The effects of grazing were explained in detail in previous pages. Many native grazers got extinct in many parts of the world due to habitat loss and degradation, overharvesting, or land use changes (Mallon and Jiang 2009; Sitters *et al.* 2009). Livestock have replaced the natural grazers on grasslands in many parts of the world since up to 10,000 years ago, yet most of the time they do not mimic the historic and ecological role of native grazers (Heitschmidt 1990; Fuhlendorf and Engle 2001). Effects of animal husbandry are different than those of natural grazers due to evolutionary history of the species involved and grazing management (Hartnett *et al.*1997, McNaugton 1993):

- limited mobility for optimum foraging due to human herding, fencing and territoriality,
- the goal of maximum livestock production instead of density regulation based on primary production,
- Human supply of limiting resources of animal population i.e. food, provision of water, mineral (salt),

- Practices increasing population growth by other means: predator control, veterinary practices etc.
- Use of rangeland improvement techniques for maximum livestock production: Application of fertilizers, sowing, different ways of rangeland control

Animal husbandry generally results in higher animal densities than in natural systems (McNaughton 1993) and changes the grassland ecosystem from nutrient levels to ecosystem health depending on the grazing system (distribution of grazing, intensity, use of supplies etc).

Not all livestock elements exploit and modify the grasslands in the same way. Body size, species, breed, sex, age, diet and experience affect grazing behavior of the animal so the sward heterogeneity and diversity (Rook *et al.* 2004). Height of the vegetation animals graze differs so the selection of plant species based on sward height. In addition, it is found that sheep has more variable diet, able to select forage from fine-scale mixture whereas cattle prefer to graze tall and more fibrous plants (Grant *et al.* 1985).

As discussed in the grazing part, herbivores have various effects on plant communities and plant richness depending on grazing impact on dominant plant species, selective grazing, plant regeneration opportunities, propagule transport and environmental parameters such as soil fertility and water availability interacting with the effect of grazing (Olf and Ritchie 1998). As indicated before there is not an overall-valid direction of the effect of grazing on plant diversity. But it is well documented that grazing has major effects on plant communities. For example Ramenskii identified plant associations occurring under different levels of grazing on dark-chestnut loamy soil of the dry steppe plains (Boonman and Mikhalev 2005): a low-grass sward with *Stipa lessingiana* but less *Festuca sulcata* on non-grazed sites; predominantly *Festuca sulcata* after a few years of grazing; *Poa bulbosa* associations with intensive grazing and an association with *Polygonum aviculare* after heavy grazing. A study done at steppe-like grasslands of Romania (Enyedi *et al.* 2008) showed that *Stipa lessingiana dominated* grasslands which were formerly grazed but abandoned for 35 years are dominated by *S. pulcherrima,* adapted less to arid conditions, with lower diversity and evenness than continuously grazed sites.

Three major global results of grazing are desertification, grazing-resistant shrub encroachment and deforestation (Asner *et al.* 2004). Desertification is "the sum of the geological, climatic, biological and human factors which lead to the degradation of the physical, chemical and biological potential of lands in arid and semi-arid zones, and endanger biodiversity and the survival of human communities" (FAO 2012). Schlesinger *et al.* (1990) explained desertification by grazing as follows: Desertification of productive semiarid grasslands occur as long term grazing causes increase in spatial and temporal heterogeneity of water, nitrogen and other soil resources which results in invasion of desert shrubs, further localization of soil resources under shrub canopies, further loss of soil fertility between shrubs with erosion and gas emissions and climate change will increase future desertification. The recovery of overgrazed desertified and desert-shrub dominated sites after exclusion of grazing takes considerable time i.e. more than 20 years at extreme (Valone *et al.* 2002).

Large herbivores affect trees by browsing on leaves, young shoots, damaging young trees, causing damages and affecting survival rates (Gill 2006). They may accelerate succession in semi-natural to persistent forest states, if resources are abundant but retards succession in earlier stages like old field succession (Davidson 1993). However, Gill (2006) states the effect of herbivores on trees in a different way and he indicates that retarding effects of herbivory occurs in woodlands or existing areas of tree cover whereas facilitation occurs in grasslands by grazers. Shrub encroachment, increase in density and cover of bushy and woody desert species at the expense of perennial grasses, is one of the most striking land cover changes in rangelands worldwide over the past 150 years caused mainly by change in climate towards desert conditions, heavy grazing by folivores and activity of granivores, reduction in browsers, suppression of fire, increases in atmospheric CO_2 and Nitrogen deposition (Archer 2009; Van Auken 2000; Hobbs and Huenneke 1992). The possible mechanisms are alteration herbaceous composition and reduced above and belowground biomass production below the threshold level required for competitive exclusion of woody vegetation (Archer 2009) and fire exclusion (Van Auken 2000).

Herbivore-induced changes in the vegetation are the main causes of changes in other animal populations of the community. The impact can be positive or negative depending on the animal species considered, its feeding behavior and habitat requirements of all life stages and especially whether it is using the same resources with the large herbivore. Large herbivores can induce changes which can affect many different animal species of the ecosystem in three dimensional vegetation structure, layering, vegetation cover, amount of open ground, other physical modifications, plant composition, biomass, plant diversity, food availability heterogeneity of plant community (Danell *et al.* 2006). Grassland bird species tended to be associated with either sheep or cattle, which may reflect the widely different characteristics of herbaceous vegetation in pastures: intensive grazing by sheep reduces sward structural complexity and promotes short and uniform pastures proffered by birds such as the short-toed lark; whereas moderate grazing, especially by cattle, increases structural heterogeneity and leads to patchy swards with areas of long and short cover preferred by birds feeding on seeds and foliar invertebrates during the chick rearing period such as corn buntings (Reino *et al.* 2010). Insect species differ in their preference for successional stages determined by grazing management (Pöyry *et al.* 2005).

3.1.1.4 Mowing

Mowing, non-selective cutting grasslands at a certain height in certain frequencies, is a common practice especially in European meadows (Gibson 2009). It encourages grasses, suppresses forbs and tree growth, changing competitive relations and altering plant composition in those ways (Gibson 2009). The effects of grazing and mowing are different: Mowing reduces the plant biomass and reduces the growth of dominant grasses, allowing the growth of less competitive species but not creating gaps for new establishment, nor heterogeneity, seed dispersal and nutrient deposition (Hobbs and Huenneke 1992).

It is found that mowing either maintains or increases plant diversity in grasslands (Collins *et al.* 1998). Mowing intensity and timing can change plant community composition such as decline in grass species with increasing frequency of mowing (Fynn *et al*. 2004). It is found that grasses and forbs respond differentially to mowing in African mesic grasslands (Fynn *et al.* 2005). Similar to the effects of other disturbances, abandonment of mowing results mostly in lower plant richness (Stampfli and Michalea 1999).

Mowing affects grassland birds as it changes vegetation structure and composition so suitability of grassland for the species, it disturbs birds and force them to use habitats outside; it can destroy nests if practiced in breeding season so reduces fecundity (Horn and Koford 2000).

Depending on the timing, frequency and method, mowing affects butterflies by directly killing adults or juvenile nests, removing nectar resources (Settele *et al.* 2009). Mowing also influences endangered butterfly species such as *Maculinea* sp. in positive or negative ways by affecting abundance of host plant *Sanguisorba officinalis,* ants and their nests needed for egg and instar stages; destruction of eggs or larva on mown plants (Johst *et al.* 2006).

Mowing is a common practice in grass-covered orchards of Black Sea and high mountain grasslands in the vicinity of villages of East Anatolia regions. But the effect of mowing on biodiversity of those regions has not been researched yet.

3.1.1.5 Grassland Improvement and Restoration

Grassland improvement is application of various techniques such as shallow ploughing, reseeding, application of fertilizers, pesticides and herbicides, improved drainage etc. for increased efficiency of grassland production (Humpreys 1997). Nutrient enrichment is the commonest way of grassland improvement. Enrichment causes grasses to dominate over broadleaved plants (Hobbs and Huenneke 1992). It is known that additions of inorganic fertilizers such as nitrogen, phosphorus and potassium to European grasslands to increase productivity resulted in a decline in plant species richness (Critchley *et al.* 2002a). The effect of pesticide use found to be dramatic on ground beetles and spiders (Rushton *et al.* 1989).

The intensively used grasslands are unable to self-recover which need restoration for sustainability of grassland and retrieval of biodiversity. But previous intensive use results in high nutrient inputs, degradation of previous hydrological conditions in the soil, acidification in the soil, impoverished seed banks which impedes successful restoration (Bakker and Berendse 1999). Some tools of restoration are rewetting, remowal of topsoil to get rid of high level of nutrients, sowing seeds of local species pool. Input of atmospheric nitrogen it thought to be the reason for the increasing dominance of one grass species and the loss of many forbs and other grasses, regardless of management (mowing, grazing, burning) in chalk grassland (Bobbink and Willems 1987). Gough and Marrs (1990) suggested that high phosphorus levels in the soil of abandoned pastures precluded the reestablishment of species-rich grassland there.

Fire is an important land management tool for many cultures especially in the developing countries (Goldammer 2006) for centuries. In grasslands, fire is used to for managing vegetation for various purposes mostly keeping the grassland at a successional stage useful and productive for humans (Evans *et al.* 1989), i.e. good for livestock grazing. Burning favors rapid growing species with high nutrient concentrations in many places. Altın and colleagues (2005) list 4 main and 22 additional purposes or benefits of meadow fires. The main benefits according to the publication are suppressing or killing unwanted shrubs, prevention of expansion of unwanted species in the ground layer, and an increase in forage and grazing capacity. But there is not any research about effect of fire on biodiversity of Anatolian steppes.

2.2.9. Land Abandonment

The grasslands that are not naturally limited need management such as grazing, moving, burning or wood cutting for existence otherwise they may turn into forests that are destructed in expense of grasslands and arable lands. Starting in 1950s, agricultural activities in many parts of the world such as Europe focused on more fertile and easily accessible lands and mechanization, which led to abandonment of traditional practices and marginal agricultural lands (MacDonald *et al.* 2000). Land abandonment is increasingly taking place all over the world due to environmental and socio-economic reasons (Cramer *et al.* 2007). A study of in Spanish Mediterranean highlands lists agricultural changes since 1950s as replacement of sheep with cattle but an overall dramatic decrease in livestock numbers, revegetation of crop fields by forests (Lasanta-Martinez *et al.* 2005). Studies show that higher, steeper places, places with shallow soils and with poor accessibility are more readily abandoned (Gellrich and Zimmermann 2007b; Uematsu *et al.* 2010).

The environmental impact of land abandonment in Europe are revegetation of old fields, loss of biodiversity-rich grasslands to shrublands or forests, loss of woodland clearings, change in landscape heterogeneity, risk of natural hazards in marginal lands (MacDonald *et al.* 2000). In semi-natural sites with a long grazing history, abandonment of livestock keeping in the absence of natural grazers causes the land revert to woodland. Because of this reason, it is emphasized that active management is needed to compensate the removal of disturbance from disturbance-dependent grassland ecosystems in protected areas (Hobbs and Huenneke 1992).

Hobbs and Huenneke (1992) claim that plant diversity and compositional changes are predictable in old-field succession. Cramer and her colleagues (2007) state although the effects of past cultivation practices is reflected in the vegetation even hundreds of year later; old filed succession usually follows a repeatable pathway if not arrested in an alternative state as it happens some of the old fields.

Critchley and Fowbert (2000) give the sequence of succession on set-aside lands of England as first establishment of annuals crops of soil bank for the first 2-3 years, dominance of perennial grasses in the fifth year and after 9^{th} year the vegetation was dominated by perennials and monocots. Booth (1941) predicts a four-stage sequence of succession for grasslands of Oklahoma: (i) 2- year weed stage, (ii) 9-13 years of annual grass stage (iii) perennial bunchgrass stage of variable length (iv) mature prairie. (Hobbs and Huenneke 1992). But Collins and Adams (1983) found that abandoned lands succeed beyond prairie towards dominance of trees in the absence of fire in prairie-forest zone in 33 years in Oklahoma. Similarly, a study on steppe-forest zone in Loess Plateau, China (Zhang 2005) it is found seven plant communities belonging to grassland (0-20 years), shrubland (15-30 years) and forest (30-50 years) successional stages. There can be several intermediate stages of succession one of which is shrub clusters such as on uplands of Texas in the conversion of grassland to woodland within woodland historical range (Archer *et al.* 1988). Alternate but stable stages may be reached in grassland succession in response to new conditions (Gibson 2009). Bertiller and Bisigato (1998) found that there are 4-7 stable stages in humid; 3-5 stable stages in drier grasslands of Patagonia depending on soil degradation and seed bank. In East Kazakhstan steppes, Cheng and Nakamura (2007) found that different subunits of *Elymus repens-Convulvulus arvensis* community occur in old field succession together with intervention of grazing.

Old field succession in Russian steppe results in dominance annuals in the first year, biennial and perennial herbs in the second and third years, appearance and more than 80% dominance of *Agropyron racemosum* 3-8 years accompanied by *Festuca sulcata, a stage of F.sulcata* dominance and finally dominance of *Stipa lessingiana* on the 15th year which is the original steppe form (Boonman and

Mikhalev 2005). Those vegetation types can be represented by tens of different associations depending on agricultural legacy (Boonman and Mikhalev 2005).

Plants, gastropods and member of Lepidoptera were researched at sites with different successional stages including forests and shrubby steppes by Cremene and colleagues (2005). They found that diversity in grassland successional stages were high whereas they were low in forests and tree plantations with a decrease in open-habitat species of plant, lepidoptera and gastropods. Sirami and colleagues (2007) found that in a landscape mosaic the abandonment resulted in decrease in openings and maturation of existing woodlands favoring woodland bird species and decreasing open-habitat bird species but at local scale the diversity of vegetation has increased. As some of this subject was covered in succession part, further information will not be given here.

2.3. Aim and Objectives of the Study

Aim of this research is to find out major biotic and abiotic factors on steppe biodiversity so a better understanding of the dynamics and biodiversity patterns of steppes can be possible. The specific objectives are:

- To find out basic biodiversity pattern of steppes in the study area by collecting data on surrogate species groups of birds, butterflies and common plants at site level,
- To reveal major plant, bird and butterfly species assemblages of the region,
- To reveal the role of major environmental factors on species assemblages, richness and diversity of steppes,
- To reveal the role of vegetation structure and landscape heterogeneity on species composition, richness and diversity,
- To find out the effect of current and old land use especially cultivation and livestock grazing on biodiversity,
- To find out interactions on richness and diversity between different species groups as well as interaction between major factors on biodiversity.
- To develop conservation recommendations for steppes of similar conditions.

CHAPTER II

MATERIALS AND METHODS

3.1. Study area

3.1.1. Location and Geography

The study area is located at the borders of Central and East Anatolia (see Figure 2.1) and in the central part of the Anatolian Diagonal, a chain of mountains that was identified as a floral break for the distribution of plant species in east-west direction and as an endemism center (Davis 1971). The significance of the Diagonal is supported also by studies on small mammal distributions (Gülkaç and Yüksel 1999, Özkurt *et al.* 2002).

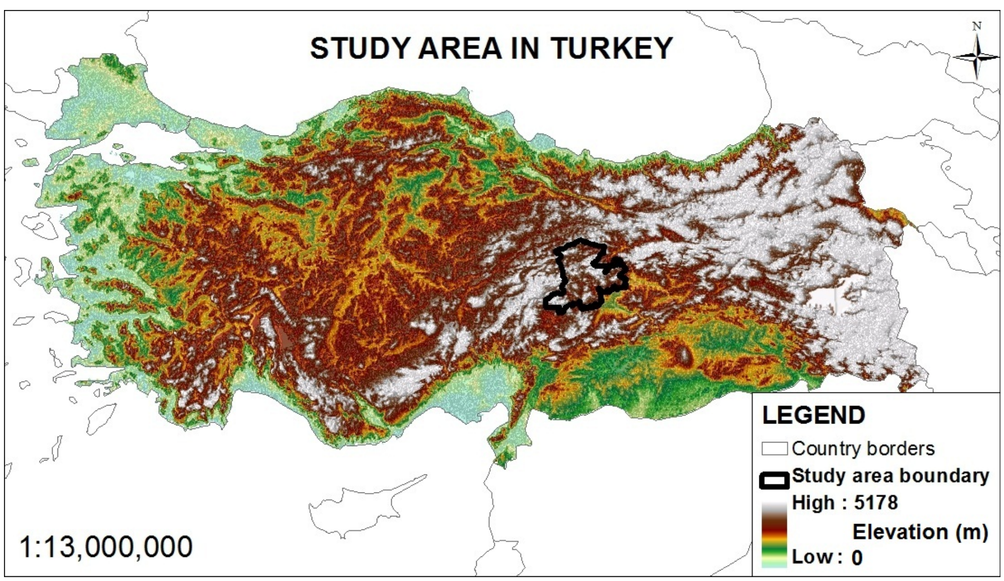


Figure 3.1: Location of study area in Turkey

The study area is located between 38°20'-39°40' North and 36°50'-38°40' East and covers a total of 1,062,554 ha. Administratively it spreads over parts of Sivas and Malatya provinces, as well as smaller parts of Kahramanmaraş and Erzincan provinces. Districts of Gürün, Kangal, Zara and Divriği (Sivas); Darende, Kuluncak, Hekimhan, Arguvan and Arapgir (Malatya); Kemaliye (Erzincan); and Afşin and Elbistan (Kahramanmaraş) wholly or partly fall within the study area.

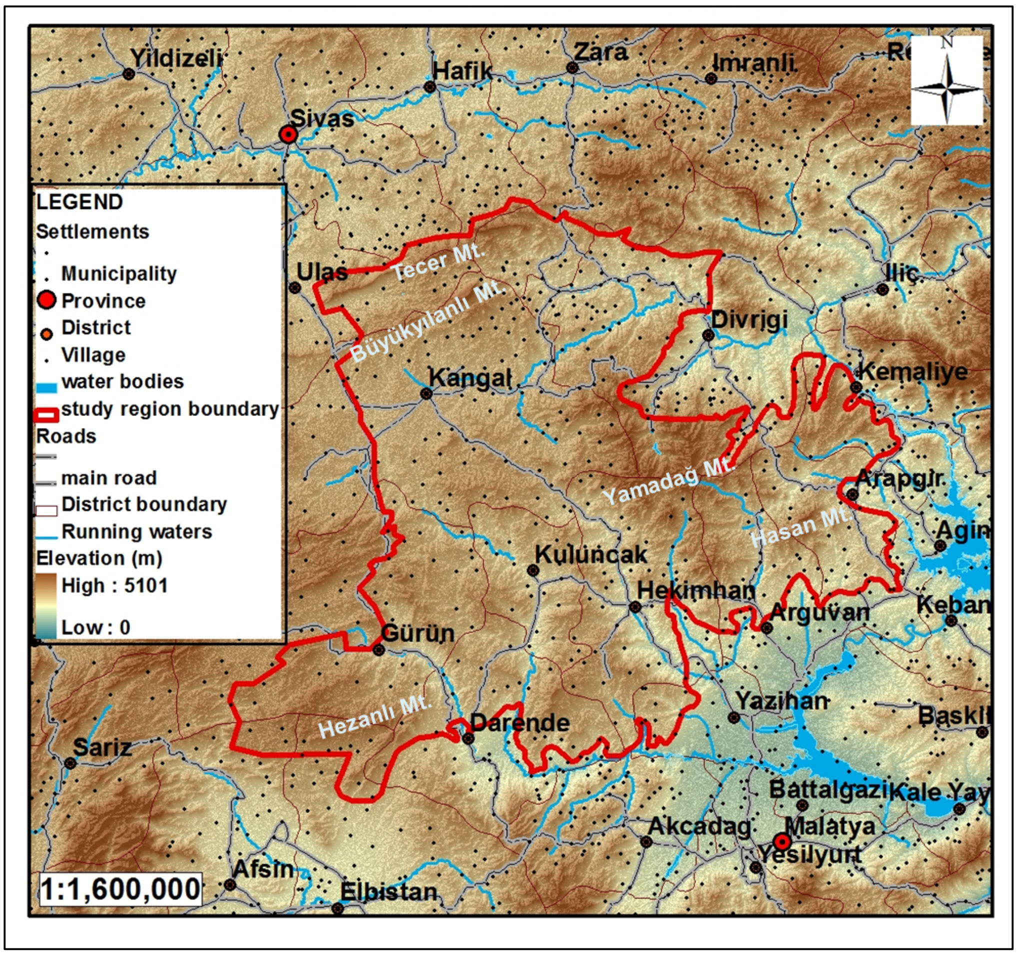


Figure 3.2: Study area in detail

The landscape is mountainous, ranging from 850m to almost 2800m elevation, with Tecer Mt. (2262m) and Büyükyılanlı Mt. (2599m) in the northwest, Yamadağ in the east (2777m) and Hezanlı Mt. (2659m) in the southwest and Hasan Mt. in the southeast (2402m) as major mountains (see Figure 2.2). The mountains are dissected by valleys of many streams. While only a small area in northwestern part is in Kızılırmak Watershed, most of the study area falls within the Euphrates (Fırat) watershed. The main streams of the area are Tohma, Balıklı Tohma, Ayvalı Tahması, Karaboğaz and Karabel branches of the Euphrates. A major plain is found around Kangal district center which is mostly converted to arable land with intensive agricultural practices. Although there are no large water bodies in the region, two large dams, Keban and Karakaya, are neighboring the eastern boundary.

The reason for choosing this region is its variability in terms of abiotic factors and richness due to its position in the transition of geographic regions, subecoregions and in the center of the Anatolian Diagonal.

3.1.2. Climate

Located in the center of the Anatolian land mass, the region experiences continental climate although lowlands located towards the south experience milder climate. The climate diagram constructed with data from 6 climate stations around the region (flags in Figure 2.3) is given in Figure 2.3. According to Erinç's aridity index (Erinç 1965 *In* Türkeş 2005), a widely used index in vegetation and flora studies in Turkey, the climate of the region is mainly arid (see Table 2.1), with only the eastern part experiencing semi-arid climate.

However, it is important to remember that since the area is quite rugged, the climate experienced in variable topography should be quite different than the data obtained from climate stations, all of which are located in settlements. Climate maps obtained from global climate layers (Worldclim 2011) gives a general idea about distribution of annual mean temperature (Figure 2.4) and annual mean precipitation (Figure 2.5).

Table 3.1: Erinç's climate types and vegetation types for the climate stations around the region (Erinç 1965 in Türkeş 2005)

Stations	**Arapgir**	**Divriği**	**Elbistan**	**Kangal**	**Malatya**	**Sivas**	**Zara**
Annual Maximum Temperature (°C)	40.4	41	39.5	37	42.2	40	39.2
Annual Precipitation (mm)	747.6	391.4	392.4	413.4	382.2	445	533.6
Erinç's index	18.50	9.55	9.93	11.17	9.06	11.13	13.61
Erinç's climate type	Semi-arid	Arid	Arid	Arid	Arid	Arid	Arid
Erinç's vegetation type	Steppe	Desert-like Steppe	Desert-like Steppe	Desert-like Steppe	Desert-like Steppe	Desert-like Steppe	Desert-like Steppe

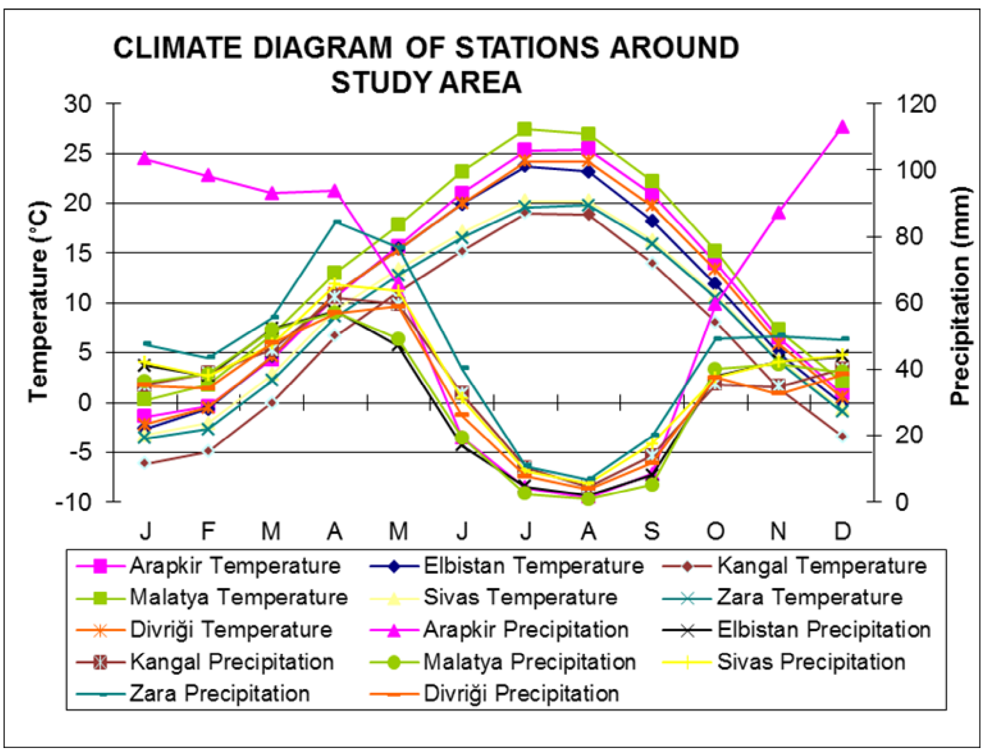


Figure 3.3: Climate diagram constructed from data of 6 climate stations around the study area

According to the BIOCLIM 1 layer (Figure 2.4), annual mean temperatures in the region range between 3.7 and 13.3°C. The annual mean temperature increases towards east-southeast as the elevation falls in valleys of Euphrates branches. The major exception is Yamadağ standing in the middle of the eastern part, top of which experiences very short summers. The mountains in the west experience the coldest temperatures with an annual mean temperature of 4-5 °C while valley bottoms experience the highest mean temperatures (11-12°C).

Annual precipitation varies between 409 and 671 mm. Most of the region experiences an annual precipitation about 400-500 mm with the lowest precipitations on the valley bottoms (see Figure 2.5). The highest precipitations are seen on mountain tops and the easternmost part covering Arguvan, Arapgir and Kemaliye, all influenced by proximity to the main Euphrates valley, with a annual mean precipitation of 550-600mm.

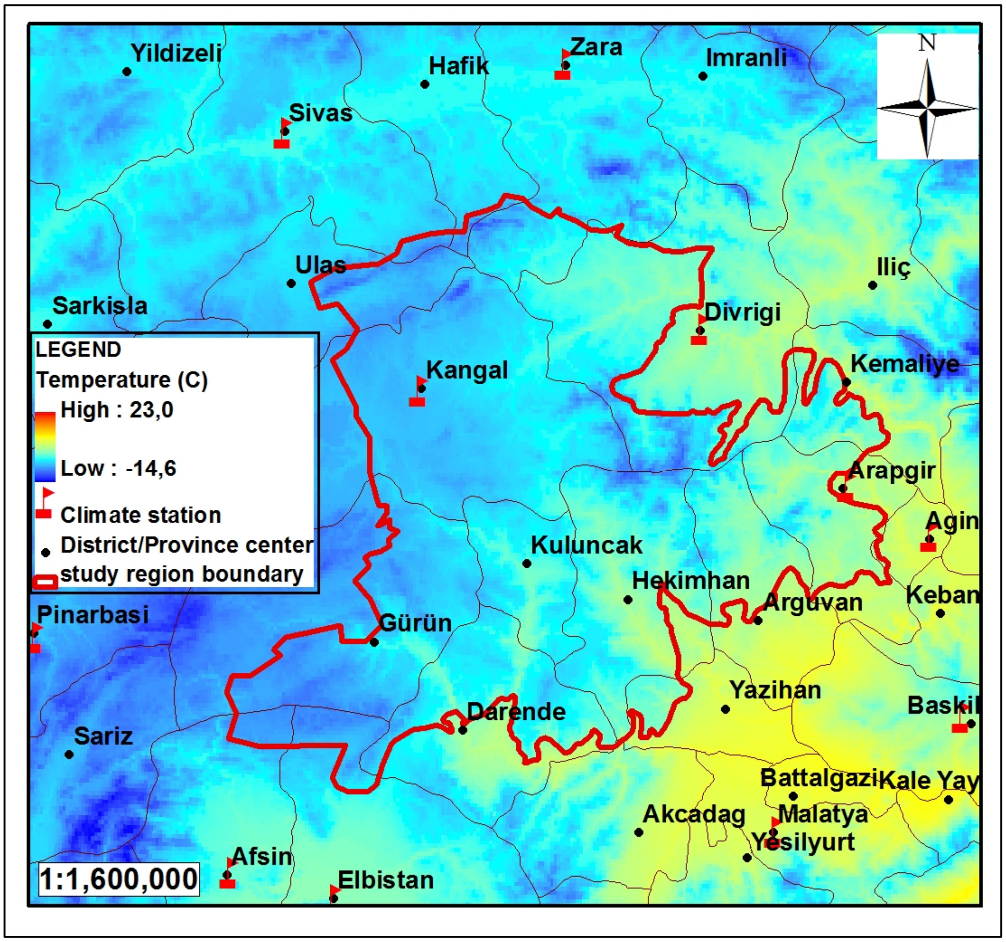


Figure 3.4: Annual mean temperature pattern of the study area based on Bioclim 1 layer (Worldclim 2011). (Stations are indicated with flags)

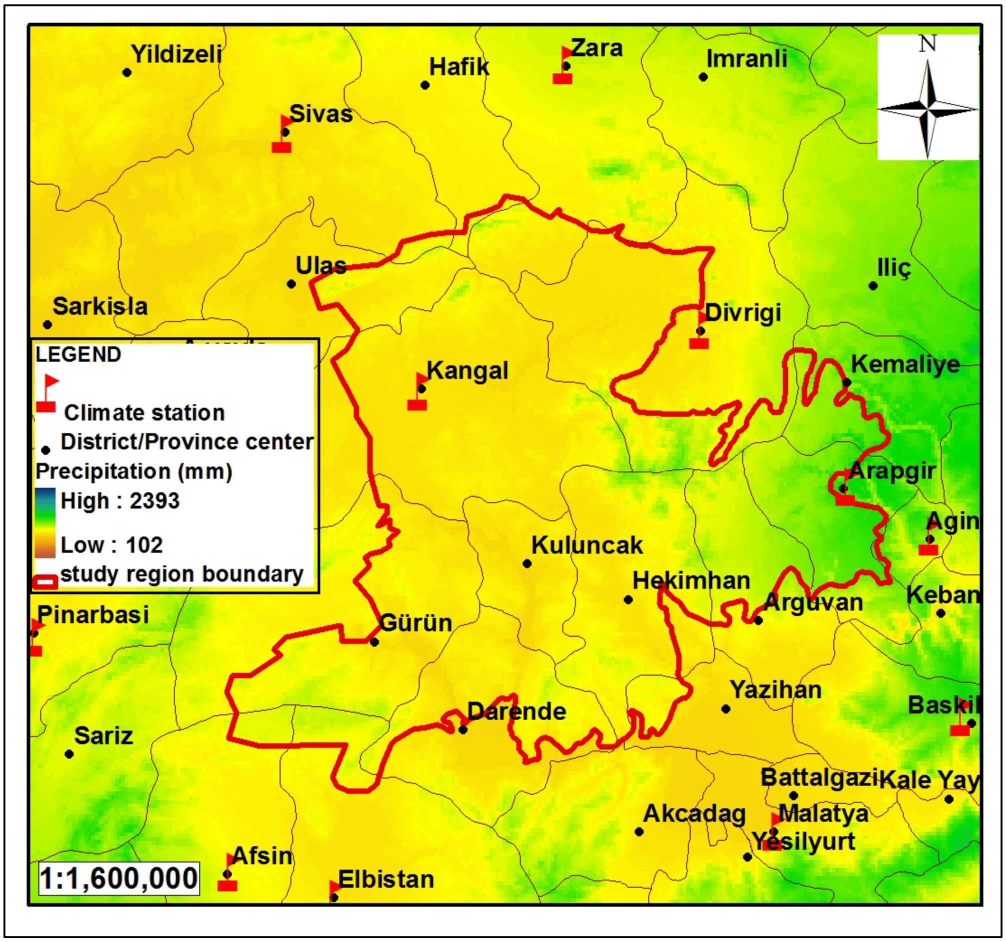


Figure 3.5: Annual precipitation pattern of the study area based on Bioclim 12 layers (Worldclim 2011). (Stations are indicated with flags)

3.1.3. Vegetation

The only large-scale study on the vegetation of the region is done by Kınıkoğlu (2008) as vegetation mapping of the Anatolian Diagonal (Figure 2.6). The main vegetation types of the region were mapped and steppes were covered as a single class without differentiation of steppe types. Based on the map, most of the land not cultivated in the study area is steppe. Mostly on the slopes of mountains, steppes cover approximately 519,000 ha (49%) of land. In the steeper slopes and rocky places, sparse vegetation or bare rock can be seen, too.

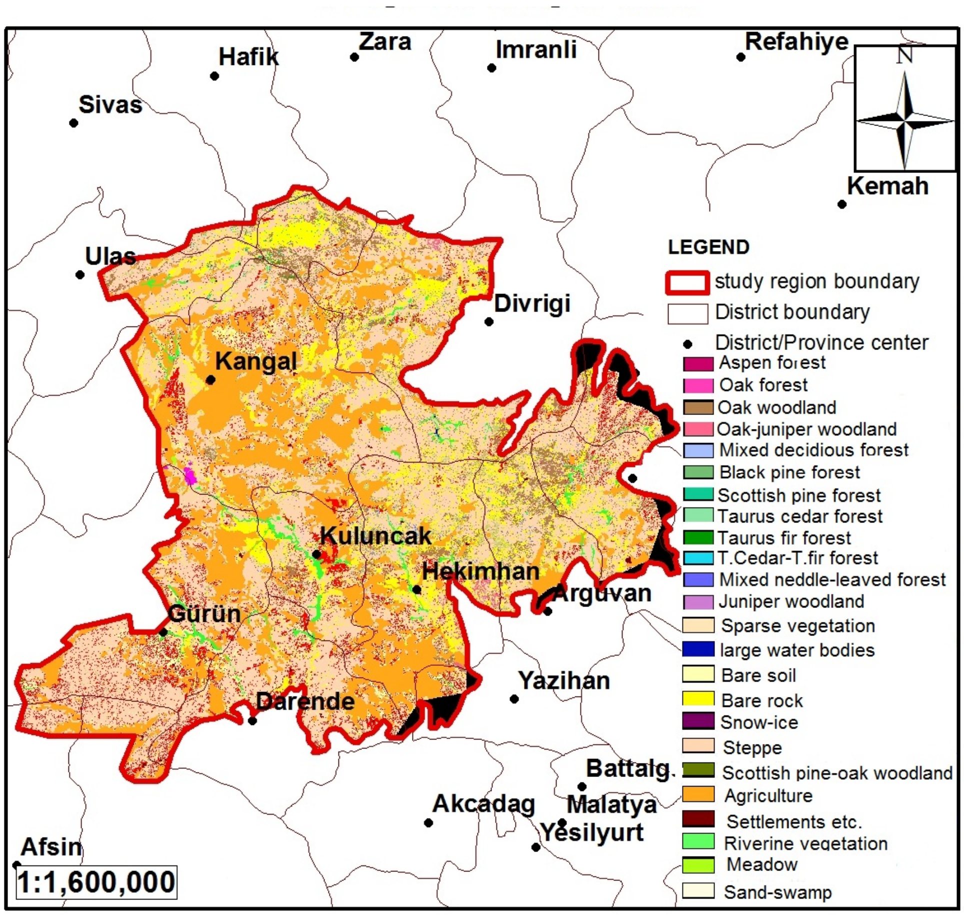


Figure 3.6: Vegetation map of the study area (Kınıkoğlu 2008)

Woody coverage in the region is dominated by oak (*Quercus*) and/or juniper (*Juniperus*) shrublands. Scots Pine *Pinus sylvestris* forests are rare in high mountains. Woodlands and forests do not cover large areas; instead they are scattered within the steppe. The distribution of natural woody vegetation indicates that the potential vegetation of the region may not be steppe but woodland. A long history of deforestation appears to have resulted in the (secondary) steppes seen today. In valley bottoms, gallery forests composed of *Salix* sp. and *Populus nigra* together with planted fruit trees can be seen.

All the flat areas close to settlements in the middle and northern parts are under cereal cultivation. The vast arable lands are seen especially around the Kangal plain. In addition, lowlands between Kuluncak, Hekimhan and Darende district centers and around Arguvan and Arapgir centers are covered with apricot orchards, a major source of income in the south of the region. The total agricultural area exceeds 26% of the region.

There is no plant sociology research within the study area but there are some studies in the broader region. Several studies indicate the distinctiveness of flora and vegetation on gypsum bedrock in Sivas (Akpulat and Çelik 2005; Ketenoğlu *et al.* 2000; Hamzaoğlu and Aydoğdu 1995). Aydoğdu and Ketenoğlu (1993) did a study approximately 20-40 km. north of the region, on the rolling hills in the north of the region, around the Sivas-Hafik-Zara-Erzincan road axis. They state that *Astragalo karamasici-Gypsophilion eriocalycis* alliance dominates the gypsum hills between Çorum and Sivas. The characteristic species of this alliance are *Astragalus karamasicus, Gypsophila eriocalyx, G. parva, Thymus leucostomus var. leucostomus, Linum mucranotum ssp. gypsicola, Ziziphora taurica, Z. tenuior, Bupleurum boissieri, Centaurea patula, Astragalus aduncus, Silene supina ssp. pruinosa, Salvia cryptantha, Lappula barbata* and *Allium flavum*. They have also identified *Helichryso-Thymenion cappodosicii* suballiance, 3 associations and 3 subassociations based on slope and aspect differences under the heavy anthropogenic effect. Ketenoğlu and colleagues (2000) indicate that in the north of their study area there is an ecotone between steppe and sylvatic vegetation of pre-Pontic range in the North, where different successional stages of different vegetation types can be seen. Hamzaoğlu and Aydoğdu (1995) state that oak shrublands appear on limestone patches located on gypsum hills.

Approximately 120 km northwest of the study region, Kurt (1995) did phytosociological research between Yozgat and Sivas. Although his study area had a well representation of Scots Pine forests, the steppe vegetation also covers large areas and represent different steppe types of plain steppes, low mountain steppes and "typical" steppes. The dominant species of those steppes are cushion forming *Astragalus* sp., *Acantholimon* sp., *Onobrychis cornuta* and *Daphne oleoides*. The common *Astragalus* species of the region are *A.*

microcephalus, A. brachyhpterus, A. angustifolius whereas for the *Acantholimon* genus they are *A. acerosum* and *A. androceum*. Other abundant species are *Asphodeline taurica, Convolvulus asyricus, Astragalus lagurus,* and *Genista sesillifolia*.

30-60 km southwest of the study area, at Binboğa and Berit Mountains, Duman and Aytaç (1994) studied the flora and vegetation of high mountain steppes above 1500m. They indicate that the steppes of the study area belong to *Astragalo lamarckii-Gundeliata tournefortii* ordo which represents the high mountain steppe vegetation of Anatolian Diagonal from Kahramanmaraş to Erzincan. The two alliances dominating the landscape are *Crepido armenae-Onobrychidion cornutae* and *Astragalo condensati-Asphodelinion globiferae* represented with 5 associations.

3.1.4. Soil

There are two main soil groups dominating the land: Brown forest soils in the north and brown soils in the rest of the region (Figure 2.7). Basaltic soils are seen north of Arguvan. Eastern part of Arapkir is dominated by non-calcic brown forest soils. Reddish brown soils cover some areas in the southwest and northwest of Hekimhan center.

The information given below about major soil groups seen in the region is summarized from Atalay (2006):

- Brown (steppe) soils develop on lands with less than 400 mm annual rainfall and support mainly steppe vegetation, but they are also quite suitable for agriculture. Their characteristic feature is the calcification below topsoil. A horizon is in brown, dark brown or yellowish-brown in color. The organic matter is integrated into mineral soil. B horizon is in light brown or yellowish-brown color. The texture is clay-loam and pH is 7.5-8.5. An intense calcification occurs in lower parts to an extent that $CaCO_3$ content can exceed 40-80%. The color of C horizon is variable and the $CaCO_3$ content can exceed 50%.
- Brown forest soils are common under forests and are usually seen in Central Anatolia above 1200m. Climate, bed rock and slope are the main determinants. The horizons developed under forests can be covered with a considerable depth of litter. A horizon is of brown or dark-brown color

due to high organic content. The $CaCO_3$ content can be washed away completely. pH ranges between 5.5-7.8. B horizon is in light brown or yellowish-brown color. The texture can be clay, clay-loam and in coarse granules. Accumulation of lime or iron is common. C horizon can be quite deep and calcification can be seen in this horizon.

- Of the less widespread soil type, non-calcic brown (forest) soils occur under steppe forests or forests developed in arid environments especially in north and east of Inner Anatolia, at 1000-2000m elevation on volcanic bedrock. Basaltic soils develop over basalt bed rock and have high cation exchange capacity. Reddish-brown soils are widespread in south-east Anatolia and the high temperature results in red color and low organic matter.

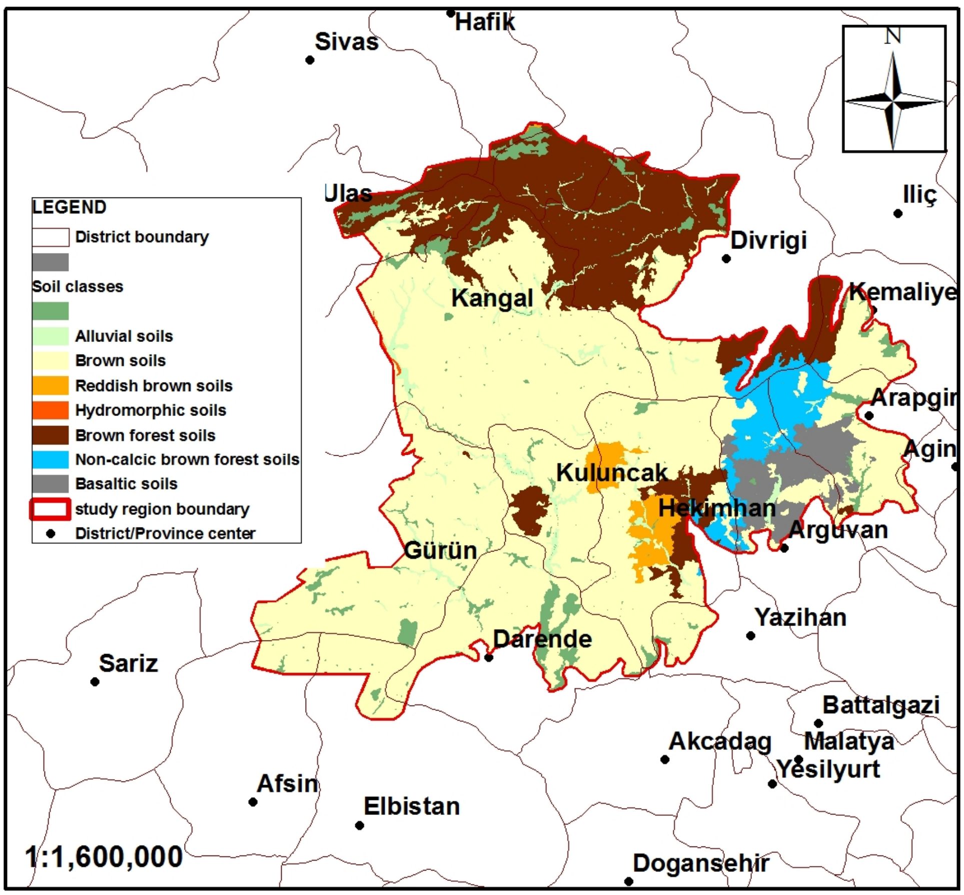


Figure 3.7 Soil map of the study area (Source: Ministry of Agriculture and Rural Affairs 2007 from DKM archives)

3.1.5. Geology

The study area is covered by rocks of various lithology (Figure 2.8). In the northernmost part, Tecer Mt. is made up of mostly the undifferentiated ophiolites accepted to be an igneous rock assemblage. South of it, the valley of Karaoğlan stream is dominated by continental clastic rocks. The large area circling the Kangal plain is dominated by sedimentary rocks of lacustrine limestone, marl and shale in the North, and undifferentiated continental clastic rocks in the west. The western part of the region is dominated by sedimentary and metamorphic rocks. In the eastern part, west of Divriği is covered with igneous rocks, mainly peridotide, granotoids and basalt. Yamadağ and the immediate south are covered by huge areas of igneous rocks of basalt, pyroclastic rocks and andesite. The south, southeastern and southwestern parts are mainly dominated by clastic and carbonate rocks and neritic limestone. Schists and undifferentiated continental clastic rocks cover comparatively smaller areas. Hezanlı Mt. is covered mostly with neritic limestone which is apparent as bare rock bodies in the landscape.

Although not shown on the geology map, the northern part of the region has patchy distribution of gypsum bedrock, on which very shallow gypsiferous soils develop. Akpulat and Çelik (2005) indicate that gypsum ($CaSO_4.2H_20$) of Miocene age is very widespread in Sivas.

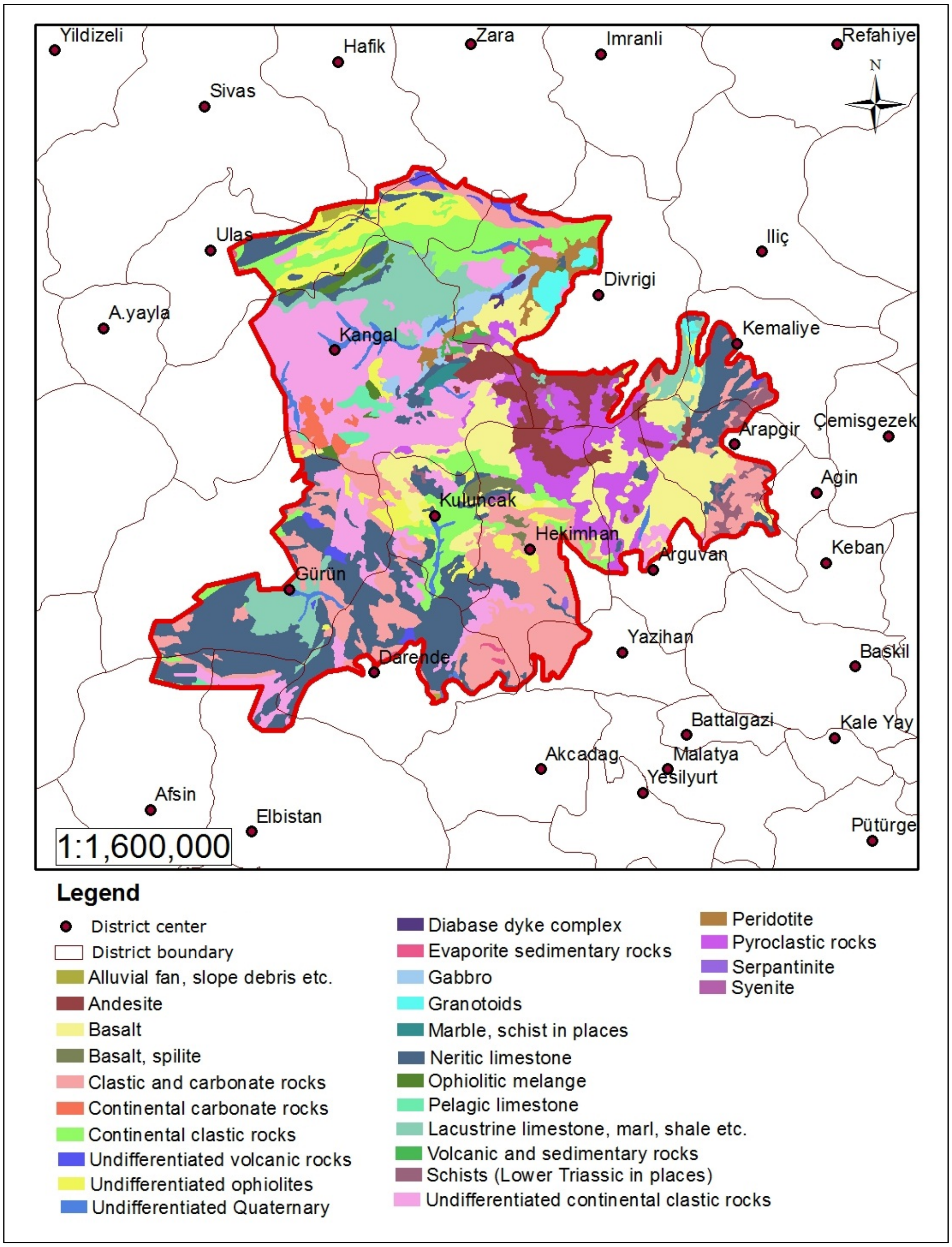


Figure 3.8 Lithology map of the study area (Source: METU Department of Geological Engineering)

3.1.6. Biodiversity

There is a good amount of literature on the flora and fauna of the study area. New studies keep revealing species new to science such as *Gypsophila turcicum* (Hamzaoğlu, in prep). A major regional biodiversity study, Anatolian Diagonal Biodiversity Project, covered the study area with field surveys to fill data gaps in the literature and to reveal conservation priorities (Ambarlı *et al.* 2009). Based on the project and existing literature, there are 33 rare plant species with CR, EN or DD threat category (Ekim *et al.* 2000), 146 butterfly species, 145 breeding bird species, 29 small mammal species and 31 herptile species found in the study area. Brown bear (*Ursus arctos*), lynx (*Lynx lynx*) and wild goat (*Capra aegagrus*) are among the key large mammals. It has been claimed by the locals that leopard (*Panthera pardus*) and European otter (*Lutra lutra*) were once living in the region.

According to that study, six of the 55 Priority Conservation Grids selected are found in the study area (Figure 2.9):

- "Gürlevik Dağı Güneyi" comprises of two 10 km x 10 km UTM grids covering south of Gürlevik Mountain. It is important in terms of a globally threatened species, the Saker Falcon *Falco cherrug*, and the montane Scots Pine forests representing the subecoregion.
- "Tatlısu Havzası" priority cluster located in the Tatlısu watershed is one of the richest in terms of plant diversity. The endemic species *Galium baytopianum* and *Onobrychis albiflora* are only known from this area. It also houses a rare butterfly *Polyommatus mithridates* living in dry places. Furthermore it is rich in wildlife with all key mammals of the region.
- "Karaseki Düzü" priority site is important for two rare endemic plant species and for rich montane steppes. The plant species *Onobrychis occulta* and *Scrophularia gypsicola* are only seen here in the region, with former on steppes on limestone bedrock and the latter on steppes on gypsum bedrock.
- "Tohma Vadisi" priority site is located at the upper Tohma watershed. It is important due to one regionally endemic plant species *Pimpinella flabellifolia* and and two bird species with restricted ranges on the

Anatolian Diagonal: Sardinian warbler *Sylvia melanocephala* and Trumpeter Finch *Bucanetes githagineus.*

- "Hezanlı Mountain" is one of the Prime Butterfly Areas of Turkey with 11 conservation priority butterfly species: *Papilio alexanor, Glaucopsyche astraea, Pseudophilotes bavius, Ployommatus actis, P.menalcas, P.mithridates, P.hoppferi, P.poseidon, P.wagneri and Hyponephele naricinoides (*Karaçetin *et al.* 2011*)*. The nonfragmented steppes are rich especially for anomalous blue butterflies.
- "Hekimhan" priority cluster is made up of 3 grids. It houses 2 endemic and restricted-range plant species (*Echinophora lamondiana* and *Acanthophyllum oppositiflorum*), 4 conservation-priority butterflies (*Cigaritis maxima, Eogenes alcides alcides, Hipparchia parisatis, Thaleropis ionia*), a reptile (*Mabuya vittata*), a recently reintroduced population of Red Deer (*Cervus elaphus*), and low-mountain juniper shrublands. The butterflies typical of South Anatolia, such as *Cigaritis maxima,* can be seen here. The site is also important as an upland-lowland gradient between South and Central Anatolia.

A nationwide study by Eken *et al.* (2007) revealed that three of the 305 Key Biodiversity Areas (KBA) of Turkey are found in the region (see Figure 2.9):

- Tecer Mountains KBA lies to the north of the region. It is important in terms of 40 regionally threatened plant species and 6 globally endangered bird species.
- Divriği Tepeleri (Divriği Hills) KBA is important in terms of 9 regionally threatened plant species and an endemic butterfly species *Glaucopsyche alexis* found in the region.
- Tohma Vadisi (Tohma Valley) KBA is important for many regionally-threatened species. Numerous rare plants, 6 bird species, 8 butterfly species and a dragonfly species together with an endemic small mammal *Dryomys laniger* live in here.
- In addition, Hafik-Zara Tepeleri (Hafik-Zara Hills) KBA lies 40 km. north of the region indicating 21 regionally threatened and/or endemic plant species on gypsum hills and many bird species breeding in small lake systems among the hills.

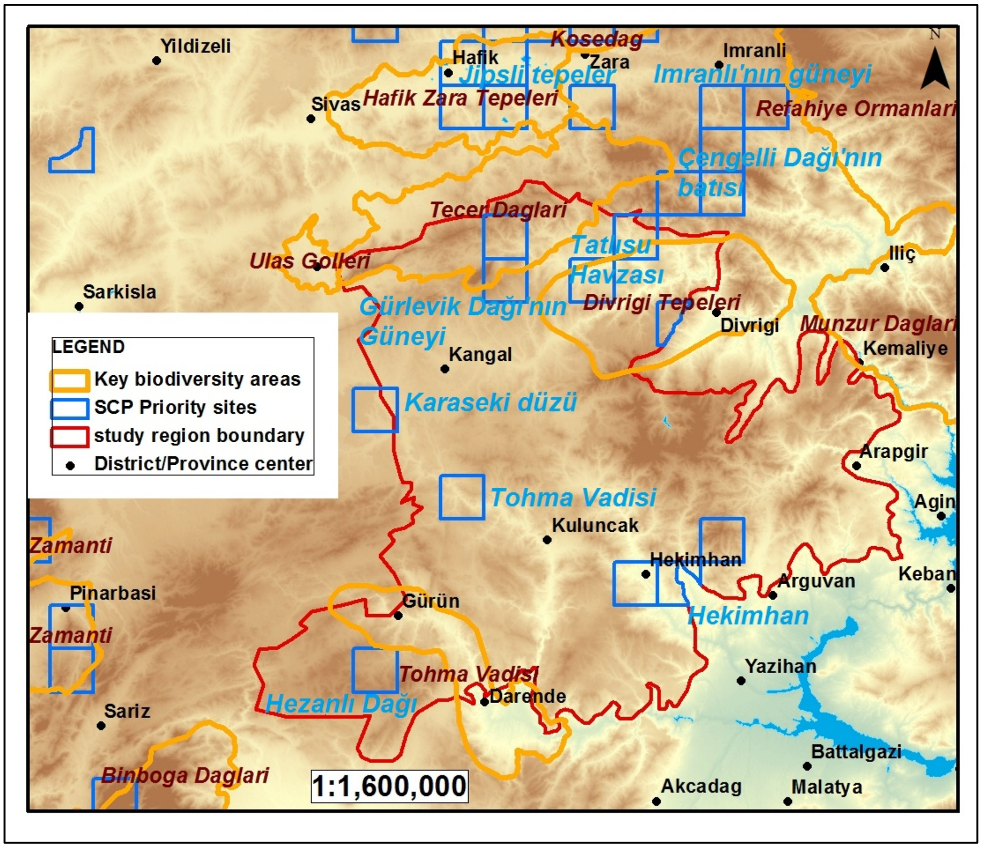


Figure 3.9 Conservation priority sites and key biodiversity areas of the study area.

A floristic study on gypsaceous soils in and around Hafik revealed 371 vascular plant species belonging to 53 families 25.3% (94) of which are endemic to Turkey (Hamzaoğlu and Aydoğdu 1995). Another study on the flora of Tohma Vadisi revealed that the valley has 680 plant taxa, of which 128 (18,82%) are endemic (Karakuş 2009). The study completed by Bani (2009) 20-70 km. southwest of the region on Tahtalı Mountains (Adana-Kayseri) revealed that the Tahtalı Mountains are quite rich in terms of plant species. He found that 243 (21.3%) of 1195 taxa of the region are endemic and 15 species are threatened.

3.1.7. Land Use

To understand the anthropogenic effects on natural resources, it is useful to know the human population size, livestock and main economic activities in the study area. According to the data obtained from Turkish Statistical Institute web sites (TUİK 2011), total population living in districts of study area is 160,626 people ranging between 8289 (Arguvan) and 32192 (Darende). The rural population comprises between 12.4% (Gürün) and 87.7% (Kuluncak) of the total population. There is an overall decline in rural population in all districts. Since 1950s, immigration to big settlements has been taking place in the study area.

According to database of Ministry of Internal Affairs (ILEMOD) records by 2007 for the region reveal that most of the villages have less than 100 people. The population is aggregated in districts (see Figure 2.10).

The main source of income in the study area is through agricultural activities. In 2010, 66.5% of people were employed in the agriculture sector, 28.1% in the services sector, and 5.4% for the industry (TUİK 2011). The number of people employed in agriculture in Sivas decreased from 74% to 66.5% in 1990 due to immigration (Sivas İl Çevre ve Orman Müdürlüğü 2004). Fallow lands covering 2.191.150daa in Sivas corresponding 16.99% of total arable lands (Sivas İl Çevre ve Orman Müdürlüğü 2004). The proportion of people working in agriculture and services sectors are around 40% in Malatya with the rest being in the industry sector (Malatya İl Çevre ve Orman Müdürlüğü 2009).

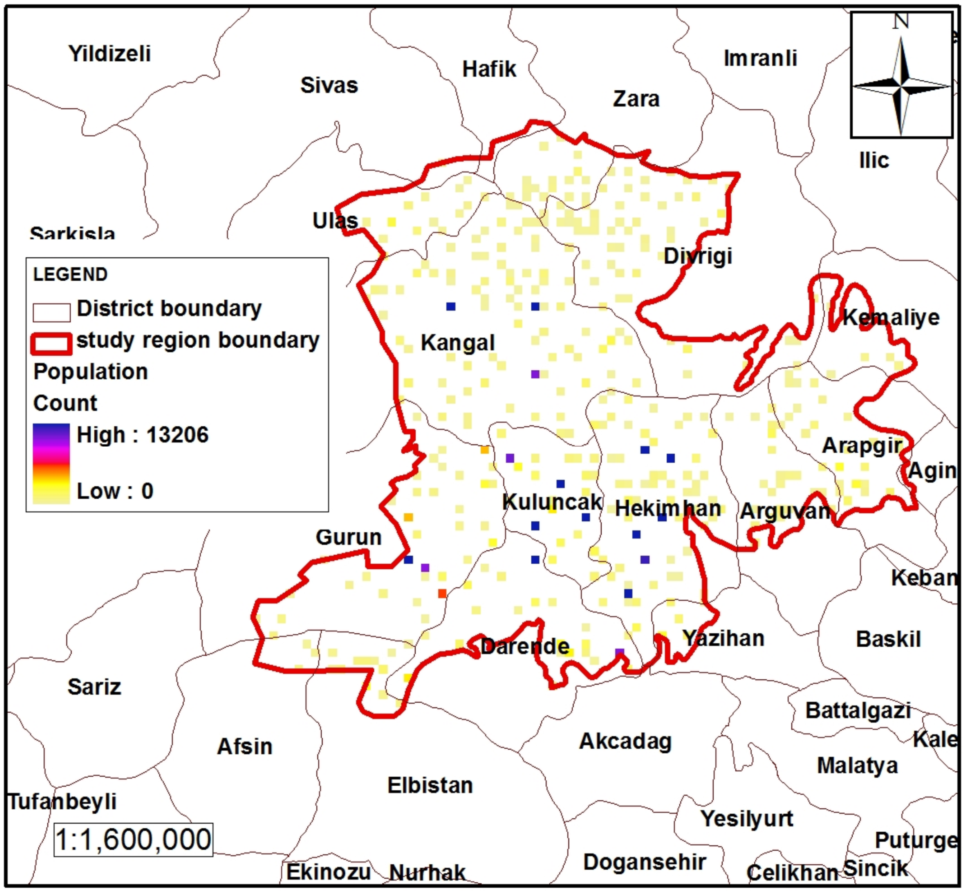


Figure 3.10 Population count of each settlement in the study area

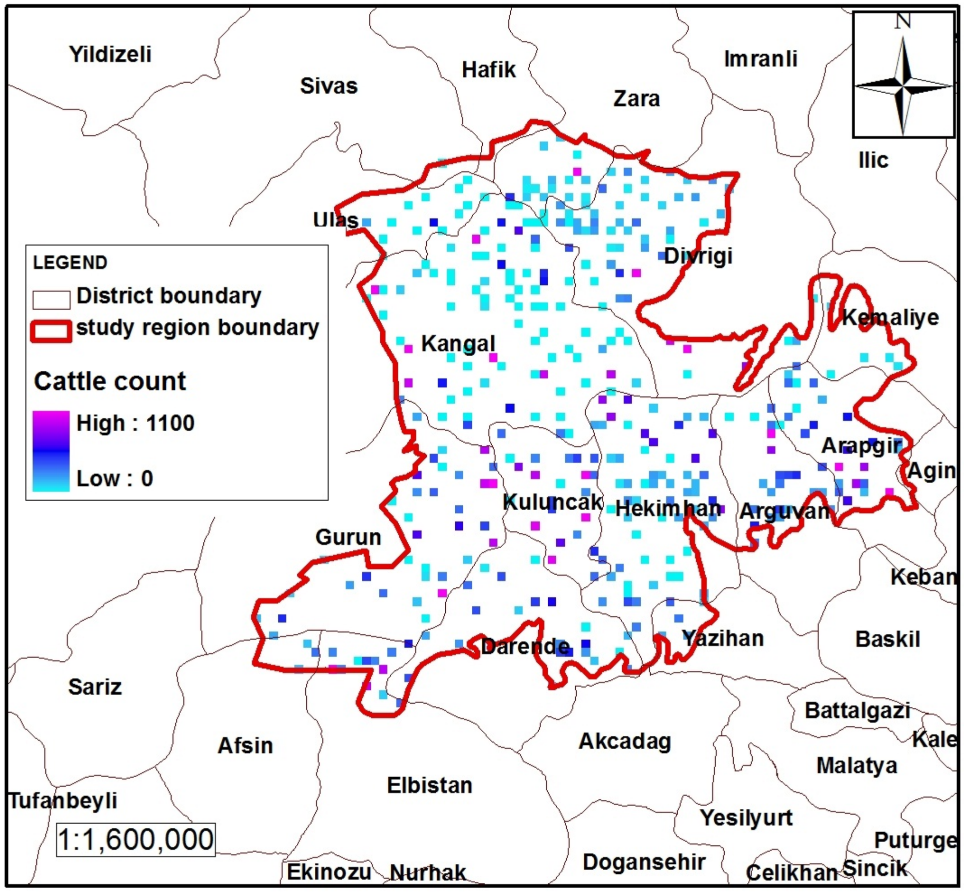


Figure 3.11 Cattle stock in each settlement in study area (Data source: İLEMOD 2007)

Sivas is among the provinces of Turkey with largest total area of rangelands ("mera"): 1.207.916 ha. Livestock numbers are in decline in parallel with the human population. For example, sheep and goat numbers decreased from 1,508,000 to around 400,000 during 1985 and 2008, whereas they went down from 400,000 to 75,000 for cattle in the same period (Sivas İl Çevre ve Orman Müdürlüğü 2008). The livestock numbers in each settlement are given in Figures 2.11 and 2.12. The main problem of rangelands is erosion i.e. very shallow soils on steep slopes experience water and wind erosion due to overgrazing (Sivas İl Çevre ve Orman Müdürlüğü 2008). Total arable land of Malatya is 425,450 ha whereas total rangeland is 580,423 ha (47%). The number of sheep and goats is

233,552 and of the cattle 6298 in 2009 (Malatya İl Çevre ve Orman Müdürlüğü 2009).

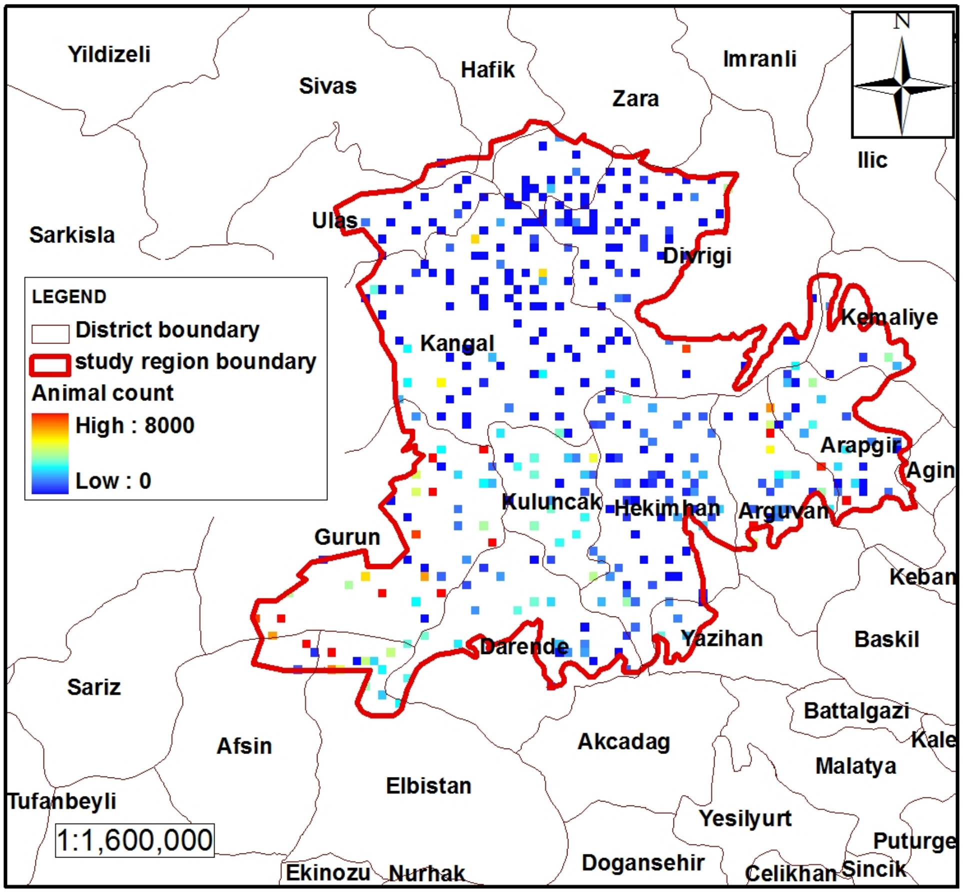


Figure 3.12 Sheep and goat stock in each settlement of the study area (Data source: İLEMOD 2007)

3.2. Data Collection

The main approach adopted for this study is to collect data on selected biodiversity elements, abiotic factors and land use at several survey points. Fieldwork aimed to sample steppe sites with different environmental conditions, yet large enough to represent the general pattern in terms of ecology and biodiversity.

The main limitation during the data collection phase of the study was the lack of reliable maps and data on environmental factors and human use, especially the history, as well as limited human resource and logistics for the fieldwork. Therefore, fieldwork was designed to collect maximum data with minimum resources.

3.2.1. Determination of Survey Sites

3.1.1.6 Environmental Stratification

To determine where to survey, a gradsect approach has been adopted. Gradsect sampling is similar to stratified sampling in which a heterogeneous study area is divided into more homogenous subareas and the survey sites are chosen randomly in varying numbers and densities depending on the characteristics of each subarea (Sutherland 1996). The difference is that the surveys are not distributed randomly in each stratum but concentrated within a few geographic transects designed across the main landscape gradients to increase cost-effectiveness (Hirzel and Guisan 2002).

This approach, first described by Gillison and Brewer (1985), is based on the distribution of patterns along environmental gradients which usually the main determinant of distribution of plants and animals. The gradsect sampling design (Gillison and Brewer 1985, Austin and Heyligers 1989) is intended to provide a description of the full range of biotic variability (e.g., vegetation) in a region by sampling along the full range of environmental variability. Transects that contain the strongest environmental gradients in a region are selected in order to optimize the amount of information gained in proportion to the time and effort spent during the vegetation survey (Austin and Heyligers 1989). In addition, sampling sites are deliberately located to minimize travel time. The method has been shown statistically to capture more information than standard designs (Gillison and Brewer 1985) and to be more cost-effective than full random stratified design (Wessels *et al.* 1998).

To identify the gradsects for this study, first the maps of each important variable is classified into important attribute classes. Then the maps with different classes were intersected. The method is limited with the available data on the spatial distribution of environmental variables. Literature survey has revealed that grassland biodiversity is affected mainly at the macro level by a few environmental factors i.e. soil, bedrock, climate and elevation as indicated in the first chapter. Human use was another important factor shaping the grasslands but there is not a reliable map showing effect of human use on the study area**.**

The variables used were soil type, soil depth, bed rock and climate. Soil map was grouped into 5 soil types (see Table 2.2) dominating the land as seen in Figure 2.7 and three soil depths. The geology was grouped into three classes as igneous, sedimentary and metamorphic (see Table 2.2).

Thornthwaite's pioneering study (1931) for the classification of world's climate based on a precipitation effectiveness index is used for the classification of the climate of the study area. It is a sort of climatic aridity index reflecting the lack of precipitation (Heim Jr., 2002). Thornthwaite's formula given below (Figure 2.13) is applied to the relevant Bioclim layers (Worldclim 2011). The resultant aridity map had two major divisions of Thornthwaite (1931) plus further subdivisions for the regional work, making 6 aridity classes in total (Figure 2.14).

$$PE\ Index = \sum_{1}^{n=12} 115*(P/(T-10))^{10/9}$$

where, P = monthly precipitation in inches;

T = temperature in °F; and

n = months = 12.

Figure 3.13 Thornthwaite precipitation effectiveness index

Since strong correlation was observed between the Thornthwaite index and the elevation, it was decided not to include elevation in gradsect identification but to represent it through the aridity index. The variables, classes and data type used in the stratification can be seen in Table 2.2.

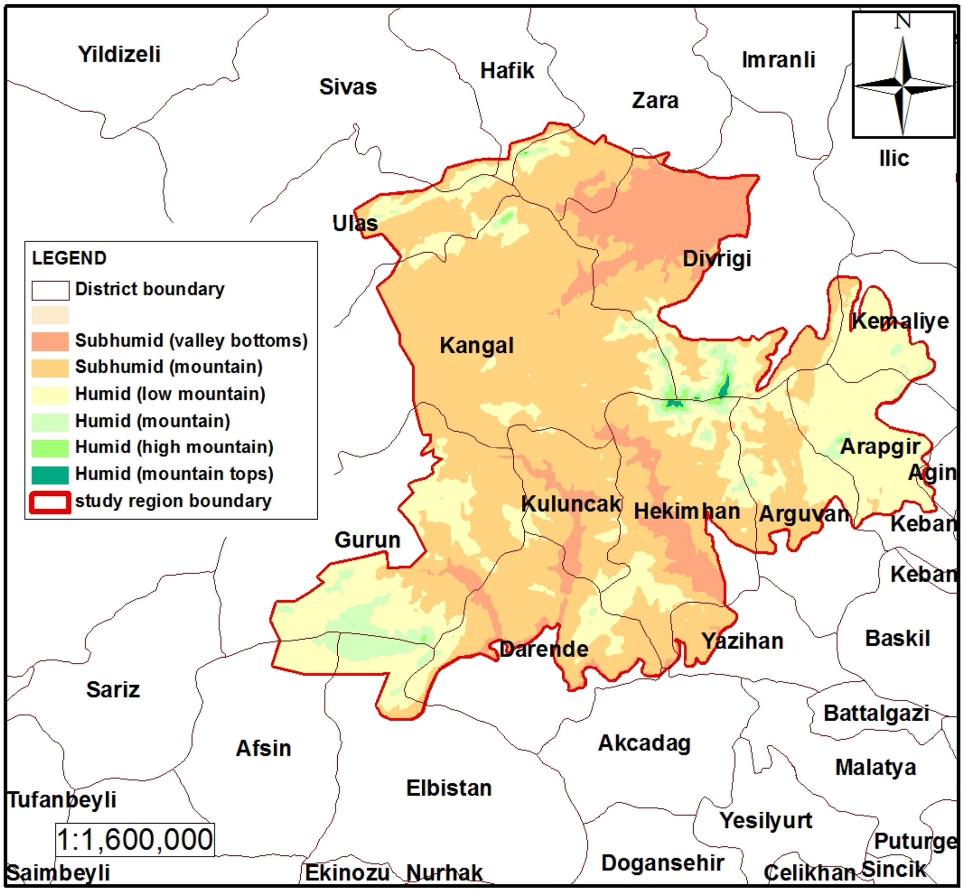


Figure 3.14 Climatic aridity of the study area based on Thornthwaite's precipitation effectiveness index (Thornthwaite 1931).

The combinations of different types of four environmental factors were mapped by overlapping the maps. The processing and mapping layers were done with TNT Mips software (MicroImages, Inc. 2012). The resultant map can be seen in Figure 2.15. Each unit with a different combination of environmental variables was named as an environmental section. Hundreds of polygons belonging to 270 different environmental sections were identified in the study area. A further filtering was made based on the total area of each environmental section and steppe coverage on it since some environmental sections were either too small to be representative of the study area or covered totally with arable lands. Therefore, sections covered with arable land and sections smaller than 5000 ha were not targeted for the fieldwork. Out of 270 sections, 59 were found eligible as targets of the fieldwork.

Table 3.2 The variables, classes and data type used in the environmental stratification

Name	Classes	Data type
Soil type	Alluvial soils	Qualitative from soil map
	Brown, reddish brown and chestnut-color soils	
	Brown forest soils	
	Non-calcic brown and non-calcic brown forest soils	
	Basaltic soils	
Soil Depth	Deep	Qualitative from soil map
	Shallow	
	Lithosolic	
Geology	Volcanic	Qualitative from geology map
	Sedimentary	
	Metamorphic	
Thornthwaite dryness index	Sub-humid (valley bottoms)	Calculated, Range: <= 50
	Sub-humid (mountain)	Calculated, Range: >50 and <=64
	Humid (low mountain)	Calculated, Range: >65 and <=80
	Humid (mountain)	Calculated, Range: >81 and <=95
	Humid (high mountain)	Calculated, Range: >96 and <=110
	Humid (mountain tops)	Calculated, Range: >111

3.1.1.7 Identification of Gradsects and Survey Sites

The gradients were identified manually by examination of resultant map in detail. The areas where polygons of different sections are aggregated, in other words where environmental conditions change a great extent within a short distance, were located. South of Zara, around Divriği and east of Darende-Zara direction possessed many sections and it was decided to focus on those areas. In the aggregation areas, survey polygons were selected to represent each target ecosection. Survey points were selected in the middle of homogenous patches inspected manually from Landsat images and Google Earth (Google Inc. 2011). 42 points were identified as survey sites with 73 alternatives for them in case fieldwork at selected points was impossible due to logistic or weather problems.

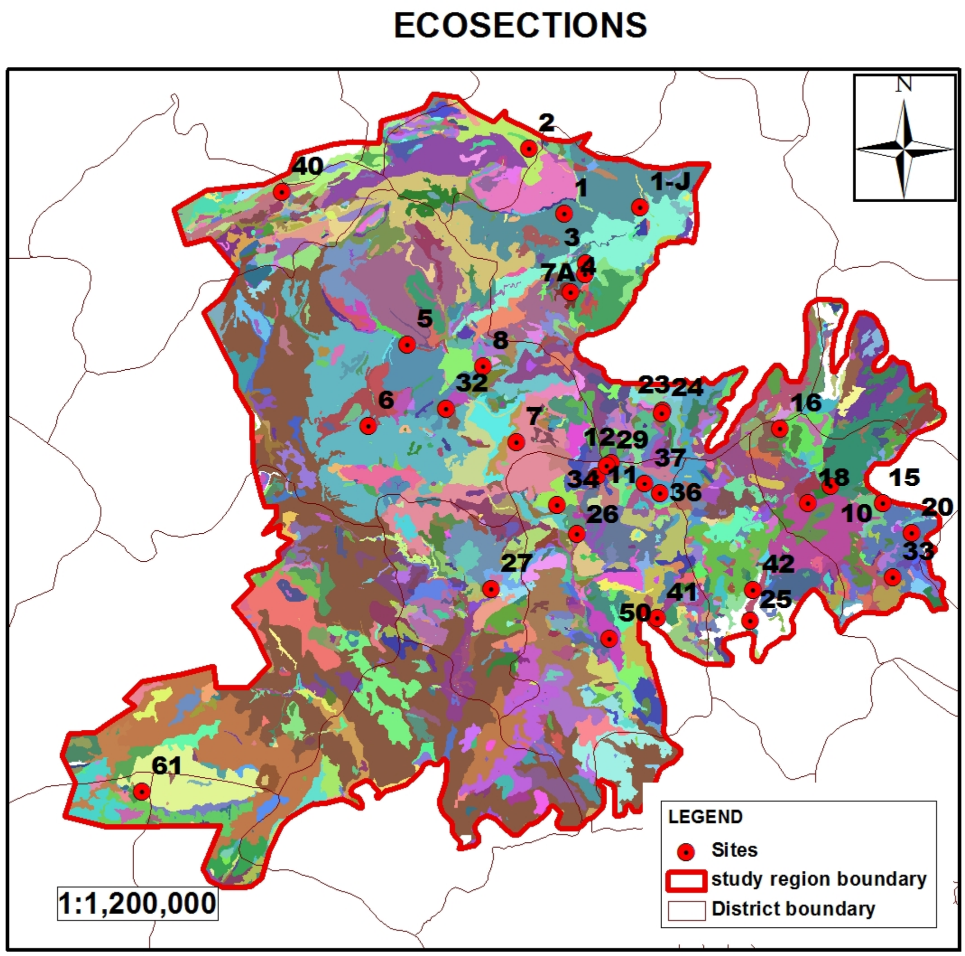


Figure 3.15 Map showing survey points on environmental sections. (The legend is not given since there are more than 500 different ecosections. Environmental properties of each site are given in Table 3.1.

The survey sites were further refined in the field based on local conditions not visible in satellite images but apparent in the field, such as avoidance of small arable land. Two replicates apart at least 100 meters from each other were sampled at each site.

3.2.2. Methods for Biodiversity Data Collection

3.1.1.8 Bird Surveys

Hutto and colleagues (1986) suggested fixed-radius point count method as a good tool to get a relative index of abundance of birds and also understand differences in community composition among sites. Sutherland and colleagues (2004) find point counts (point transects) better suited for bird-habitat studies than line transects and they suggest 1 minute settling time, 5- or 10- minutes count, 2 or 3 distance bands to record (like 0-30, 30-100 and over 100m) and finally 2-4 visit per plot. Bonthoux and Balent (2011) found that five minutes is enough for researching bird-habitat relationships and the structure of communities at landscape level in France (Bonthoux and Balent 2011)

The bird surveys were designed based on suggestions in the literature. Surveys were carried out by experienced birdwatchers in the breeding season (June and beginning of July) mostly in 2009 and additional few days in 2010. Surveys took place when birds are most active i.e. either early in the morning or in the evening under good weather conditions suitable for bird watching.

50-m fixed radius point counts of 8 minutes were made for each replicate. Two experienced birdwatchers did the counts. The observers walked to their respective replicate points and started to count after 3-5 minutes for birds to settle. The birds were identified visually or from calls or song. The observer identified and recorded the birds observed as either within 50m or beyond 50 m. The records were divided into those in the first 5 and the following 3 minutes. Juveniles and flyovers were recorded separately. Observers also took notes whether individual birds are associated with the habitat sampled, whether there is evidence of breeding etc. Additional records were also noted after the survey if a new species was detected for the site.

During the analyses of bird data some species are eliminated from the dataset to focus only on the species related to survey sites. The species and the reasons of their elimination are listed below:

- Species of reedbeds heard from distance: *Acrocephalus arundinaceus* Great Reed Warbler and *Cettia cetti* Cetti's Warbler
- Raptors that cover long distances for food: *Hieraaetus pennatus* Booted Eagle and *Neophron percnopterus* Egyptian Vulture
- Species that spend most of their time in flight (aerial): *Apus apus* Common Swift and *Hirundo rupestris* Crag Martin
- Species difficult to detect due to nocturnal habit or good camouflage: *Athena noctua* (also not related with grasslands)

3.1.1.9 Butterfly Surveys

Butterflies are popular taxa both as surrogates (Scott *et al.* 1993) in conservation prioritization and as indicator species (Blair 1999, van Swaay *et al.* 2006). Relatively settled taxonomy, high delectability and identifiability in the field, occurrence in many ecosystems as abundant and diverse taxa and finally sensitivity to environmental or human-induced changes (Ricketts *et al.* 2002) make them a good indicator group. Since most are host specific, they are assumed to be good indicators of plants or other invertebrate taxa like grasshoppers (Zografou *et al.* 2009).

Butterfly fieldwork took place from end of May to mid of July in 2010. Each site was visited at peak flight activity period depending on the elevation i.e. it is the end of May at lower land in the southeast, but the mid of July in mountain tops.

The common survey method especially used for monitoring schemes for butterflies is the Pollard-Yates method (Pollard and Yates 1993). This method is based on the identification and counting of butterflies along a long route (e.g. 3 km) divided into sections in which the observer records any butterflies flying 5 m on either side of the transect. Transect counts are suggested to be repeated weekly between April and September since different species occur at different time periods in a season. The minimum conditions to be met in terms of weather are a temperature higher than 17°C, and wind less than 5 on Beaufort Scale.

In this study, a slightly modified form of the Pollard-Yates method was used. First, the observer did a general count in the 100m diameter survey replicates. The aim of this count was to get familiar with the species flying at the site. The observer spent as much time as she/he needed until she/he saw no more new species for the site. Then the observer started a transect count with fixed walking speed along the edges and one diameter of the survey replicate site. She/he identified and counted all the butterflies in the transect with binoculars and a camera. The observer did not catch the butterflies or sample them, which needed special permissions. Therefore, species that needed closer inspection, especially the *Agrodietus* group, were recorded as "unidentified" and consequently may be underrepresented in the data set. But luckily there weren't many examples of such cases. Information on behavior like feeding, egg laying, territory defending and habitat use of the butterflies were noted as much as possible.

Each replicate was surveyed once by an experienced butterfly watcher. This is the main deviation from Pollard-Yates Walk method. Because of non-availability of experienced butterfly watchers for longer periods of fieldwork, each site has been surveyed only once which means that the butterfly species flying earlier or later are missed. Therefore the results do not reflect the butterfly diversity of the region in total but instead provide a snapshot of the peak flight period.

In addition, weather conditions and butterfly-attracting features such as a nearby microsite for mud puddling, wind-refugee or a wet place with more flowers were noted as a variable that may affect the local butterfly fauna.

3.1.1.10 Plant Community Surveys

Plant species are used as surrogates for identifying global hotspots (Myers *et al.* 2000). They are commonly used as surrogates of biodiversity and main determinants of other species groups since they are the primary producers that the rest of the community relies on.

The traits of a plant community most often recorded are composition, density, abundance and cover of the plant species. Although many studies rely on data of all plant species present at a site, some studies are focused only on some habitat–specific plants such as open-land plants, endemic or threatened vascular plants (Cremene *et al.* 2005).

At the peak season of vegetation, the surveys were carried out during four periods depending on the altitude of the sites. 10 random quadrats of 2m x 2m size were set within 100m diameter of each replicate point. Since the regional flora is quite rich with more than 1000 plant species and since the aim of this study is not purely floristic, data was gathered only for plant species with more than 10% cover.

Species cover was estimated visually in each quadrat as the percentage of surface area covered by each plant species (with a maximum of 100% total cover). Specimens collected in the field were identified in the Gazi Herbarium with valuable helps of Prof. Dr. Mecit VURAL and Prof.Dr. Zeki AYTAÇ based on the Flora of Turkey and recent literature on taxonomy of plants of Turkey (Hamzaoğlu, in prep; Doğan and Akaydın 2007, Yıldız *et al.* 2004).

3.2.3. Environmental Data Collection

Several habitat features were visually determined and recorded in each survey. In addition, some factors related with landscape are calculated with the use of GIS. Furthermore data on soil parameters are obtained by taking soil samples and analysis by the soil lab. They are listed below:

3.1.1.11 Topographic Features

- **Latitude and longitude:** UTM coordinates are used as variables reflecting north and east position of the sites.
- **Elevation:** Elevation from sea level is determined with Global Positioning System (GPS) device and recorded in meters.
- **Aspect:** The aspect info is obtained from digital elevation map for each replicate and recorded as 0-360°. Then it is converted into northness and eastness values to overcome the circularity of the compass values. The conversions are done by equations below developed by Zar (1999) found in Wallace and Gas (2008):

$$\text{Northness} = \cos(\text{Aspect} \times \Pi/180)$$

$$\text{Eastness} = \sin(\text{Aspect} \times \Pi/180)$$

- **Slope:** It is determined from the photos of the sites with the use of a scale. It is measured in degrees.

3.1.1.12 Soil Properties

Data on soil properties were obtained by physical and chemical analyses of soil samples. Different sampling methods are used to sample soils in order to seek answers for different questions. For example Li and colleagues (2005) did sampled soils in cores of 5 cm diameter and 20cm depth for mineral analysis. Steinbeiss and colleagues (2008) studied the relationship between plant biodiversity and soil carbon storage through 5 replications in each site and a size of 4.8 cm diameter and 30 cm depth with split tube sampler. Schnoor and Olsson (2010) studied the effect of different agronomic activities on steppe plant biodiversity. They used an auger to get six 10-cm deep soil samples at each site of 5 x 60 m size. The replicates were mixed to form a composite as representative sample of each site. Nautiyal and colleagues (2010) sampled soil to observe changes in relation to the conversion of steppes to arable lands for 14 years. They set 4 homogenous plots of 10m X 10m sites at each site. They sampled randomly 15cm deep at 3 locations of the plots. Those samples were mixed in groups of four to get 3 replicates of soil samples for each site.

As seen in above examples, soil sampling in grasslands varied in terms of equipment, number of replicates, and sampling depth but the basic approach is the same: large (2x2m to 10x10m) and homogenous plots are chosen at the survey site whose quantity changes with the size of the survey site. Random points of 5-10 are chosen inside such plots. Soil samples are taken as replicates usually with the auger up to 30 cm. then the replicates of each plot or site are mixed to obtain a composite of desired volume or weight.

The method advised by Soil, Nutrient and Water Resources Central Research Institute (the lab that made the analyses) is based on sampling arable lands to find out amount and type of fertilizer to be used. After meetings with soil experts of the institute and trials in the field, it was decided to follow a modified version of the suggested method:

- 3-5 random points were chosen in 50m radius of each replicate.
- All the plant material and debris on the soil surface were removed.
- With the use of shovel, a V-shaped hole was digged to a depth of 30-40 cm.
- Then a 5-cm thick slice of soil sample was cut to 30cm from one edge of the V.
- The sampling was repeated and samples were mixed until 4kg of moist soil composite was obtained.
- If any the plant material i.e. roots, decaying leaves are seen in the soil sample, it is removed.

Not all the sites were sampled since the cost of the tests were quite high. Instead, one replicate from each site was sampled and analyzed. The sampled replicates are given in Table 2.3 below.

Table 3.3 List of the replicates sampled for soil properties.

Replicates that sampled for soil							
1-CB	1J-SO	2-CS	3-SE	4-SO	5-CB	6-CB	6-SO
7A-SO	8-CB	8-SO	10-CB	11-SO	12-SO	15-CB	16-SO
18-SO	20-CB	23-SO	24-CB	25-SO	27-CB	29-SO	32-CB
33-CB	40-SO	41-CB	42-CB	50-CB	61-HW		

Standard physical (soil texture, field capacity, wilting point and bulk density) and standard productivity (saturation %, salt content %, pH, pH of saturated soil, $CaCO_3$ content %, Phosphorus in the form of P_2O_5 (kg/da), Potassium in the form of K_2O (kg/da), % organic matter, % organic carbon, % Calcium (Ca) and Magnesium (ppm) and electrical conductivity (EC) (dS/m)) tests were applied to the samples.

In addition, total Nitrogen (N) and Cation Exchange Capacity tests were conducted to 14 samples which came out to be quite different than the rest of the sites. Those are 1J-SO, 25-SO, 4-SO, 27-CB, 5-CB, 29-SO, 6-SO, 33-CB, 6-CB, 40-SO, 7A-SO, 50-CB, 18-SO and 61-HW.

Further details about how productivity tests are conducted can be found in the Institute's webpage in Turkish:
http://www.tgae.gov.tr/www/tr/Icerik.ASP?ID=755

Soil depth information was obtained from the soil map of Ministry of Agriculture and Rural Affairs and used as a categorical variable.

In addition, the **bedrock** information obtained from METU Department of Geological Engineering geology maps is included in the plant data analyses.

3.1.1.13 Vegetation Structure

- **Coverage:** Percent of the ground covered by vegetation. Average minimum and maximum were recorded in the field.
- **Vegetation height:** Height of the herbaceous vegetation were determined visually as average minimum and average maximum in cm. Usually creeping forbs determine the mininimum and infloresences of grasses determine the maximum values.
- **Shrub/tree density:** The number of any shrubs within a 50 m radius was counted. Shrub/tree is defined as any woody plant with one to several major stems between 50 cm-4 m. Junipers, oaks, *Rhamnus, Cotoneaster, Crataegus, Berberis* were common shrubs of the study area.

3.1.1.14 Site Properties

- **Heterogeneity:** Heterogeneous sites in terms of topography, water table and land use result in different vegetation types. Some examples from the survey sites are presence of small arable lands in flat land and natural steppe on the slopes; dominance of Cyperaceae at sites with high water table, and appearance of many *Onobrychis fallax* individuals at sites that were previously planted with that same species. Since it is important to separate the effects of heterogeneity on biodiversity, heterogeneity was added as a binary input in the analyses.
- **Presence of big rocks:** Rocks provide nesting sites for some of the birds. They are also sites providing refugia for plants from herbivory. Furthermore, some butterflies prefer rocky environments. Therefore, presence of big rocks or rocky outcrops was added as another environmental variable for the analysis and recorded as a binary variable.
- **Butterfly key features:** Presence of wind shelter, mud-puddling sites or refugia enables high butterfly richness and abundance at a site. They are called "key features". Those features are noted in the field and added to inputs as presence/absence data.

3.1.1.15 Climatic Variables

- **Humidity:** Thornthwaite precipitation effectiveness index was calculated for each replicate of survey sites and used as humidity measure. The method for calculation was given in Figure 2.13.

- **Possible climatic limiting factors as BIOCLIM layers:** Four more climatic variables were used to understand the effect of aridity on vegetation: Temperature annual range (BIO7), precipitation of the driest quarter (BIO17), mean temperature of the warmest quarter (BIO10), mean temperature of the coldest quarter (BIO11). Those layers were downloaded from the Worldclim website and processed with ArcGIS software to obtain values for each replicate.
- **Productivity:** NDVI values can represent the productivity of an area (Turner *et al.* 2005). NDVI values were obtained from 23 June 2009 dated no-cloud Landsat images and processed with TNTMips software (MicroImages, Inc. 2012) and with ArcMap 9.3.1 (ESRI Inc. 1999-2009) NDVI toolbox to obtain NDVI value for each replicate.

3.1.1.16 Landscape Features

- **Landscape diversity:** It is calculated as follows:
  - First nested set of circles were determined around survey point in each replicate: 500m, 2 km, 5km.
  - The amount of different habitat types in nested circles were calculated as % grassland, agriculture, forest, urban, water resources from CORINE Land Cover map (European Environment Agency 2006) in 100m resolution.
  - Shannon-Wiener diversity index was calculated from above values as:

$$HS = - \sum^{i}_{1} p_i * \ln p_i$$

Here p_i is the proportion of each different land use type (Krebs 1989).

- **Distance to certain land cover types:** Distance of nearest arable land, grassland and woodland is calculated by using ArcGIS tools with data from Corine Land Cover map. In addition, distance to settlement and trees are obtained from Google Earth (Google Inc. 2011).

3.2.4. Land Use Data Collection

Studies focusing on the history of land use benefit from old aerial photographs, cadastral maps, land use maps of 50-100 years ago (Lindborg & Eriksson 2004). For example, Mapedza and colleagues (2003) used aerial photography, governmental resources, participatory mapping and interviews with local community and forest guards to understand changes in land use and their causes. It is common to use semi-structured interviews to understand current or past land use activities such as the study of Mottet and colleagues (2006), especially in social sciences.

Since the available governmental sources were not of high resolution and rarely went back to more than 100 years ago, it was decided to make interviews to collect land use data at point resolution. Interviews were conducted in the villages closest to survey sites with a knowledgeable person, usually an elder one or the muhtar. If a shepherd knowledgeable about historical land use was met, he was interviewed, too. Questions about the history of the site (forest, arable land or steppe history), the type of use (type of farming, crop type, livestock race), the degree of use (number of years, number of livestock), and the presence of any other economic value (collecting plants etc.) were asked to the villagers about survey sites. Data are used as one categorical variable of agricultural production (no production, cereal or cereal and legume cultivation) and three continuous variables indicating past and current livestock numbers and years since cultivation abandonment as duration.

As indicated in the first chapter, the effect of grazing by cattle and sheep are different in amount and selectivity. But to combine the stock rates as a single grazing measure, the cattle stock is converted into sheep equivalent as multiplied by 5 as proposed by European Commission on Agriculture and Environment (2012).

3.3. Analyses

3.3.1. Data Preparation

To apply analyses based on regression like hierarchical partitioning or stepwise regression square, square root, exponential and log transformations were applied to some variables.

Predictably, many environmental factors were correlated with a few major ones. For example elevation affects soil formation, climate and human use.

An ordination technique, Principal Component Analysis PCA, was performed to remove redundancy of strongly correlated environmental variables and to reduce collinearity or overweighting, problematic for some analyses (Gotelli and Ellison 2004):

- Elevation and climatic variables were summarized with PCA. As a result, the first axis with 83% of variation explained was used in some analyses.
- Soil water PCA: The three variables related with soil water based on texture i.e. field capacity, wilting point and saturation are reduced to a single PCA axis which explains 84% of the variance in the data.
- Ca PCA: The variable related with ions in the soil and determined mainly by Ca amount i.e. salt content, pH at saturation, electrical conductivity, Ca content are reduced to a single PCA axis which explains 70.89% of the variance in the data.
- Sand and clay PCA: Sand and clay contents are joined into single variable as the first axis of a PCA explaining 93.46% of their variance.

3.3.2. Richness Measures

Richness is defined as the number of species in an area. Although the definition is straightforward, finding the richness of a community is quite difficult. Since the study area is large and it is usually not possible to detect every species, sampling is performed. Observed species richness is simply the sum of all species recorded at a site. However, most of the time only a proportion of species are recorded during surveys. Instead of using the number obtained from the surveys (S_{obs}), estimation of richness is possible with species accumulation or rarefaction curves to get more accurate results (Gotelli and Colwell 2001). Rarefaction is a common method used for two purposes: i) to estimate a richness value by standardizing the sampling effort in the data and make the richness estimate comparable, and ii) to get a better estimate even when the sampling effort in each site is standard in case the surveys do not sample most of the species in that site and do not reflect the true richness (Colwell and Coddington 1994). Therefore, both the observed species richness (S_{obs}) and rarefaction results are presented in this study.

The richness estimators used in the study are Chao 1 and 2 (Chao 1984, 1987) and Jackknife 1 and 2 (Burnham & Overton 1978, 1979). All are based on presence/absence data although Chao 1 appears to be sensitive to abundance data. The estimates are based on the calculations with the number of species observed at a site and the number of species sampled once or twice in surveys. The formula can be found Figure 2.16. Brose and colleagues (2003) claim that Jackknife 1 is the overall best estimator. Colwell and Coddington (1994) claimed that the Chao 1 estimate performs well on data, mostly on lower frequency classes whereas jackknife is good for reducing bias. They suggest to use Chao 2 and Jackknife 2 for small number of samples. However, Hellmann and Fowler (1999) suggest to use first the Jackknife 2 then Jackknife 1 as the best estimators for small size of samples.

Chao 1=S_1*=S_{obs}+(a^2/2b) (Chao 1984, 1987)

Chao 2= S_2*=S_{obs}+(L^2/2M) (Chao 1984, 1987)

Jackknife 1 (first order)= S_3*=S_{obs}+L((n-1)/n)

Burnham & Overton (1978, 1979)

Jackknife 2 (second order)= S_4*=S_{obs}+ $\left[\frac{L(2n-3)}{n}+\frac{M(n-2)^2}{n(n-1)}\right]$

Burnham & Overton (1978, 1979)

S_{obs}=Observed number of species in a sample

a= is the number of observed species that are represented by only a single individual in that sample (the number of singletons)

b= number of observed species represented by exactly two individuals in that sample (the number of doubletons)

L= number of species that occur in only one sample ('unique' species)

M= number of species that occur in exactly two samples

n= number of samples

Figure 3.16 Formula for richness estimates

ESTIMATES (Colwell 2005) software Version 7.5.1 is used to get estimates for plant and bird species richness. Richness analyses were performed for each site by combining the data from each replicate. Chao and Jackknife estimates are given together with their standard deviations in tables. Bird abundance data is used for the estimates. Plant data are converted to binary to avoid overestimations due to high abundances of dominant plants. For each species group, trials were carried out to figure out the best data format for a better estimate of the richness. It is seen that data from a single replicate is usually not enough to obtain leveling off in an accumulation curve, hence indicating a good estimate. Instead, data from two replicates combined had a better estimate of the richness of a site. Therefore all data is combined on a site basis for all species groups. Only the sites with only one sampling (Site 1 and 34) had half of the data compared to other sites with two replicates.

The estimators find quite different but correlated values for richness as given in Tables A4-6. For comparisons and further statistics, Jackknife 1 estimates, which have the small standard deviations and mostly preferred, were used.

Rarefaction was not performed on butterfly data since the data collection method did not have repeated surveys or divided efforts to allow rarefaction. Only the results of two replicates can be joined for a site but two is too small a sample size to get a good estimate. Hence it was decided to combine the species list and use observed richness as (S_{obs}) a richness value for butterflies.

3.3.3. Diversity Estimates

Species diversity is the most common expression of diversity at a site. It considers both the number of species (richness) and the number of individuals of each species (evenness) (Colinvaux 1993). Named as alpha diversity, the diversity of species within a habitat is calculated with the use of indices. The two most common diversity indices used are Simpson and Shannon indices. Calculations were performed using PC-ORD software Version 4.39 (McCune and Mefford 1999). The formula are given below:

Shannon-Wiener index $H' = -\sum p_i \log p_i$

Simpson index $\lambda = \sum p_i$

where p_i is the proportion of the total number of individuals in *i*th species.

3.3.4. Functional Type and Generalist/Specialist Approaches

3.1.1.17 Functional Type Approach for Plants

Functional type approach has increasingly been used to answer ecological questions at the landscape, ecosystem or biome level (Cornelissen *et al.* 2003). With this approach, plants are classified based on their similar functioning at the organismic level, such as deciduous or evergreen trees, similar responses to environmental factors and similar roles in ecosystems like nitrogen-fixing due to their common set of key functional traits (Lavorel and Gariner 2002). It is used for simplification of floristic complexity instead of high level taxonomy, for understanding and mapping vegetation patterns, and for monitoring the effects of various factors, especially of management, on vegetation distribution (Lavorel *et al.* 1997, 1999).

There are various plant functional traits i.e. whole plant traits like growth form, life form, clonality, flammability; leaf traits like photosynthetic pathway; stem traits, belowground traits like root diameter, and regenerative traits like seed mass (Cornelissen *et al.* 2003). It is laborious to measure and record all of them so usually databases are used to gather information about functional traits.. In grassland studies the most commonly used traits are life form, growth form, longevity, aboveground cover density and plasticity, plant height, canopy structure, specific leaf area, storage organ, spread, clonality, plant persistence, fecundity, seed mass, dormancy, seed bank longevity, germination season, inflorence position, start of flowering, duration of flowering, leaf morphology and composition, leaf dry weight, and foliar toughness (Kahmen and Poschold 2004; Kahmen *et al.* 2002; Cingolani *et al.* 2005; Lavorel *et al.* 1999; Louault *et al.* 2005). Because of lack of comprehensive literature about the above traits of most of the species that occur in Turkey, only some of those traits are targeted in this research. They are:

- Lifespan: Annual, biennial and perennial
- Growth form: Forb, shrub/tree, grass
- Response to grazing: The relative abundance of species to increased grazing intensity is categorized as increasers, decreasers or invaders (Noy-Meir *et al.* 1989)

3.1.1.18 Classification of Bird Species Based on Dependency to Steppes

The concept of generalist versus specialist strategies is associated with niche breath or width. They are based on resource utilization patterns in different niche dimensions (Kitahara and Fuji 1994) or under different selective pressures (Kithara *et al.* 2000). Habitat generalist and habitat specialists respond differently to habitat and landscape features in the environment and to the level of disturbances (Krauss *et al.* 2003). The approach is widely used in community level studies at the landscape level. Although the classification is species-group specific i.e. use of voltinism and larval food resource for butterflies (Kitahara *et al.* 2000) and behavior and morphology of birds (Batary *et al.* 2007) the easiest method is counting the number of habitat classes a species occurs in; scoring the species is another approach which usually requires expert knowledge or opinion (Julliard *et al.* 2006).

Following the same idea, many studies specific to certain habitat type i.e. forests, grasslands, wetlands classify species as specific to that habitat type or not. For example, steppe birds are distinguished by ground nesting, cryptic coloration, tendency to walk or run and accompanying adaptations, behavior adapted to cope with strong sun and shortage of water, song flights and aerial displays and adaptations to compensate for nest predation (de Juana 2005). In a study covering North American grassland birds, they are defined as "any species that has become adapted to and reliant on some variety of grassland habitats for part or all of its life cycle" (Askins *et al.* 2007). In a study about local, landscape and regional effects on grassland versus non-grassland birds, the species breeding on the ground in grasslands are classified as grassland birds and the rest is the opposite (Batary *et al.* 2007).

In this study, birds were scored by an expert (C.C. Bilgin) with a similar approach:

- Cryptic coloration: scored as 1 if well camouflaged in a grassland setting.
- Nest site: scored as 1 if ground nesting, 0.5 if nest is near ground (<1 m) or sometimes ground nester.

- Habitat preference for Turkey: Scored as 0, 1 or 2 depending on steppe dependency.

The scores were summed. Dependency to grassland is determined based on the total score: total scores of 0: species not usually seen in steppes, 1-1.5: generalist species seen sometimes in steppes, 2-2.5: steppe species but can be seen in other habitats or they need some other features like rocks to exist in steppes and 3-4: obligate steppe species, not seen in other habitats. For each replicate or site, the scores for each species is multiplied by the abundance of species and divided to species richness.

3.1.1.19 Classification of Butterfly Species Based on Dependency to Steppes

The approach is also applied to butterflies. In the study of biotope use and trends on European butterflies (van Swaay *et al.* 2006), the biotope-specialist species are defined as the ones in which the total number of mentions a specific biotope as main biotope in country-specific information is more than all the other scores obtained for other biotopes for than species. In a study about effects of habitat geometry and landscape features on butterflies, Krauss and colleagues (2003) identified calcareous grassland specialist butterflies as species to be found on grasslands of a specific region almost exclusively. A study done in the prairies (Swengel 1998) accepted specialist species as the ones restricted or nearly so to the prairie, savanna and/or barrens with sensitivity to vegetation quality, and subdivided them in terms of habitat narrowness and tolerance to habitat degradation. In this study, the data available for habitat preferences of butterfly species in Turkey and nearby regions (mostly Europe) were used to identify the steppe butterflies. Habitat preferences in Turkey are not studied in detail but it is well-known in Europe and provided as percentages. The habitat was scored between 0-3 for Turkey and 0-2 for Europe, and then the average was taken. The resultant scores ranged between 0-2.5. In addition, the expert opinion of Dr. E. Karaçetin was obtained to some species-specific minor corrections. The data was extracted from Butterfly Database of Nature Conservation Centre which involves all the literature about taxonomy, ecology and distribution of butterflies of Turkey.

3.3.5. Correlation

Correlation is used to check whether there is a relationship between environmental variables and biodiversity measures. The most common method is the Pearson's product moment correlation which relies on normal distribution and checks for linear relationship between two variables. Since the data do not have normal distribution and the relationship may not be linear (Townend 2002), it was decided to apply a nonparametric method. Spearman Rank Correlation with two tails was used instead of Pearson's. Level of significance accepted to be 0.05. SPSS software PASW Statistics Release 18.0.0 (Polar Engineering and Consulting, 1993-2007) is used for this analysis.

3.3.6. Ordination Techniques: CCA and DCA

Ordination is a collective term for multivariate techniques that arrange sites along axes for maximum explained variance based on species data which results in a two-dimensional space of two or more axes in which sites similar in terms of species composition are located close to each other (Jongman *et al.* 1995). Correspondence Analysis (CA), an ordination method, examines the species assemblages to site characteristic so that separation of species abundances is maximized along each axis. Detrended correspondence analysis maximizes site versus species data in one data matrix. Canonical correspondence analysis (CCA) focuses on generating a unimodal axis with respect to the response variables like species occurrences or abundances, and a linear axis with respect to the predictor variables like environmental variables. The biodiversity data were analyzed with CCA as single species groups. In this way, species assemblages similar to each other were identified. For the ordination analyses, PC-ORD software was used.

3.3.7. Two-Way Indicator Species Analysis

Two-Way Indicator Species Analysis (TWINSPAN) is a popular vegetation classification technique developed by M.O. Hill (1979). It uses species data and results in a hierarchical classification where different communities are identified based on presence and relative abundance of indicator species (Southwood and Henderson, 2000). It is based on dichotomy dividing samples as positive and negative from the centroid of Reciprocal Averaging (RA) ordination in iterative and hierarchical way until the minimum group size is obtained. Species are chosen as indicator of the groups based on presence/ansebce in the group (Pisces Conservation Ltd 2012).

Although the aim of the study is not classification of steppe vegetation and data have not been collected to serve that purpose, analysis of plant data would reveal useful results about identification of the different plant communities in the steppes. The findings can give insights about biodiversity patterns in the region. Therefore, the data was prepared for TWINSPAN and analyzed with PC-ORD software Version 4.39 (McCune and Mefford 1999).

3.3.8. Hierarchical Partitioning

Data deviation from normality and multicollinearity cause failures in regression analyses to determine the relative importance of independent factors on the fact being researched. As an alternative to overcome this problem, hierarchical partitioning is developed by Chevan and Sutherland (1991). It is based on building all possible regression models with N independent variables to explain one dependent variable, calculating goodness of fit measures for the entire models and then applying hierarchical partitioning algorithm to find out independent and conjoint contributions of each variable to explained variance (MAcNally 2002).

The outputs are relative contribution of each variable for explaining plant richness of a site as independent (I) and dependent (J) contribution, sum of *I*s which is equal to the goodness of fit measure of the full model minus the goodness of fit measure of the null model (Walsh and McNally 2004).

Hierarchical partitioning is used to find out most important parameters for plant, bird and butterfly richness and diversity of a site. Hier.part Version 1.0 package (Walsh and McNally 2004) was run in R Studio (RStudio Inc. 2009-2011) software. Since the analysis uses up to 12 variables, the variables in high correlation with dependent variable and results of PCA are used.

CHAPTER III

RESULTS

3.2 Summary of the Data

3.2.1 Survey Sites

33 sites were surveyed by the end of the fieldwork. 31 of them had two replicates each whereas 2 of them lost one replicate to afforestation, making a total of 64 replicates overall. Descriptive information about the survey sites are provided in Table 3.1.

Due to the methodology of gradsects, survey sites are found more densely in certain regions where highest environmental changes occur within short distances (Figure 2.15, also see Chapter II). Most of the sites are in the region delimited by main roads connecting Kangal, Hekimhan, Arapkir and Divriği to each other. Yamadağ is intensively sampled due to sharp changes in bedrock and elevation.

The environmental properties of the survey sites can be summarized as below:

- The average temperature of the sites range between 4.6-11.5°C. Average monthly rainfall is between 422-628 mm.
- Average elevation of survey sites is 1668 ± 369 m (range 1199-2651 m).
- Volcanic and sedimentary rocks are represented in 32 and 27 replicates, respectively. Whereas only three replicates are on metamorphic rocks and two replicates are on gypsum rock which is a special type of sedimentary rock.
- Most of the sites (61%) occur on brown soils while 17% occur on brown forest soils, 6% on non-calcic brown forest soils, 6% on basaltic soils and 3% on reddish brown soils. 22% of the soils are deep or moderately-deep, 61% shallow, 19% very shallow and 14% lithosolic.

- The results about land use activities are summarized and used as input to analyses. The summary can be seen in Appendix H. The main findings of land use and history of the sites are as follows:

- Land use activities are highly correlated with elevation, climate and slope. As the elevation increases and climate becomes colder and more humid; various agricultural activities taking place in the low mountains are replaced by extensive grazing on highlands. The mozaic landscape composed of arable lands, woodlands and shrubby grasslands are replaced by extensive treeless grasslands.
- All of the survey sites below alpine zone were once covered by the woodlands. Oak and juniper woodlands were dominant but some highlands were covered by Scottish Pine (*Pinus sylvestris*) forests. Forest history goes more than 60 years since the oldest members of the village remember it barely or information is passed on to them by their recent ancestors. Land abandonment and decline in grazing enables woody vegetation to recover slowly in many sites.
- There is one site (site 2) managed only for charcoal production. The oak woodland is managed in rotation as coppice, with the oaks recovering in 10-20 years' time.
- Deforestation was followed by cultivation in many sites. After ploughing stopped, grazing and over collection of tragacanthic plants for fuel or livestock food has taken place. In high elevation, steep or rocky places there is usually no precursor cultivation history. Intensive land use has declined sharply 20-60 years ago and continues to decline. The land was abandoned for economical and life-quality reasons. Consequently steppes are recovering and then develop into woodlands. Some of the mid-elevation sites once had less than 10% vegetation coverage when heavily grazed but now have almost 90% coverage.
- The herds were composed of sheep and various races of cattle. The numbers were up to 100-120 sheep and 70-80 cattle per family. Sheep grazing decreased in many parts. The highest-known livestock populations of the past in terms of dry sheep equivalent range between 400 and 5357 per 1000 hectares, but have declined between 40 and 100% in many sites.
- Most of the grasslands experienced removal of woody *Astragalus* species as food for the livestock or a fuel for heating. However, according to the

information from villagers *Astragalus* species have high recovery rates as species like *A. plumosus* can grow 15 cm. in crown diameter within 5 years.

Table 3.1 Descriptive information about the survey sites

Sites	**1**	**1-J**	**2**	**3**
Province, District	Sivas, Divriği	Sivas, Divriği	Sivas, Zara	Sivas, Divriği
Elevation (m)	1383	1232	1500	1602
UTM Coordinates (Approximate)	0401800 4367400	0414600 4368400	0395900 4378400	0405500 4359000
General Description	Shrubby steppe with diverse forbs	Gypsiferous steppes	Steppes of *A.gummifer* and forbs surrounded by oaks and junipers	High-diversity steppe dominated by forbs and perennial grasses
Soil type	Brown forest soils	Brown forest soils	Brown forest soils	Brown forest soils
Slope	Moderate	Moderate	Moderate	Mild to moderate
Aspect	N	E	W	N
Bedrock	Evaporite sedimentary rocks	Continental clastic rocks	Clastic and carbonate rocks	Gabbro
Annual Mean Temperature (C)	9.6	10.7	8.8	9.3
Annual Mean Precipitation (mm)	427	430	441	432
Forest History	Oak-juniper woodland 100 ya	oak woodland 100 ya	Oak-juniper forest 100-150 ya	Oak woodland more than 200 ya
Arable land history	Cereals, 20-30 ya (years ago)	Cereals only on plains (1J-CB), 40-50 ya	never	cereals and legumes, 60 ya
Past Grazing Intensity (sheep equivalent)	10350	4750	5000	4600
Current Grazing Intensity (sheep equivalent)	0	150	150	0

Table 3.1. Descriptive information about the survey sites (cont'd)

Sites	**4**	**5**	**6**	**7**
Province, District	Sivas, Divriği	Sivas, Kangal	Sivas, Kangal	Sivas, Kangal
Elevation (m)	1759	1441	1715	1842
UTM Coordinates (Approximate)	0402900 4354100	0375300 4345300	0368800 4331500	0393800 4328800
General Description	Short-height vegetation dominated by annual grasses	*Bromus, Festuca, Thymus* dominated chalk steppe	Grazed and rocky steppes dominated by *Astragalus, Thymus, Stipa* sp.	Very rocky high mountain steppes
Soil type	Brown forest soils	Brown soils	Brown soils	Brown soils
Slope	Moderate	Moderate	Mild	No slope to mild
Aspect	S	E	NA, E	NA, SW
Bedrock	Basalt	Undifferentiated continental clastic rocks	Pelagic limestone	Basalt
Annual Mean Temperature (C)	8.9	8.2	7.1	7.8
Annual Mean Precipitation (mm)	439	423	442	457
Forest History	Juniper-pine forests before	juniper forest 200ya	forest long before	Oak-juniper before
Arable land history	vineyards 200 ya, cereals 6-20 ya	never	never	Not known
Past Grazing Intensity (sheep equivalent)	17500	1800	1500	Not known
Current Grazing Intensity (sheep equivalent)	300	40	250	Not known

Table 3.1. Descriptive information about the survey sites (cont'd)

Sites	**7A**	**8**	**10**	**11**
Province, District	Sivas, Divriği	Sivas, Kangal	Malatya, Arapgir	Malatya, Hekimhan
Elevation (m)	1727	1723	1605	2371
UTM Coordinates (Approximate)	0405300 4357200	0388100 4341700	0446800 4321400	0407300 4323100
General Description	Annual and perennial graminoid dominant stony steppe	*Astragalus* and *Thymus* dominated rocky steppes	*Astragalus* dominated steppe with abundant *Phlomis sp*.	High mountains steppe dominated by *Astragalus* and forbs.
Soil type	Brown soils	Brown soils	Brown soils	Brown soils
Slope	No slope	No slope to mild	No slope	Mild to moderate
Aspect	NA	E, S	NA	W-SW
Bedrock	Basalt	Andesite	Clastic and carbonate rocks	Andesite
Annual Mean Temperature (C)	9.1	7.9	10.1	5.6
Annual Mean Precipitation (mm)	431	438	552	506
Forest History	not known but suitable	not known, but should be very old	Oak-juniper forest before	Juniper forest 50 ya
Arable land history	cereals, sometimes legumes, 20 ya	never	Cereals, 100 ya	never
Past Grazing Intensity (sheep equivalent)	18750	5833	12500	5000
Current Grazing Intensity (sheep equivalent)	500	1700	2500	1750

Table 3.1. Descriptive information about the survey sites (cont'd)

Sites	**12**	**15**	**16**	**18**
Province, District	Malatya, Hekimhan	Malatya, Hekimhan	Malatya, Arapgir	Malatya, Arapgir
Elevation (m)	2453	1317	1631	1558
UTM Coordinates (Approximate)	0409700 4325400	0455600 4318400	0438300 4331100	0442900 4318400
General Description	High mountain steppe with *Juniperus communis* and *Prangos* sp.	Rocky steppe dominated by *Thymus* sp. and short graminoids.	Graminoid-dominant steppes along high mountain	Diverse steppe with high vegetation
Soil type	Brown soils	Brown soils	non-calcic brown forest soils	Basaltic soils
Slope	Steep	Moderate	Mild to moderate	Moderate to steep
Aspect	E	N	S	N
Bedrock	Andesite	Basalt	Basalt	Basalt
Annual Mean Temperature (C)	5	11.3	10	10.2
Annual Mean Precipitation (mm)	564	609	516	536
Forest History	Juniperus communis was common before	not known, but suitable	not known but suitable	forest 150 ya
Arable land history	never	not known, only plains are suitable	Wheat only on nonrocky plains, 30 ya	Cereals only in 18-CB, 60 ya,
Past Grazing Intensity (sheep equivalent)	5000	Not known	7650	4000
Current Grazing Intensity (sheep equivalent)	1750	Not known	2550	60

Table 3.1. Descriptive information about the survey sites (cont'd)

Sites	**20**	**23**	**24**	**25**
Province, District	Malatya, Arapgir	Sivas, Divriği	Sivas, Divriği	Malatya, Arguvan
Elevation (m)	1291	2130	2259	1228
UTM Coordinates (Approximate)	0460500 4313400	0418400 4334100	0418300 4333700	0433200 4298600
General Description	Vegetation dominated by short, annual grasses	High mountain steppe with scattered *Prangos* sp.	High mountain steppe dominated by cushion forming plants	Ruderal steppe
Soil type	Brown soils	Brown soils	Brown soils	Alluvial soils
Slope	Mild	Steep	Mild to steep	Moderate
Aspect	S,N	NE, SW	W, NW	SE, E
Bedrock	Clastic and carbonate rocks	Andesite	Andesite	Pyroclastic rocks
Annual Mean Temperature (C)	11.4	6.2	6.4	11.5
Annual Mean Precipitation (mm)	627	534	534	492
Forest History	oak forest before	Juniper more than 80 ya	Juniper more than 80 ya	Oak, juniper forest at least 300 ya
Arable land history	suitable	not suitable	never	cereals and legumes, 30 ya
Past Grazing Intensity (sheep equivalent)	Not known	14100	14100	1400
Current Grazing Intensity (sheep equivalent)	Not known	106	106	0

Table 3.1. Descriptive information about the survey sites (cont'd)

Sites	**26**	**27**	**29**	**32**
Province, District	Malatya, Hekimhan	Malatya, Kuluncak	Malatya, Hekimhan	Sivas, Kangal
Elevation (m)	1336	1356	2559	1567
UTM Coordinates (Approximate)	0403900 4313300	0389500 4304000	0409000 4324900	0381900 4334500
General Description	Mixed steppe of short grasses and *Astragalus* sp.	*Artemisia*, *Thymus* and graminoids dominant short steppes.	Alpine meadows	Steppes dominated by perennial grasses and *Astragalus* sp.
Soil type	Brown soils	Brown soils	Brown soils	Brown soils
Slope	Moderate	Mild to moderate	Mild	Moderate
Aspect	E,N	W, S	N, S	NW, SW
Bedrock	Basalt, spilite	Continental clastic rocks	Andesite	Undifferentiated continental clastic rocks
Annual Mean Temperature (C)	10.1	9.7	4.6	8
Annual Mean Precipitation (mm)	431	423	565	431
Forest History	Oak and juniper long before	Oakland before	not suitable	oak-juniper before
Arable land history	Cereals and lentil, 70 ya	not known but suitable	never	never
Past Grazing Intensity (sheep equivalent)	2000	3000	5000	12000
Current Grazing Intensity (sheep equivalent)	150	50	1750	400

Table 3.1. Descriptive information about the survey sites (cont'd)

Sites	**33**	**34**	**36**	**37**
Province, District	Malatya, Arapgir	Malatya, Hekimhan	Malatya, Hekimhan	Malatya, Hekimhan
Elevation (m)	1455	1477	1771	1942
UTM Coordinates (Approximate)	0457300 4306000	0400600 4318200	0417900 4320100	0415300 4321800
General Description	Steppes dominated by annual grasses on rocky plains	Steppes dominated by annual grasses on rocky place	Steppes dominated by *A.plumosus*, *Thymus* and grasses.	Steppes dominated by *Astragalus*, perennial grasses and sedges.
Soil type	Brown soils	Brown soils	Brown soils	Brown soils
Slope	No slope	Moderate	Steep-mild	Mild-moderate
Aspect	NA	S	E, W	S
Bedrock	Schists (Lower Triassic in places)	Basalt	Pyroclastic rocks	Pyroclastic rocks
Annual Mean Temperature (C)	10.7	9.6	8.9	8.3
Annual Mean Precipitation (mm)	596	432	47.9	484
Forest History	not known but suitable	oakland before	oak juniper forest more than 80 ya	juniper forest 60 ya
Arable land history	Cereals, some untill 5 ya	Not known	some plains are sown meadows of 80 ya	possible in some parts of 37SO
Past Grazing Intensity (sheep equivalent)	10000	Not known	12000	8333
Current Grazing Intensity (sheep equivalent)	6000	Not known	410	1666

Table 3.1. Descriptive information about the survey sites (cont'd)

Sites	**40**	**41**	**42**	**50**	**61**
Province, District	Sivas, Ulaş	Malatya, Hekimhan	Malatya, Arguvan	Malatya, Hekimhan	K.maraş, Afşin
Elevation (m)	1821	1311	1289	1201	1967
UTM Coordinates - Approximate	0354100 4371100	0417500 4299100	0433700 4303900	0409400 4295600	0330500 4269800
General Description	Steppes dominated by Thymus, grasses and few forbs.	Astragalus, Thymus, Elymus abundant steppes with oaks around.	Annual grass and legume dominant vegetation	Mixture of rudeal and forb-dominated natural steppes	*Astragalus*, *Thymus* and *Bromus* dominant rocky steppes
Soil type	Brown forest soils	Non-calcic brown forest soils	Basaltic soils	Reddish-brown soils	Brown soils
Slope	Mild	Mild to moderate	Moderate	Mild to moderate	Mild to moderate
Aspect	S	S	SE	E, NE	W, SW
Bedrock	Neritic limestone	Clastic and carbonate rocks	Basalt	Clastic and carbonate rocks	Neritic limestone
Annual Mean Temperature (C)	6.6	10.4	11.4	11	5.8
Annual Mean Precipitation (mm)	450	452	502	438	497
Forest History	juniper forest more	oak recently	oak forest more than 100 ya	oak and juniper forest before	juniper forest 70 ya
Arable land history	Wheat, 30 ya	Not known	Wheat, 110 ya	Not known	never
Past Grazing Intensity (sheep equivalent)	4500	Not known	3375	Not known	4500
Current Grazing Intensity (sheep equivalent)	500	Not known	375	Not known	2000

3.2.2 Summary of Plant Data

526 records of 168 plant species belonging to 33 plant families were collected. The list of plant species is given in Appendix A. The families with the highest number of species are Fabaceae (37 species), Poaceae (27 species), Lamiaceae (23 species), Asteraceae (16 species), Caryophyllaceae (14 species), Rosaceae (7 species) and Cistaceae (4 species). Other families are represented by 3 or less species. The genera with highest number of species are *Astragalus* (12 species), *Phlomis* (6 species), *Thymus* (6 species), *Trifolium* (5 species), *Bromus* (5 species) and *Festuca* (5 species).

The commonest plant species can be inferred from the frequency of the species i.e. number of replicates each species recorded. *Taeniatherum caput-medusae* is the most frequent species occurring in 28 of the 68 replicates surveyed for plants (frequency [f]:41%). This reflects the widespread presence of ruderal steppes in the region. It is followed by typical steppe species: *Astragalus plumosus* (f:33.8%), *Bromus tomentellus* (f:32.3%), *Festuca valesiaca* (f: 29.4%), *Thymus sipyleus* (f:27.9%), *Thymus migricus* (f:20.6), *Koeleria cristata* (f: 19.1), *Salvia multicaulis* (f:17.6 %), *Stipa holosericea* (f:17.6%), *Aegilops triuncialis* (f:14.7%). The rest of the species are recorded at less than 10% of the replicates.

Highest coverage scores are as follows: *Taeniatherum caput-medusae* (57.1%), *Astragalus plumosus* (30.7%), *Festuca valesiaca* (28.3%), *Aegilops triuncialis* (21.3%), *Aegilops umbellulatus* (19.1%), *Thymus sipyleus* (16,7%), *Astragalus gummifer* (15.5%), *Trifolium pauciflorum* (11.25%). The rest of the species have coverage less than 10% per site.

40 endemic taxa were recorded at species level based on Davis (ed) 1965-1985, 1989; Güner *et al.* 2000 and Ekim *et al.* 2000. The endemic species are indicated in species list given in Appendix A with an asterisk. 26 of the endemic species were threatened. Additionally, 3 non-endemic species are threatened. The threatened species are listed in Table 3.2 from highest to lowest threat category.

Table 3.2 List of threatened plant species recorded during standard field surveys

Scientific Name	**Endemism**	**Threat Category**
Astragalus barbarae BORNM.	Endemic	DD
Silene oligotricha HUB.-MOR.	Endemic	EN
Hedysarum pycnostachyum HEDGE ET HUB.-	Endemic	EN
Thymus spathulifolius HAUSSKN. ET VELEN.	Endemic	EN
Onosma sintenisii HAUSSKN. EX BORNM	Endemic	VU
Ebenus macrophylla JAUB. ET SPACH	Endemic	VU
Phlomis physocalyx HUB.-MOR.	Endemic	VU
Anthemis aciphylla BOISS.		LR
Anthemis pungens YAVIN	Endemic	LR
Alkanna megacarpa DC.	Endemic	LR
Onosma bornmuelleri HAUSSKN.	Endemic	LR
Arenaria acerosa BOISS.	Endemic	LR
Gypsophila parva BARK.	Endemic	LR
Convolvulus assyricus GRISEB.	Endemic	LR
Astragalus condensatus LEDEB.	Endemic	LR
Astragalus cymbibracteatus HUB.-MOR. ET	Endemic	LR
Astragalus lamarckii BOISS.	Endemic	LR
Hedysarum pestalozzae BOISS.	Endemic	LR
Onobrychis armena BOISS. ET HUET		LR
Onobrychis fallax FREYN ET SINT.	Endemic	LR
Phlomis linearis BOISS. ET BAL.	Endemic	LR
Phlomis oppositiflora BOISS. ET HAUSSKN.	Endemic	LR
Phlomis sieheana RECH. FIL.	Endemic	LR
Salvia caespitosa MONTBRET ET AUCHER EX	Endemic	LR
Salvia cryptantha MONTBRET ET AUCHER EX	Endemic	LR
Thymus haussknechtii VELEN.	Endemic	LR
Festuca glaucispicula MARKGR.-DANNANB.	Endemic	LR
Festuca longipanicula MARKGR.-DANNENB.	Endemic	LR
Veronica multifida L.		LR

Almost 20% of the plant species recorded are threatened. This value is quite high considering that only the species more than 5% coverage in a plot are recorded. The results are in parallel with a well-known fact that the region i.e. the Anatolian Diagonal is so rich in endemic and rare species that even a community sampling based on common species resulted with 20% threatened species. A study by the Nature Conservation Centre (Ambarlı 2009) revealed 27 endangered species living in the study area of this thesis. Only four of the taxa have been recorded in this study because most of those species are only known from one or few localities.

3.2.3 Summary of Bird Data

The fieldwork resulted in 533 records. Of the 76 species recorded, 60 species are recorded during 5'+3' standard surveys (see Appendix B). The average number species per standard surveys across sites is 5.12±1.94, and the average number of individuals per standard survey is 8.80±7.07. The families with the highest number of individuals are Alaudidae (122) and Emberizidae (117) followed by Passeridae (83) and Turdidae (63). The most abundant species are house sparrow with 69 individuals, 51 of which are seen in one flock, skylark with 54 individuals, and black-headed bunting with 51 individuals. The most frequent species of the standard surveys are black headed bunting (f:36), ortolan bunting (f:25), northern wheatear (f:19), skylark (f:18), corn bunting (f:17) and linnet (f:15).

128 of the records come from within 50m and are presumed to be more associated with the specific grassland habitat. 300 individuals of 36 species were recorded inside the 50m zone. Those 36 species belong to 15 different bird families. 90% of the individuals belong to the families of Emberizidae (48%), Alaludidae (16%), Turdidae (8%), Fringillidae (5.33%), Motacillidae (4.67%), Laniidae (4.67%) and Passeridae (3.33%). 16 replicates did not have any bird records within the 50m zone. 20 of 36 species were recorded less than 5 times during the surveys. However, most of those species are actually neither rare nor adapted to steppes. Some examples are rock dove*,* hooded crow*,* little owl*,* nightingale*,* bee-eater*,* house sparrow and blackbird. The methodology used results in low number of counts per survey since it targets the species that are related to specific delimited grassland habitat. So the analyses were done with standard survey data without 50m limitation.

A majority of the species recorded in the surveys have threat category of "Least Concerned" globally and also for Turkey (Kılıç *et al.* 2004). Little ringed plover is "Near threatened" and a further seven species (*Tringa hypoleucos, Coturnix coturnix, Hieraaetus pennatus, Neophron percnopterus, Perdix perdix, Pterocles orientalis, Saxicola torquata*) are "Vulnerable". In addition, two "Data Deficient" species were recorded: Pale Rock Sparrow and Cuckoo. The Egyptian Vulture *Neophron percnopterus* is a breeding species of the study area which is endangered globally. European Roller *Charadrius dubius* is also a globally "Near Threatened" species.

3.2.4 Summary of Butterfly Data

The fieldwork produced 916 records. 900 of them were identified at the species level whereas 16 of them, mostly *Agrodietus* species, were only identified to generic level. 111 butterfly species from five families flying in Turkey were recorded (see Appendix C). The highest number of records was from Nymphalidae family with 384 records, followed by Lycaenidae (263), Pieridae (155), Hesperidae (100) and Papilionidae (14). The most common species were generalist species: *Melanargia larissa* (69 records), *Colias crocea* (45 records), *Chazara briseis* (39 records) and *Vanessa cardui* (35 records). The rest of the 107 species are recorded less than 30 times.

Half of the records (465) were obtained during general counts. Transect counts were in the minority: 151 accounting for 16,4% of the total. 91% of the species in transect counts were recorded less than 10 times. A large number of species observed in quite low frequency will make the analysis more difficult since there will be many sites where a species will be observed nowhere else. In 19 transects, no butterflies were observed. This was due to vegetation that dried quite earlier than expected during the survey year. Also in 36CB, the transect count did not take place because of the heavy rain. At four of the replicates (36CB, 6CB, 24SE, 11SO) the weather was cool which impeded a proper count. In addition, cloudiness was recorded to be (6/8) in 33SO, 6CB, 6SO, 36SO, 12SO and 12CB replicates; (7/8) in 36CB, 29CB and 29SO replicates. Lack of abundance data from transect counts also prevents analysis of butterfly community. Transect counts and general counts will be combined in data analysis. When data from different observation methods were joined, it was found that most of the species were recorded less than 10 times. 22 species were recorded only once and 17 species were recorded twice. On the other hand, 10 species have high frequency of records (f>20).Those facts are the main limitations of butterfly data analyses.

All species except two are categorized as "Least Concerned" in the Red Book of Butterflies in Turkey (Karaçetin and Welch 2011). *Pieris napi* is "Not Evaluated" for Turkey due to no proven distribution. *Chilades (Lacides) galba* is "Not Applicable". Four of the butterflies are endemic to Turkey: *Glaucopsyche* *asteraea, Polyommatus cornelia, Polyommatus menalcas* and *Polyommatus ossmar.*

3.3 Community Analyses

3.3.1 Plant Communities of the Steppes

3.3.1.1 Results of TWINSPAN Analysis

The analysis resulted in a dendogram with four levels of dichotomy and six major plant communities:

1. Gypsiferous steppes
2. Alpine meadows
3. Subalpine steppes
4. Semi-natural mountain steppes
5. Old segetal steppes
6. Young segetal steppes

The naming follows the dichotomic division. Gypsiferous steppes and alpine meadows are both natural state steppes but occur as outliers fom the rest due to distinctive flora.

The graphical presentation is given in Figure 3.1 and the relative coverage of dominant and co-dominant species for each group are given in Table 3.3.

The environmental factors effective on this classification (in accordance with the results of nearest neighbor classification analysis) are given below:

- The **gypsum bedrock** supports the distinctive flora of gypsiferous steppes. Two factors explaining the first level division of the plant communities are gypsum bedrock and arable land history which discriminates 1J-SO from its replicate with old field patches.
- The snow-melt of Yamadağ Summit maintains alpine meadows on the mountain and is separated with the second division. In 3-D space of the nearest neighbor classification alpine meadows are discriminated by **elevation** (2550m), **eastness** (between 0.40 and 0.82) and **occurrence on brown soils**. Among the three factors, elevation is the main determinant, whereas the selection of aspect and soil type is possibly a result of bias due to small sample size (n=2).
- **Land use** is the driver of third level division. Absence of arable land history is the determining factor primarily.

- An **elevation** between 1900-2500m and the correlated climatic conditions, **volcanic bedrock** and **no arable land history** is the determinant of fourth level division of semi-natural steppes as subalpine steppes versus mountain steppes.
- **Land abandonment history** divides segetal steppes as older and younger. In addition, **humidity** reflects the position of recently abandoned fields as they are all low elevation valley bottoms with driest climates. A **south-southeast aspect** is common to recently abandoned fields.

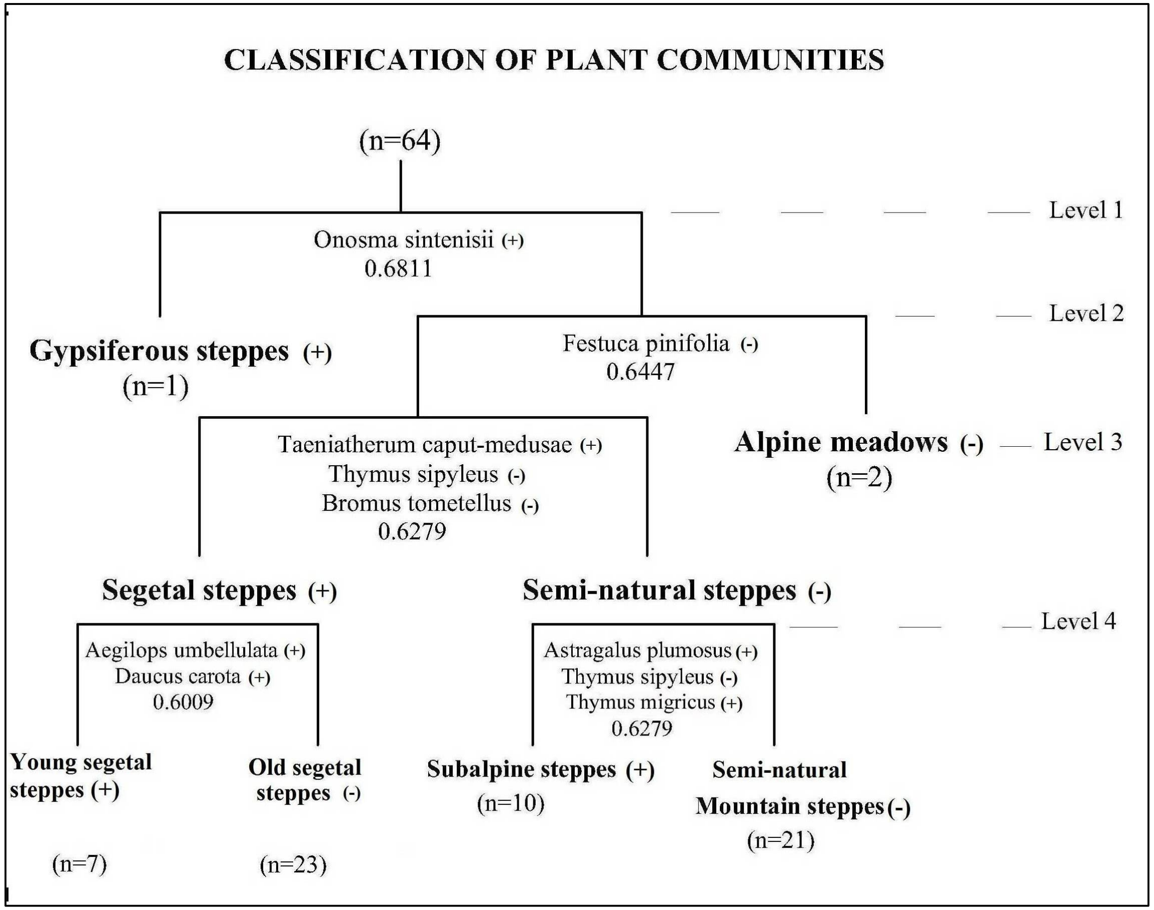


Figure 3.1 Dendogram obtained with TWINSPAN of common plant data (Division levels, indicator species and eigenvalues of divisions are given in the junction points; names of plant communities and number of units are given at each end point of dendogram)

Table 3.3 Relative coverage of species in different plant communities

Species	Relative coverage of species in different plant communities (the species more than 1% coverage is included)					
	Gypsiferous Steppes	**Alpine meadows**	**Subalpine Steppes**	**Semi-natural mountain steppes**	**Segetal steppes older than 30 years**	**Segetal steppes younger than 30 years**
Aegilops triuncialis	.	.	.	7	7.7	.
Aegilops umbellulata	.	.	.	1.9	1	**25.9**
Artemisia spicigera	.	.	.	2.4	.	.
Astragalus chthonocephalus	.	.	.	.	.	2.2
Astragalus condensatus	.	.	.	2.1	0.3	.
Astragalus cymbibracteatus	.	.	.	2	.	.
Astragalus gummifer	.	.	3.9	3.2	4.7	.
Astragalus kurdicus	.	.	.	.	2.2	.
Astragalus microcephalus	.	.	.	3.2	.	.
Astragalus plumosus	.	2.3	**24.3**	1.9	6.9	0.3
Astragalus pycnocephalus	.	.	.	1.4	.	.
Astragalus xylobasis	.	.	.	.	1.3	.
Bromus japonicus	.	.	.	1	0.1	.
Bromus tectorum	.	.	.	1.7	0.9	.
Bromus tomentellus	.	.	4	**7.1**	0.5	.
Convolvulus assyricus	.	.	.	2	.	.
Crepis sancta	.	.	.	.	.	2
Cynodon dactylon	.	.	.	1.5	.	.
Dactylis glomerata	.	.	.	.	1.6	.
Daphne oleoides	.	**5.4**	.	.	.	.
Daucus carota	.	.	.	.	.	2.6
Ebenus laguroides	.	.	.	1.4	.	.
Ebenus macrophylla	**19**	.	.	.	0.2	.
Eryngium campestre	.	.	.	.	0.3	1.7
Festuca callieri	.	.	3.7	.	3.6	.
Festuca glaucispicula	.	.	1.1	.	.	.
Festuca longipanicula	.	.	2.2	.	.	.
Festuca pinifolia	.	**69.9**	.	.	.	.
Festuca valesiaca	.	.	**15.2**	6.4	4.3	.
Galium verum	.	.	.	2.7	1.1	.
Globularia trichosantha	.	.	.	1.9	.	.
Gypsophila parva	**42.9**	.	.	.	0.6	.
Hedysarum pestalozzae	.	.	.	1.6	.	.
Hedysarum varium	.	.	.	1	.	2.5
Helicrysum arenarium	.	.	1.2	.	.	.

Table 3.3. Relative coverage of species in different plant communities (cont'd)

Species	Relative coverage of species in different plant communities (the species more than 1% coverage is included)					
	Gypsiferous Steppes	Alpine meadows	Subalpine Steppes	Semi-natural mountain steppes	Segetal steppes older than 30 years	Segetal steppes younger than 30 years
Helianthemum ledifolium	.	.	.	.	0.6	1.2
Helicrysum pallasii	.	.	.	1.6	.	.
Juniperus communis	.	**18.7**	7.4	.	.	.
Koeleria cristata	.	.	2.9	1.9	1.9	.
Malus sp.	.	.	.	.	1.1	.
Medicago rigidula	.	.	.	.	.	**5.4**
Medicago x varia	.	.	.	.	1.4	.
Minuartia hybrida	.	.	.	.	1.4	0.5
Onobrychis armena	.	.	.	1	.	1.3
Onosma sintenisii	**9.5**	.	.	.	.	.
Phlomis linearis	.	.	2	.	0.1	.
Phlomis rigida	.	.	.	.	1.2	.
Pilosella hoppeana	.	2.5	.	.	.	.
Prangos platychlaena	.	.	**8.7**	.	.	.
Quercus pubescens	.	.	.	.	2.1	.
Salvia multicaulis	.	.	1.1	2.9	1.1	5.3
Sanguisorba minor	.	.	.	0.3	1.4	.
Stipa holosericea	.	.	0.4	1.2	3.9	.
Stipa lessingiana	.	.	.	3.6	.	.
Taeniatherum caput-medusae	.	.	.	0.3	**23.3**	21.6
Thymus migricus	.	1.1	**9**	0.1	1.9	.
Thymus pubescens	.	.	3.8	.	.	.
Thymus sipyleus	.	.	.	**16**	0.2	.
Thymus spathulifolius	**28.6**	.	.	.	0.1	.
Trifolium lucanicum	.	.	.	.	0.1	**5.5**
Trifolium pauciflorum	.	.	.	.	1.6	**8.9**
Triticum sp.	.	.	.	.	0.1	2.8
Verbascum sp.	.	.	1.8	.	0.1	.
Xeranthemum annuum	.	.	.	.	3.5	0.3

3.3.1.1.1 Gypsiferous Steppes

The replicate with gypsiferous vegetation, 1J-SO, is different from the rest of the replicates. The gypsiferous site (Figure 3.2) is dominated by *Gypsophila parva*, *Thymus spathulifolius*, *Ebenus macroclada and Onosma sintenisii,* which are also positive preferentials of the first level division. Among those, *Thymus spathulifolius* deserves attention as an endangered endemic (Ekim *et al.* 2000). Other replicate on gypsum bedrock, 1J-CB, is at the borderline and classified as old segetal steppe since it has some old arable field patches with very high annual grass coverage and a few elements of steppe species like *Stipa holosericea.*

The naming of semi-natural steppes at level three not covering gypsiferous steppes can be misunderstood as if gypsiferous steppes are not natural. They are of course natural represent natural vegetation but they are as distinctive as to be an outlier of all steppe communities of the study area.

Figure 3.2 Gysiferous steppe at 1J-SO.

3.3.1.1.2 Alpine Meadows

Site 29 with two replicates is the only alpine meadow among the survey sites (Figure 3.3). It is located at the top of Yamadağ at 2560m. The site is dominated by the indicator species of *Festuca pinifolia* which is recorded only in that site. Other common plant species of the site are *Juniperus communis*, *Daphne oleoides* and *Pilosella hoppeana*. They are negative preferentials of the division together with *Thymus migricus*.

Figure 3.3 Alpine meadows dominated by *Festuca pinifolia*.

Semi-natural Steppes

31 replicates are classified as semi-natural steppes and separated from 30 segetal steppes. The indicator species of the third level division are *Taeniatherum caput-medusae* (+), *Thymus sipyleus* (-) and *Bromus tomentellus*(-). As mentioned before, sites without an arable history are grouped under semi-natural steppes except for 3 replicates that will be mentioned later. As expected, most of those sites are at higher elevations than segetal steppes.

3.3.1.1.3 Subalpine Steppes

As representatives of semi-natural steppes, subalpine steppes are separated from semi-natural mountain steppes with the indicator species of *Astragalus plumosus* (+), *Thymus sipyleus* (-) and *T. migricus* (+).

10 sites classified as subalpine steppes (see Figure 3.4. as an example) are located between 1940-2450m above sea level. All of them are sampled in Yamadağ which differs from other high elevation sites in some floristic elements. The dominant species are *A. plumosus*, *Festuca valesiaca, Juniperus communis, Thymus migricus, Prangos platychlaena* and *Bromus tomentellus*. Other positive preferentials are *T. pubescens, Minuartia juniperina, F. longipanicula* and *Phlomis linearis, F. callieri, A. gummifer* and *Helicrysum arenarium.* The negative preferentials of this group are *Stipa lessingiana* and *T.sipyleus*. Among the species recorded, *Silene oligotricha* deserves attention as an endemic and endangered species with nearest occurrences in Tunceli and Erzincan (Kandemir 2009).

Site 36, although located at the southern slopes of Yamadağ and very close to site 37, is not included in subalpine steppe group. Although many of the species are shared, presence of annual grasses of *Bromus cappadocicus* and *Taeniatherum caput-medusae* separates site 36 from subalpine steppe group. Because of arable land history dating back 80 years ago, it is grouped among segetal steppes.

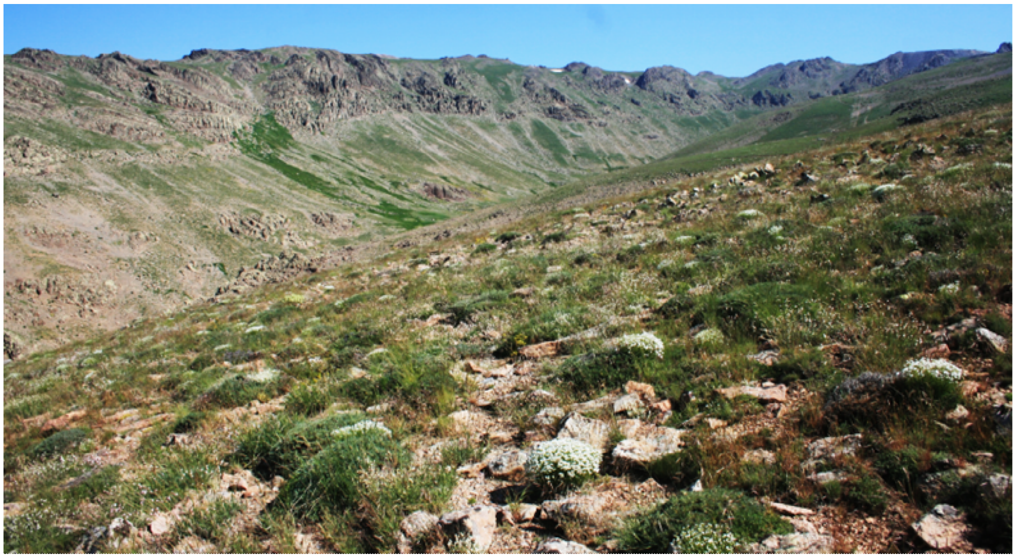


Figure 3.4 Photo showing subalpine steppes of Yamadağ both on milder (closer) and steep (distant) slopes.

Although located in subalpine zone i.e. 1966m high, site 61 in Hezanlı Mountain is not classified under subalpine steppes. This site does not have many species common to the group. For example instead of *Astragalus plumosus* or *A. gummifer*, this site has *A. condensatus* and *A.microcephalus*. It does not have *Bromus tomentellus or Festuca valesiaca* that are common at other sites. Instead of *Thymus migricus* and *T. pubescens*, it has *T. sipyleus*. These findings indicate that there may be floristic differences among subalpine steppes of Yamadağ and other subalpine sites. Abundance of *Prangos* species on steep slopes as an example of the giant umbellifer dominated mountain vegetation of East Anatolia and Iran (Davis 1965, Noroozi 2008), abundance of species of East Anatolian origin such as *T. migricus, T. pubescens* and *P. platychlaena*, and occurrence of a rare taxon of East Anatolia such as *Silene oligotricha* indicates that Yamadağ forms the boundary between Central and Eastern Anatolia in terms of floristics. Further sampling is needed to find whether the difference is significant enough to make a regional delimitation.

3.3.1.1.4 Semi-Natural Mountain Steppes

21 replicates are classified as semi-natural mountain steppes. All of them except two do not have any arable history. If they had been farmed, it must be earlier

than 150-200 years ago, since there are no signs in the field or no knowledge of it in the collective memory of the local people. All of these sites were oak or juniper shrublands before they were destroyed more than 70 years ago. The dominant species today are *Bromus tomentellus* and *Thymus sipyleus*. Other common species are *Stipa lessingiana, Festuca valesiaca, Koeleria cristata, and* various *Astragalus* species such as *A. microcephalus, A. gummifer, A. condensatus* as well as annual grasses such as *Aegilops triuncialis* and *A. umbellulata.*

Such steppes are marked with high diversity of forbs: composits such as *Centaurea virgata, Helichrysum pallasii, Chardinia orientalis, Achillea wilhelmsii*; legumes such as *Ebenus laguroides, Genista albida, Hedysarum pestalozzae* and *H. varium, Onobrychis armena*; labiates such as *Marrubium globosum, Salvia caespitosa, S. cryptantha* and *S. multicaulis, Scutellaria orientalis, Stachys lavandulifolia, Teucrium chamaedrys, T. polium, Phlomis oppositiflora, P. physocalyx*; members of Caryophyllaceae such as *Minuartia hamata, Arenaria ledebouriana, Silene supina* and other forbs such as *Globularia trichosantha, Gallium verum* and *G. incanum; Fumana procumbens, Helianthemum canum* and *H. salicifolium, Linum flavum, Polygala anatolica, Reseda lutea, Sanguisorba minor, Convolvulus assyricus* and *C. compactus, Onosma bornmuelleri* and *Veronica multifida*. Presence of annual species like *Bromus japonicus* and *B. tectorum* at some sites indicate the ruderal character of those sites. The shrubs *Berberis crataegina, Juniperus oxycedrus, J. excelsa* are recorded at some of the sites, which indicate the forest history.

Among the semi-natural steppes, only Replicate 1CB and site 40 are recorded to have recent arable history i.e. 30 years of abandonment and a decline in livestock numbers from 2000 to none. These two sites do not have segetal elements with more than 5% coverage. Instead, they have some shrubby elements. They are also surrounded by open shrubland. This may indicate that succession is faster at those sites and they have already passed the segetal stage. The common features of those two sites are development on deep brown soils, a decline in grazing intensity from 2500-3000 livestock heads to 100-0, and high landscape diversity. These features can provide favorable conditions in terms of a large seed bank and high nutrient availability, leading to an accelerated rate of successional change.

Site 2 (Figure 3.5) is found to be the most different among mountain steppes. It is distinguished by absence of many perennial grass species characteristic of mountain steppes. The site is a secondary steppe after removal of woody vegetation for charcoal production. High coverage of tragacanthic plants such as *Astragalus gummifer*, *A. pycnocephalus* and a mat-forming species *Salvia multicaulis* are seen; also *Arenaria* sp. are widespread. This site has high tragacanthic and forb abundance among the mountains steppes.

Figure 3.5 An example of mountain steppes: Site 2

The second most different is site 61 at Hezanlı Mountain, differentiated from the rest of the group with an abundance of *Bromus tectorum*, an indicator and a negative preferential. As indicated before, although it is at 1966m elevation, it is not classified with subalpine steppes. The common species at the site are *Astragalus condensatus, A. microcephalus* and *Thymus sipyleus.* Grasses such as *Elymus lazicus*, *Bromus tectorum* and forbs such as *Silene supina* are widespread. Again many perennial grass species are absent and tragacanthic plants are dominant. This may be due to a history of overgrazing. In addition, the high nitrogen detected in the soil probably due to grazing and contributes to higher forb abundance.

The rest of mountain steppes are composed of 17 replicates. Most of the perennial grass species of Central Anatolia are represented at those sites although their coverage is not always high. Therefore this group of sites probably represents the natural state grassy steppes of Central Anatolia.

To understand the variability within the 17 replicates, they are analyzed with TWINSPAN and the replicates are forced to be separated further. The hierarchical branching of the TWINSPAN resulted in two groups separated with indicator species of *Stipa lessingiana* (-), *Koeleria cristata* (+), *Bromus tomentellus* (+), *Stipa holosericea* (+) and *Convolvulus assyricus* (+). The eigenvalue of the division is 0.5727 which shows that it is a weak division due to high similarity between the groups. The groups differ in their land use history, homogeneity and shrub density.

Figure 3.6 Photo showing swards of *Stipa holosericea, Koeleria cristata, Bromus tomentellus, Festuca valesiaca* together with *Asphodeline* sp. at the site 6.

- In the positive group are the sites 5, 6 (see Figure 3.6), 8 and 18SO replicate which share common species of *S. holosericea, T. sipyleus, B. tomentellus* and *K. cristata*. In addition *C. assyricus* and *C. compactus, Centaurea virgata* and other 16 forb species; a few *Astragalus* sp., *Acantholimon caryophyllaceum,* and few perennial grasses like *Festuca valesiaca* are seen with more than 5% coverage. They are homogenous shrubless steppes located between 1400-1700m on brown soils, except for 18SO (on basaltic soil).

- In the negative group (sites 27, 32, 40, 50 and replicates 1CB, 20SO) more forbs (37 species) and annual grasses are seen. The dominant species are *Stipa lessingiana, Bromus tomentellus* and *Thymus sipyleus*. These sites have various forbs, all of which with very low coverage and constancy. *Aegilops triuncialis, Bromus japonicus* and *Festuca valesiaca* are other abundant grasses whereas *Teucrium polium, Minuartia hamata* and *Hedysarum varium* are widespread species of this group. *A. condensatus, A. lamarckii* and *A. cymbibracteatus* are seen though none of them has high coverage. Their elevations range between 1200-1800m, on sedimentary rock. Some of them have arable history dating back to 30 years. The sites are more heterogeneous than the negative group with many shrubs. Among this group, site 27 has two important species that are not found at other surveyed sites: a characteristic species of Central Anatolian plain steppes i.e. *Artemisia spicigera* and *Krascheninnikovia ceratoides.* Since it shares other species such as *T. sipyleus* and *B. tomentellus,* it is classified as mountain steppe.

Segetal Steppes

30 replicates are classified as segetal steppes and differentiated from the semi-natural steppes with the presence of *Taeniatherum caput-medusae,* and the absence of *Bromus tomentellus* and *Thymus sipyleus*. *Taeniatherum caput-medusae,* medusahead, is an annual grass well-known as exotic weeds invading grasslands in North America (Blank and Sforza 2007).

The segetal steppes are divided into two main groups as old segetal steppes in the positive group and young segetal steppes in the negative group. The indicator species of the division are an annual grass *Aegilops umbellulata* (+) and an annual forb, wild carrot, *Daucus carota* (+). Other positive preferentials are mostly annual legume species such as *Trifolium campestre, T. lucanicum, Medicago rigidula, T. pauciflorum; Helianthemum ledifolium* and perennial forbs *Eryngium campestre, Salvia multicaulis, Phlomis kurdica*. Negative preferentials are mostly perennial species of semi-natural steppes such as *Astragalus gummifer, A. plumosus, Festuca callieri, F. valesiaca, Koeleria cristata, Sanguisorba minor, Stipa holosericea, Thymus migricus* and finally an annual grass *Aegilops triuncialis*. Below given are some information about the subgroups.

Although it is not possible to delineate these two groups by an absolute length of successional history, the young segetal steppes are usually abandoned less than 30 years ago whereas older ones are generally abandoned 30-70-(100) years ago, with some older and younger exceptions: Four of the old segetal steppes are reported to be abandoned only 6 to 20 years ago. There are two possible explanations of this discrepancy: either the steppes experienced accelerated succession or the information about land use is wrong. These sites are on very deep or deep brown soils or brown forest soils on volcanic rocks. The grazing intensity declined from ten thousands to a few hundreds. Such properties are not found for other segetal sites of 30 or younger age.

3.3.1.1.5 Old Segetal Steppes

23 replicates are grouped together with absence of indicators *A. umbellulata* and *D. carota*; presence of the negative preferentials of the segetal division *Aegilops triuncialis, Festuca valesiaca, Thymus migricus, Astragalus gummifer, Koeleria cristata, Stipa holosericea, A. plumosus, Sanguisorba minor* and *F. callieri*. They are perennial species usually seen in semi-natural steppes and their presence indicates segetal vegetation becoming semi-natural with the succession. The dominant species of this group are *Taeniatherum caput-medusae*; other dominants are recorded as *Aegilops triuncialis, Xeranthemum anuum, A. gummifer, A. kurdica, A. plumosus, T. migricus, Festuca callieri, Phlomis rigida* and *Medicago varia*.

The old segetal steppes (see Figure 3.7 as an example) can be examined in detail based on a further classification summarized below. The groups show a gradient between segetal and semi-natural steppes. They may indicate different successional stages or alternative states between semi-natural and young segetal steppes.

- Seven replicates (sites 10, 15, 18 and 36SO replicate) are grouped with presence of *A.plumosus* and *Festuca valesiaca*. The common features are low coverage of annual grasses like *Taeniatherum caput-medusae*; high coverage of perennial grasses like *Festuca valesiaca* and *Stipa holosericea*; higher coverage of *Astragalus* sp. like *A. plumosus, A. lamarckii, A. kurdicus*; high coverage of members of Lamiaceae family like *Phlomis rigida*, *P. kurdica*, *Salvia multicaulis,* appearance of different forbs that were not seen in young segetal steppes such as *Minuartia hybrida, Arenaria ledebouriana, Stachys lavandulifolia, Galium verum* and *Sanguisorba minor.* The sites, located 1500-1700m elevation, were ploughed until 60-100 years ago.

Figure 3.7 Site 26 as an example of old segetal steppe

- 10 replicates (sites 4, 7, 7A, 16, 3SE and 36CB replicates) are grouped with common annuals of *T. caput-medusae, Xeranthemum annum, Centaurea virgata, C. solstitialis, Bromus tectorum, Crepis sancta*. The common *Astragalus* and perennial grass species are similar to the group explained above. Additionally, forbs such as *Coronilla orientalis, Teucrium chamaedrys, Arenaria acerosum, Thymus migricus, Helianthemum ledifolium* and *Potentilla recta* are common. They contain arable lands abandoned 30-120 years ago but grazed afterwards. These sites have still a high coverage of annuals though they were abandoned 30 to 80 years ago. Their elevations range between 1600-1850m. Soils are moderately deep to deep. The group is quite similar to the one above in environmental parameters. The main difference is much higher past livestock levels than the first group.

- Five replicates (sites 41, 26 and 42SO replicate) are grouped with presence of *Aegilops triuncialis* and *Helianthemum ledifolium* and absence of *Astragalus plumosus* (+) and *Festuca valesiaca*. *Taeniatherum caput-medusae* is dominant and *Aegilops triuncialis* is present at all sites. There are few *Astragalus* sp., few annual grasses, many annual forbs and few perennial species. In addition, *Quercus pubescens* or planted apple *trees* are seen at two sites. All of them are low elevation (1285-1340m) plains at valley bottoms that were oak woodland long ago as shrubs are still found surrounding the sites. They are all quite dry. They were used as cereal fields approximately 40 years ago and experienced moderate or low grazing later. Among the three groups, it is closest to young segetal steppes.

3.3.1.1.6 Young Segetal Steppes

Seven replicates (sites 25, 33 and replicates 34SO, 20CB and 42CB) are classified as young segetal steppes. *Aegilops umbellulata* and *Taeniatherum caput-medusae* are two species common to members of this group. *Eryngium campestre, Helianthemum ledifolium, Trifolium campestre, T. hirsutum, T. lucanicum, T. pauciflorum* are other species commonly seen at those sites. Although the dominant species changes, it is either an annual grass or a legume in each replicate. The subgroups of young segetal steppes are as follows:

- Site 33 and 20CB (explained before) are sites on the flat plain with a recent arable history of up to 10 years. *Aegilops umbellulata* and *Taeniatherum caput-medusae* are present at all the sites. *Salvia multicaulis* (+) is the indicator species of this subgroup. The site 33 continues to experience heavy grazing as presence of *Eryngium campestre, Euphorbia macroclada* and *Gundelia tournefortii* shows. The 20CB site appear to be at a more advanced successional stage with few individuals of *Astragalus chthonocephalus,* *Hedysarum varium, Medicago rigidula, Minuartia hamata*, two *Onobrychis* species and *Vicia villosa*.

- The other subgroup of this group is composed of site 25, 42CB and 34SO replicates. *Taeniatherum caput-medusae* is found in all the sites whereas *Daucus carota, Trifolium campestre, T. lucanicum and T. pauciflorum* are found in most sites. Many other annual legumes such as *T. hirtum, Trigonella spruneriana, Medicago rigidula* and *Lotus gebelia* also occur. Site 25 has 30 years of arable history with crops of cereals and chick pea. 42CB replicate (Figure 3.8) has been abandoned as arable land 100-120 years ago but a land slide caused secondary succession to take place and the ground to be dominated by annuals again.

Figure 3.8 42CB replicate as an example of recently-formed segetal steppe

3.3.1.2 Clustering of Sites based on Plant Data

As it is explained in the methodology, TWINSPAN is based on indicator species analysis. On the other hand, it is also useful to group sites according to overall distances and similarities based on plant data. To do so, a clustering analysis using Relative Sorensen distance and Group Average Linkage algorithm was performed (see the result in Figure 3.9). The results of clustering are summarized below with reference to TWINSPAN results:

- The resultant outliers are same: gypsiferous steppe is the overall outlier and alpine meadow site is the next most different site.
- The steppes are divided into two main groups: Steppes with common plants of *Thymus sipyleus, Stipa lessingiana, Bromus tomentellus,* and to lesser extent *Aegilops triuncialis*. There are 19 replicates in this group. Most of those sites were classified as semi-natural steppes by TWINSPAN but they are mixed in terms of land use history, and less homogenous than the respective TWINSPAN group. The other group is composed of sites with shared plants of tragacanthic *Astragalus* sp. and annual grasses:
    - Steppes with common plants of *Astragalus plumosus, Festuca valesiaca* and *Thymus migricus.* Among those are subalpine steppes, 4 replicates of old segetal steppes and one replicate of mountain steppes, 14 replicates in total.
    - Steppes of earlier successional stage are grouped by shared plants of *Aegilops umbellulata* and *Taeniatherum caput-medusae.* The steppes with *T. caput-medusae, Astragalus plumosus, A. gummifer* are grouped and linked to the younger steppes but the distinction in terms of age is not as clear as in the TWINSPAN analysis.
    - The groupings are difficult to explain in terms of environmental properties. In addition, they are not as homogenous as TWINSPAN in terms of environmental or land use properties. Therefore, using results of the replicate-level TWINSPAN analysis has greater value.

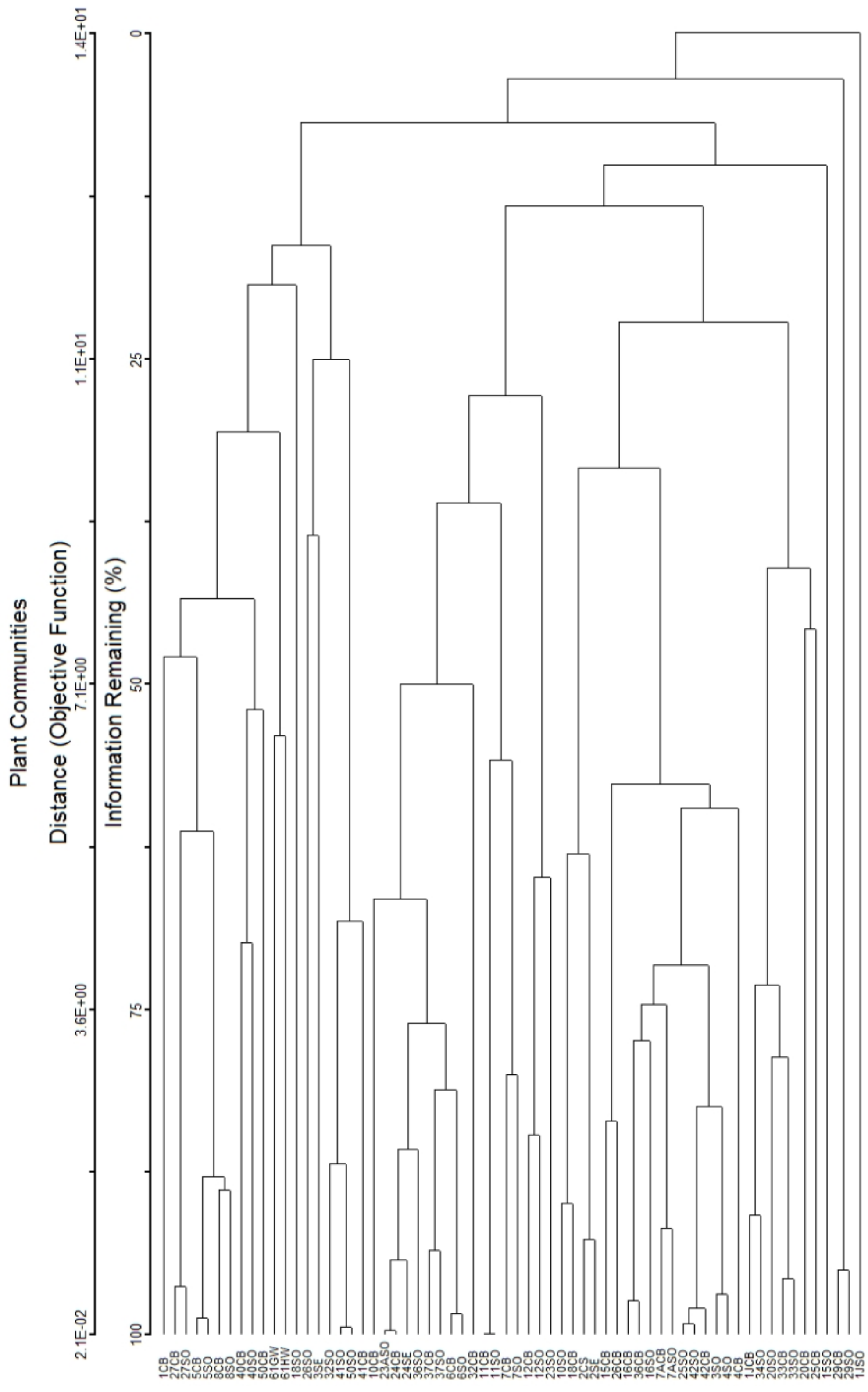


Figure 3.9 Dendogram of plant data based on relative Sorensen distances.

3.3.1.3 Detrended Correspondence Analysis with Plant Functional Types

Until now the results presented were based on species-level data. But plant functional types can give good inference about steppe community types identified with TWINSPAN analysis. The results of detrended correspondence analysis with plant functional types are given in Figure 3.10.

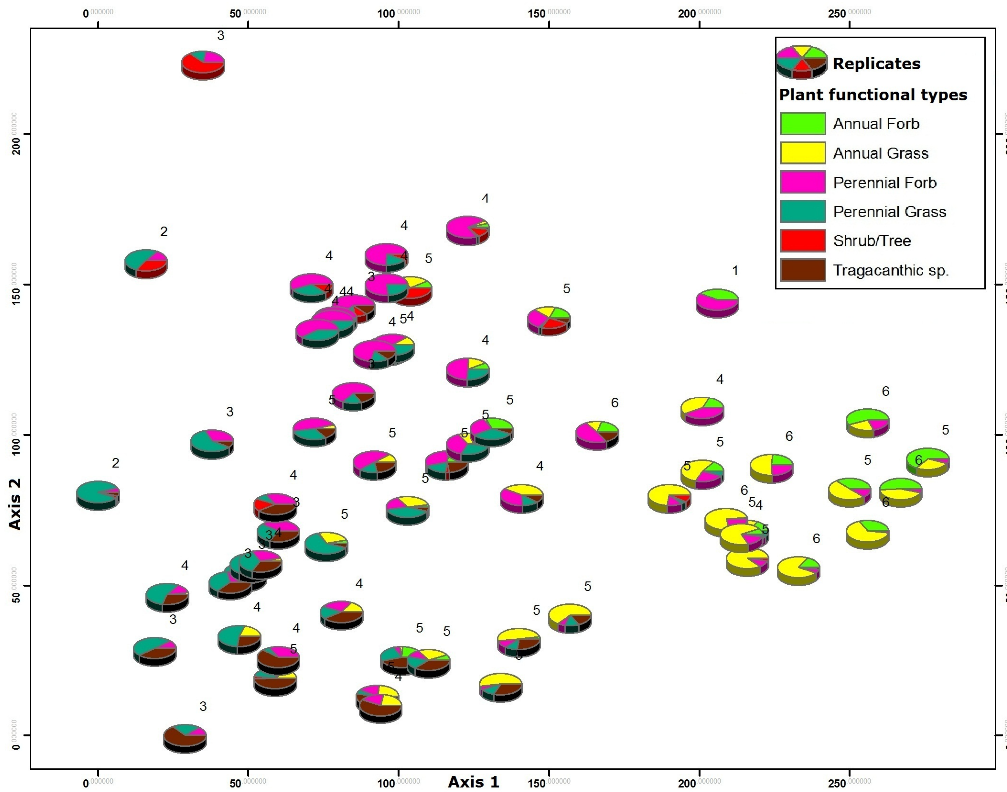


Figure 3.10 Ordination space delimited by first two axes of detrended correspondence analysis with plant functional types *(Plant communities are indicated as labels 1: gypsiferous steppes, 2: alpine meadows, 3: subalpine steppes, 4: semi-natural steppes, 5: old segetal steppes, 6: young segetal steppes).*

As it is seen in the graph the segetal steppes are separated at the end of first axis with dominance of annual grasses and forbs. Towards the origin the annuals are replaced by perennial grasses, forbs and tragacanthic species as seen in old segetal steppes. Subalpine steppes and some of the semi-natural steppes are dominated by those three functional types. Some of the old segetal and semi-natural steppes are differentiated at the end of second axis with abundance of shrubs or trees. Furthermore some of them are good mixture of annual and perennial species together with good representation of tragacanthic species. The gypsiferous steppes and alpine meadows are not well-differentiated by the plant functional types.

3.3.1.4 Canonical Correspondence Analyses

3.3.1.4.1 Environmental Factors Effective on Plant Communities

To understand the most important environmental factors for the observed variance in plant species data, data is subjected to canonical correspondence analysis (CCA). The statistics is given in Table 3.4 and ordination of sites on the space of first two axes is given in Figure 3.11.

Table 3.4 Statistics of CCA based on plant and environmental data

Total variance	15.9916	
Percent variance	15.2	
Eigenvalues	0.909, 0.804, 0.711 (in axis order)	
Environmental variables with highest contribution to the axes *(Standardized canonical coefficients in parenthesis)*		
First axis	**Second axis**	**Third axis**
Humidity (2.726)	Mean temperature of warmest quarter(3.849)	Mean temperature of the coldest quarter (7.540)
Mean temperature of coldest quarter (2.714)	Precipitation of driest quarter (3.380)	Mean temperature of warmest quarter(-9.351)
Landscape diversity at 2km (-1.303)	Years since abandonment (-1.787)	
Current livestock density (-1.098)	Humidity (-1.772)	
Elevation (-1.031)	Old cereal field (-1.740)	

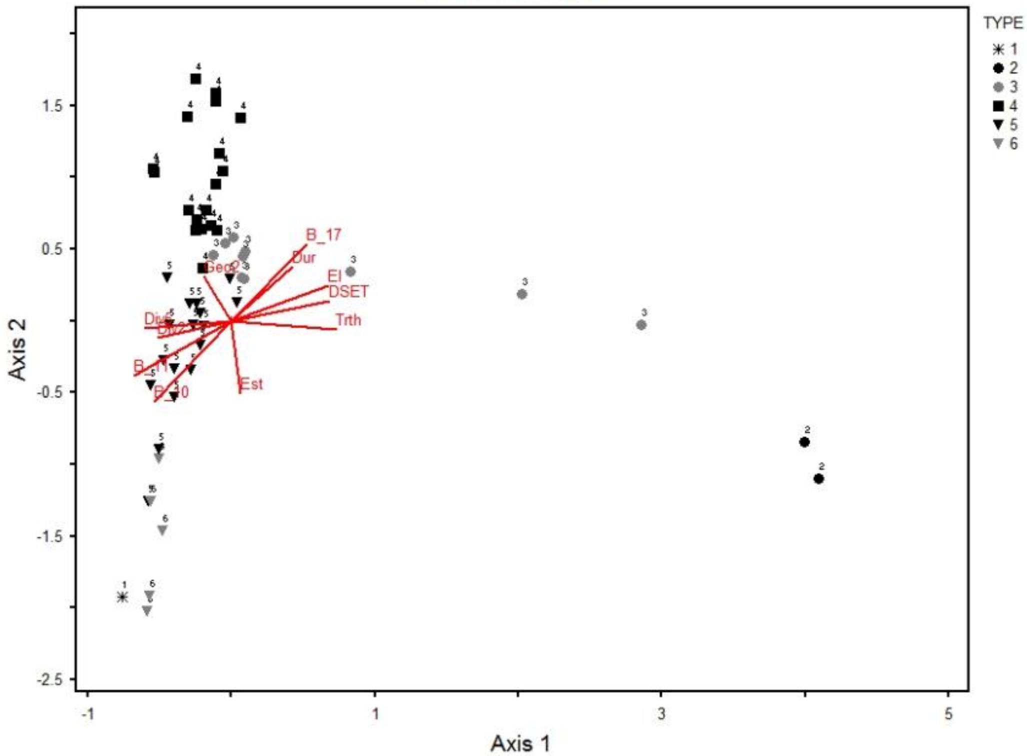


Figure 3.11 Ordination of plant data in the first two axes (the community types are: 1: gypsiferous steppe, 2: alpine meadows, 3: subalpine steppes, 4: semi-natural steppes, 5: old segetal steppes, 6: young segetal steppes. Environmental variables indicated are B17: precipitation of driest quarter, El: elevation, Est: eastness, DSET: distance to settlement, Trth: Thornthwaite precipitation effectiveness index indicating humidity, Dur: years since land abandonment, B10: mean temperature of warmest quarter, B11: mean temperature of coldest quarter, Div5: landscape diversity at 5 km, Div 2: landscape diversity at 2 km, Geo2: Sedimentary rocks)

The humidity calculated with Thornthwaite precipitation effectiveness index and other climatic limiting factors and land use are the main determinants of the ordination space. Humidity was the main factor in separation of alpine meadows and 2 nearest subalpine steppes. Mean temperature of the warmest quarter determined mostly the segetal steppes. Precipitation in the warmest quarter (i.e. summer rains) defines suitable places for semi-natural steppes, probably due to temperatures being neither warm enough for agriculture nor cold enough for typical alpine vegetation. As expected, the arable land use history, represented by the parameter "time since land abandonment" differentiates between alpine, subalpine and semi-natural or segetal steppes of two types. Current livestock density contribute to the first axis since alpine-subalpine environments are used more intensively by livestock in the transhumance tradition.

The same variables determined predominantly the axes. This shows both the importance of those variables for plant variation. But together with the low percent variance explained, it may mean at the same time that there may be other site-level i.e. historical, species pool parameters important for the communities but not covered in the data set.

When the analysis is repeated after removing alpine meadows and 2 nearest subalpine steppes appeared as outliers, the ordination shows better separation of the sites. The related statistics is given in Table 3.5.

Table 3.5 Statistics of CCA based on plant and environmental data without alpine meadows and two subalpine steppes

Total variance	14.2992	
Percent variance explained	15.5%	
Eigenvalues	0.811, 0.714 and 0.689 (in axis order)	
Environmental variables with highest contribution to the axes ***(Standardized canonical coefficients in parenthesis)***		
First axis	**Second axis**	**Third axis**
Mean temperature of warmest quarter (4.336)	Current livestock density (2.371)	Mean temperature of the warmest quarter (11.441)
Precipitation of driest quarter (3.655)	Land use in terms of crop type(-4.543 and -3.061)	Mean temperature of coldest quarter (-10.624)
Years since land abandonment (-1.494)	Years since land abandonment (-4.259)	
Land use in terms of crop type (-1.272 and -1.103)		
Volcanic rocks (-1.172)		

The main determinants of ordination space are climate and land use on the sites. Mean temperature of the warmest quarter and precipitation of the driest quarter determined the first axis dominantly. Whereas current livestock density, crop type cultivated in old arable lands and time since abandonment are main determinants of the second axis. The plant community types are differentiated mainly by the first two axes (see Figure 3.12):

- Gypsiferous steppes are separated due to gypsum bedrock.
- The subalpine steppes are located along an elevation gradient on volcanic rocks where NDVI and temperature annual range increase with elevation.
- Most semi-natural steppes are located at the higher end on a precipitation gradient of the driest quarter.
- Old segetal steppes are located opposite to semi-natural steppes, i.e. on the first two axes semi-natural steppes got positive scores whereas old segetal steppes got negative scores, fusing towards the origin.
- Young segetal steppes are located in the ordination space indicated with arable land history where mean temperature of the coldest quarter is high.

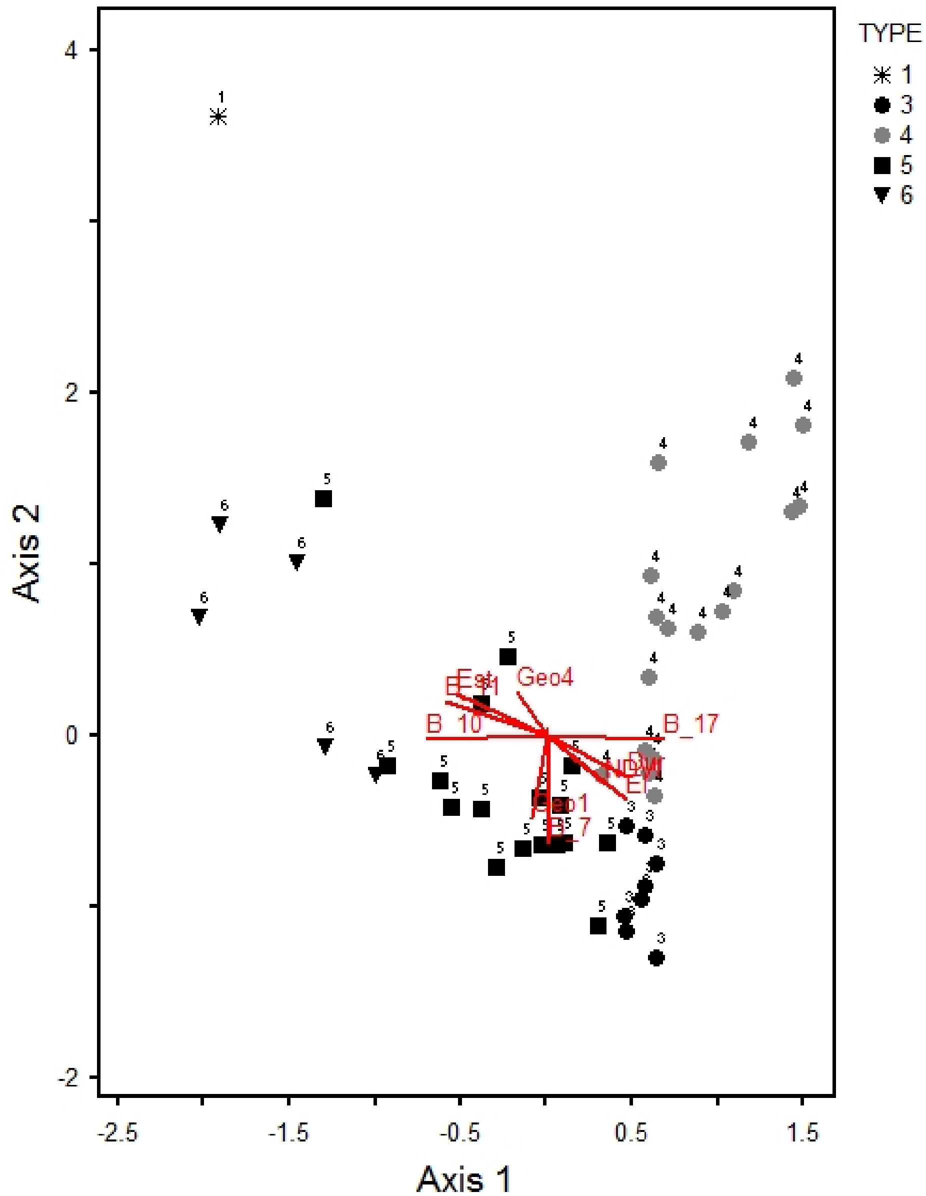


Figure 3.12 Ordination of plant data without alpine meadows and 2 subalpine steppes in the first two axes (the community types are: 1: gypsiferous steppe, 3: subalpine steppes, 4: semi-natural steppes, 5: old segetal steppes, 6: young segetal steppes. Environmental variables indicated are El: elevation, B17: precipitation of driest quarter, B10: mean temperature of warmest quarter, B11: mean temperature of coldest quarter, Est: eastness, Dur: years since land abandonment, B7: temperature annual range Geo1: Volcanic rocks, Geo 4: Gypsum rocks, NDVI: productivity index)

The removal of gypsiferous steppe and repeating the analysis results in a better dispersion of the 4 main community types (see Figure 3.13) in the ordination space.

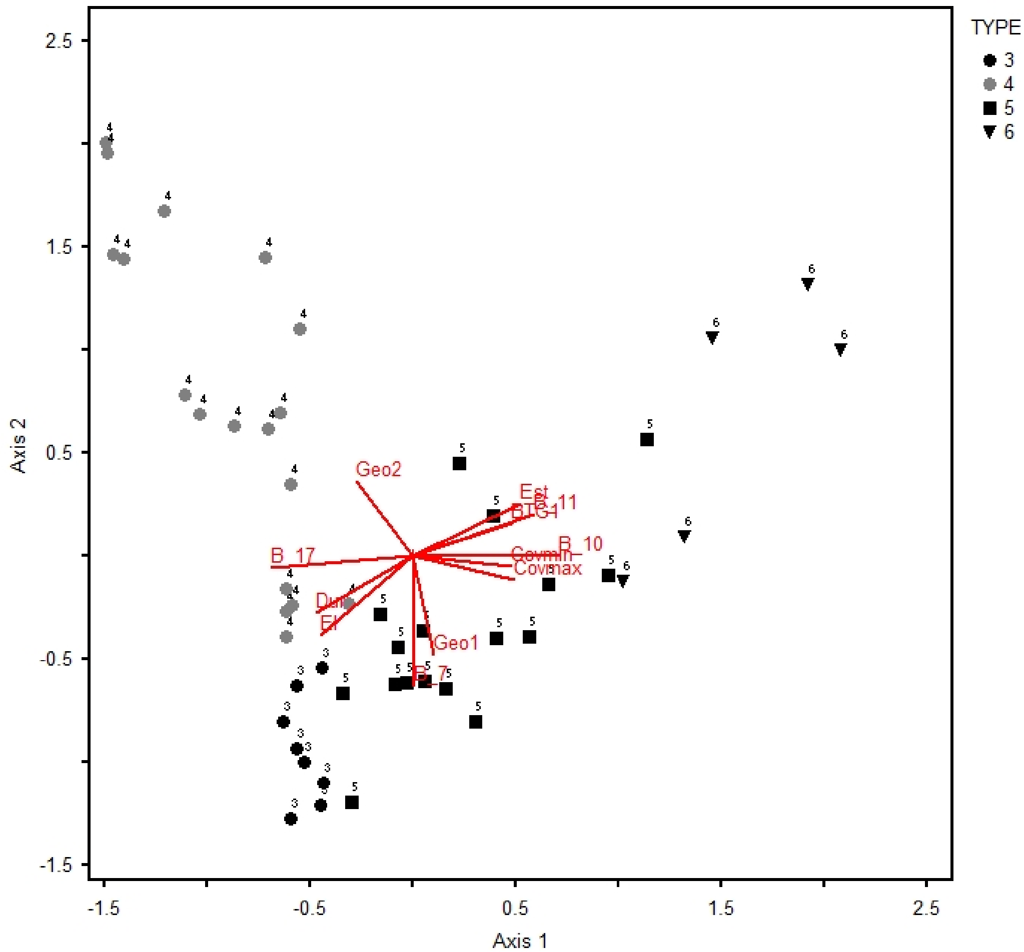


Figure 3.13 Ordination of plant data without alpine meadows, two subalpine steppes and gypsiferous steppes in the first two axes (the community types are 3: subalpine steppes, 4: semi-natural steppes, 5: old segetal steppes, 6: young segetal steppes. Environmental variables indicated are El: elevation, Est: eastness, DSET: distance to settlement, Trth: Thornthwaite dryness index, Dur: years since land abandonment, B 10: mean temperature of warmest quarter, B 11: mean temperature of coldest quarter, B 17: Precipitation of Driest Quarter, B 7: Temperature Annual Range, Geo 1: Volcanic rocks, Geo2: Sedimentary rocks, BTG 1: Alluvial soils, Covmin: Average minimum herbaceous vegetation cover, Covmax: Average maximum herbaceous vegetation coverage)

The subalpine and semi-natural steppes are differentiated from segetal steppe mainly with higher elevation and higher precipitation in the driest quarter. Segetal steppes have less years since abandonment, higher average minimum and maximum coverage, higher mean temperatures for warmest and coldest quarters. Those climatic conditions indicate actually the suitability of land for crop production. The semi-natural steppes occur mostly on sedimentary rocks which is the main bedrock type of the montane zone of the region. Yamadağ, the main volcanic body in the region, is sampled mainly for alpine and subalpine zones. The young segetal steppes occur where mean temperature of the coldest quarter is highest. The young segetal steppes are differentiated with highest maximum and minimum coverage whereas old segetal steppes occur at sites with mean temperature on the warmest quarter temperature gradient. The statistics of the analysis is given in Table 3.6.

Table 3.6 Statistics of CCA based on plant and environmental data without alpine meadows, two subalpine steppes and gypsiferous steppe

Total variance	13.6956	
Percent variance explained	15.9	
Eigenvalues	0.810, 0.712 and 0.651 (in axis order)	
Environmental variables with highest contribution to the axes ***(Standardized canonical coefficients in parenthesis)***		
First axis	**Second axis**	**Third axis**
Time since land abandonment (2.528)	Mean temperature of coldest quarter (4.761)	Mean temperature of coldest quarter (4.331)
Old cereal field (2.350)	Mean temperature of warmest quarter (-8.624)	Mean temperature of warmest quarter (-4.865)
Mean temperature of warmest quarter (-5.513)		
precipitation of driest quarter (-4.359)		

The low "percent variance explained" shows that most of the variance in species data cannot be explained with the environmental parameters used. The possible reasons for that are: (i) high diversity of sites, (ii) microsite variations in the environmental conditions that are not reflected in environmental data (iii) soil parameters not used in the analysis. The results of analysis with soil data can be found below.

3.3.1.4.2 Soil Factors effective on Plant Communities

To understand the effect of different soil properties, a Canonical Correspondence Analysis (CCA) was performed for site with both plant and soil data (see Appendix G for soil data). All the soil factors except Total Nitrogen is used. Since only a few sites have the total nitrogen data, it will be considered separately.

The first CCA resulted in explanation of 17.5% variance in species data. The eigenvalues of the axes are 0.898, 0.856 and 0.760, respectively. Gypsiferous steppe, which is the outlier of most analyses, placed in extremes of the axes with highest Ca content, high values of salt content and electrical conductivity and lowest K_2O content. It has also higher values of field capacity and other related soil water parameters.

The second CCA after removing gypsiferous steppes from the data set resulted in positioning of alpine meadows and two subalpine steppes in extremities of first axis with the highest organic matter, high silt content and loam soils. The eigenvalues are 0.894, 0.835, 0.744 respectively and 18.5 percent of the variance in species data is explained.

One more CCA with elimination of those replicates finally gave a better picture of variance. The statistics of the results are given in Table 3.7.

Two replicates are separated from the rest of the sites: Hezanlı site (61GW) is found to be different from the rest in the ordination space due to lithozolic soil, high organic matter, high values of Ca PCA. 33CB replicate is separated in the first axis with a high Ca PCA. The subalpine steppes are placed in lithozolic soils rich in organic matter. The communities vary along the organic matter gradient with highest levels of in subalpine steppes followed by semi-natural steppes, old segetal steppes and young segetal steppes in order, with few exceptions. The communities follow a weaker soil depth gradient with lowest soil depth under subalpine steppes. The salt content increases towards semi-natural steppes and two young segetal steppes.

Table 3.7 Statistics of CCA based on plant and soil data without alpine meadows, two subalpine steppes and gypsiferous steppes

Total variance	11.7434	
Percent variance explained	19.4	
Eigenvalues	0.839, 0.751, 0.689 (in axis order)	
Environmental variables with highest contribution to the axes ***(Standardized canonical coefficients in parenthesis)***		
First axis	**Second axis**	**Third axis**
Soil water PCA (0.68)	Ca PCA (1.111)	Lithozolic soils (1.302)
Clay soils (0.614)	Organic matter (1.075)	Soil water PCA (-1.331)
Cation exchange capacity (-0.786)	Sand and clay PCA (-0.857)	
Shallow soils (-0.638)		
Silt content (-0.599)		

According to CCA statistics, the most important soil parameters for differentiating plant communities are soil water PCA, soil texture contents and clay soils as a soil class, cation exchange capacity, organic matter and lithozolic or shallow soils as soil depth. Based on the results of Mann-Whitney tests with 0.05 significance level, the soil factors found to be distinctive for plant communities can be summarized as follows (see Figure 3.13):

- Subalpine steppes are located where the soil is lithozolic and organic matter is high. This is an expected result since those sites occur on steep slopes of very high elevations. The alpine meadows and subalpine steppes differ from other plant communities in the soil properties listed below:
    - Calcium levels are significantly lower in alpine meadows and subalpine steppes. The parameters related with Ca content have lower values: electrical conductivity, pH at saturation and salt content. In addition, $CaCO_3$ content is zero. Those results are probably due to the volcanic bedrock as an important soil forming factor at those sites.
    - Clay content is lower and the silt content is higher in alpine meadows and subalpine steppes. Accordingly, field capacity and saturation are higher; volume weight is lower than other plant communities.
    - Magnesium content is lower than in other plant communities.
    - P_2O_5 amount and organic matter is higher than in other plant communities.

- The semi-natural steppes have higher lime content than segetal steppes and the pH at saturation is higher compared to segetal steppes. The segetal steppes have low organic matter and moderately deep soils.

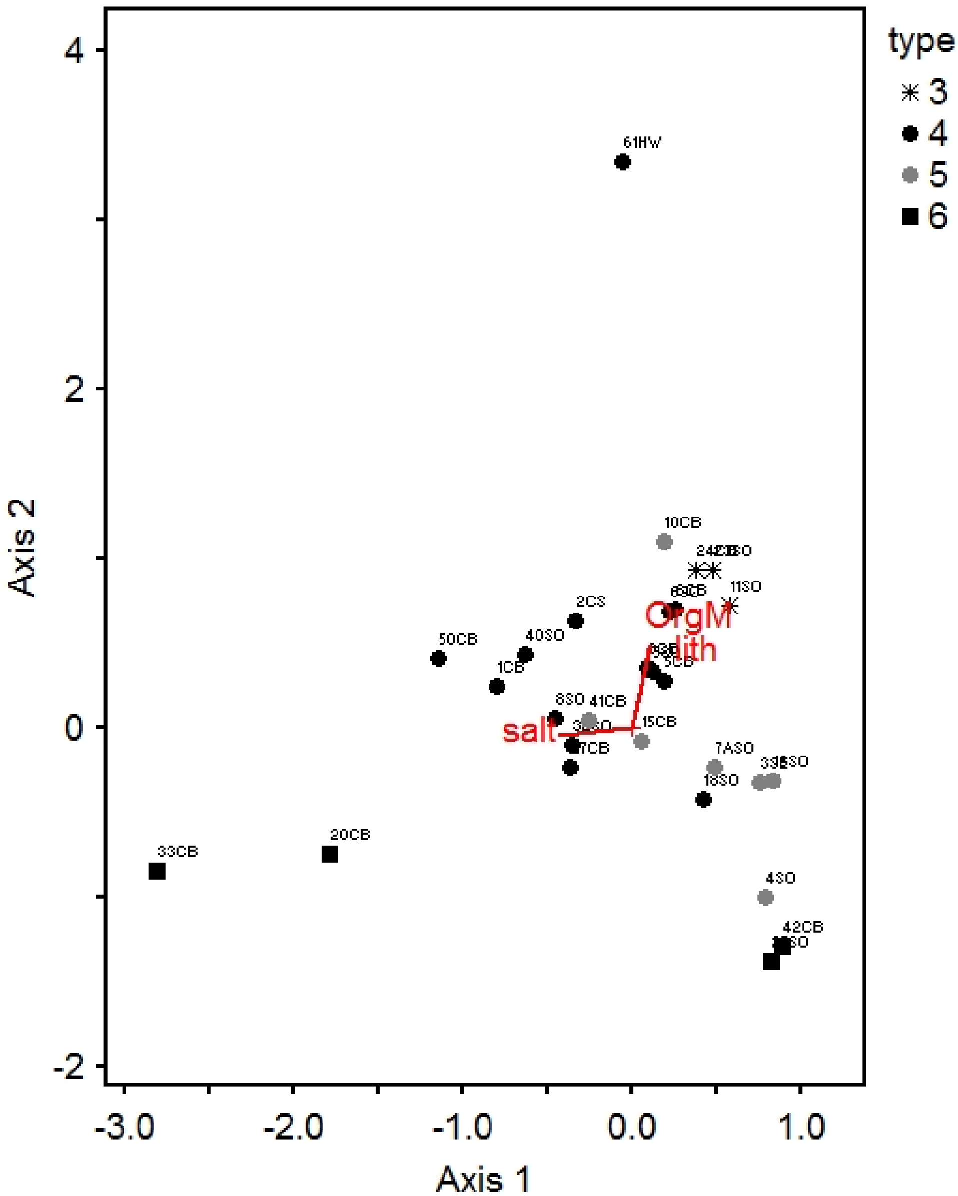


Figure 3.14 The ordination space of first two axes obtained with plant and soil data sets without alpine meadows, two subalpine steppes and gypsiferous steppes (Plant community types are indicated as 3: subalpine steppes, 4: semi-natural steppes, 5: old segetal steppes, 6: young segetal steppes. The environmental variables are coded as OrgM: organic matter, lith: lithozolic soils, salt: Ca, salt and related parameters)

3.3.2 Bird Assemblages of Steppes

3.3.2.1 Bird Assemblages of Steppes determined by TWINSPAN Analysis

The TWINSPAN analysis was done with bird data on replicate basis. It resulted in three level divisions and 8 end groups (see Figure 3.14). The naming is hierarchical and comparative between the groups of same division. Four main hierarchical groups are listed below:

A. Steppe bird assemblages of open, homogenous areas without woodlands in proximity

A.1. High mountain homogenous steppe bird assemblages

A.2. Homogenous montane steppe bird assemblages

B. Steppe bird assemblages of heterogeneous areas with woodlands or settlements in proximity

B.1. Bird assemblages of heterogeneous steppes of low wood density

B.2. Bird assemblages of heterogeneous steppes of high wood density

A summary of the results indicating indicator species, important environmental variables found with nearest neighbor classification and Mann-Whitney test is given below:

- The first division by skylark separates steppe bird assemblages of open, homogenous areas without woodlands in proximity and that of heterogeneous areas with woodlands or settlements in proximity. NDVI and precipitation in the driest period of the year discriminated two groups in nearest neighbor classification.
- Bird assemblages of high mountain homogeneous steppes and homogeneous montane steppes are divided by indicators of bimaculated lark, shore lark and corn bunting. Elevation, past livestock density and soil depth are found to be the splitters of K nearest neighboring. In addition, low shrub density, landscape diversity and features related with human-altered environments are significantly different between the two communities.
- The bird assemblages of heterogeneous areas with woods or settlements in proximity are divided by wheatear, hooded crow, nightingale, blackbird and crested lark reflecting wood density in and around the sites. Nearest neighboring classification separated the sites based on distance to trees and

homogeneity. Low wood density sites are wetter and colder with less shrubs and with more distance to settlements or trees. Landscape diversity is found to be different only at 2 km scale i.e. lower.

Below are the details of the results as indicator and common species of the assemblages, environmental properties of the sites supporting groups, significance of environmental differences according to Mann-Whitney test with 0.05 significance level. The relative abundance (number of individuals per replicate) of each species in bird communities is given in Table 3.8.

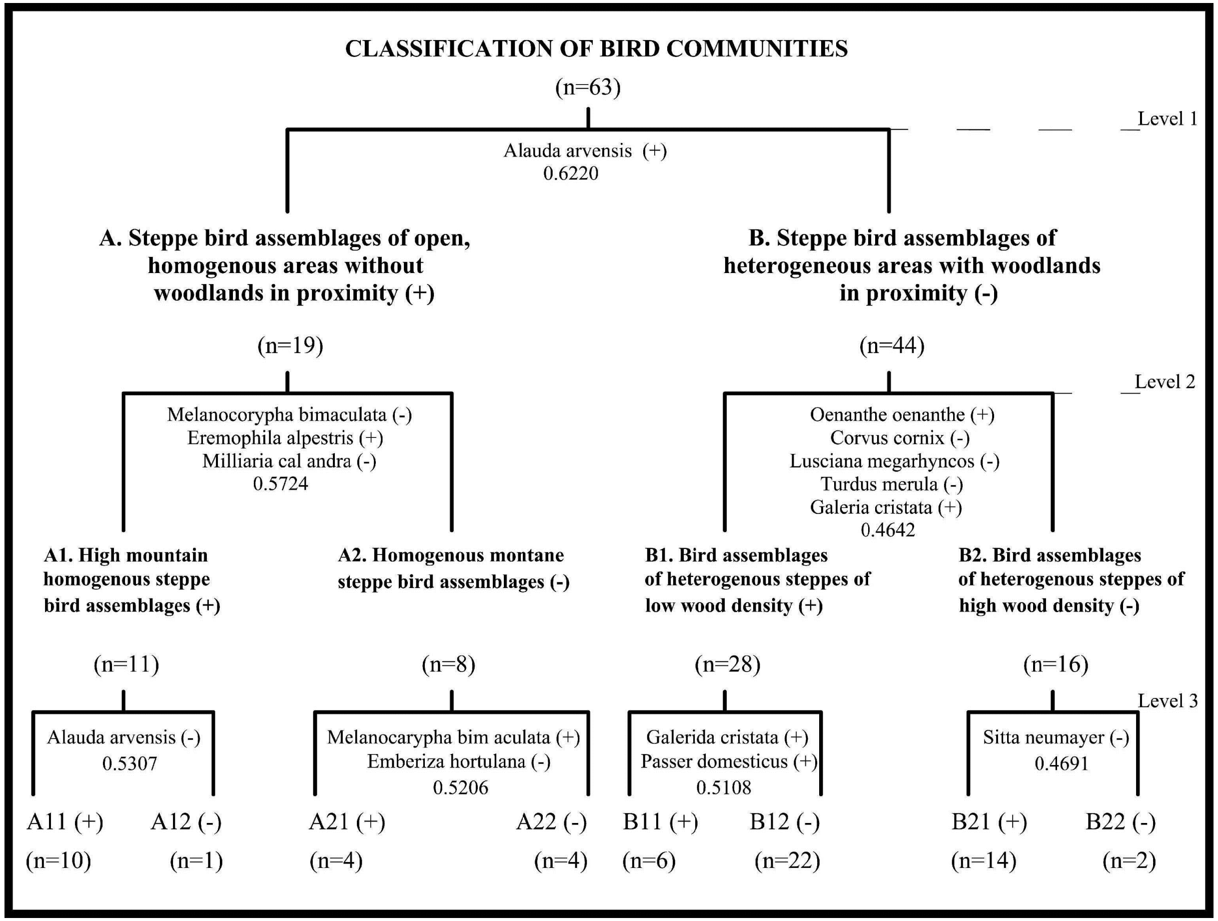


Figure 3.15 Dendogram obtained with TWINSPAN of common bird data (Division levels, indicator species and eigenvalues of divisions are given in the junction points; names of bird assemblages and number of units are given at each end point of dendogram)

Table 3.8 Percent abundance of bird species in each bird assemblage (codes starting with a letter stands for bird assemblages given in Figure 3.14).

Species	Percent abundance of bird species in each bird assemblage (species are listed alphabetically)							
	A11	**A12**	**A21**	**A22**	**B11**	**B12**	**B21**	**B222**
Accipiter brevipes	0.00	0.00	0.00	0.00	0.00	0.65	0.00	0.00
Acrocephalus arundinaceus	0.00	0.00	0.00	0.00	2.38	0.00	0.00	0.00
Alauda arvensis	**38.58**	0.00	**34.03**	**37.02**	0.00	0.00	0.79	0.00
Alectoris chukar	0.00	0.00	0.00	0.00	0.29	2.55	0.00	4.55
Anthus campestris	0.00	**8.33**	0.00	0.00	3.76	3.43	1.79	0.00
Anthus spinoletta	0.00	0.00	0.00	4.17	0.00	0.00	0.00	0.00
Buteo rufinus	0.00	0.00	0.00	0.00	0.00	1.07	0.00	0.00
Calandrella brachydactyla	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.00
Carduelis cannabina	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
Carduelis carduelis	4.17	**25.00**	8.33	0.00	1.39	5.96	2.68	0.00
Carpospiza brachydactyla	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.00
Clamator glandarius	0.00	0.00	0.00	0.00	0.00	0.91	0.00	0.00
Columba livia	5.00	0.00	0.00	0.00	3.57	0.91	0.00	0.00
Columba palumbus	1.25	0.00	0.00	0.00	0.00	0.00	1.30	0.00
Corvus cornix	0.00	0.00	0.00	0.00	1.19	1.14	6.16	21.21
Corvus monedula	0.00	0.00	0.00	0.00	0.00	2.73	0.00	0.00
Coturnix coturnix	0.00	0.00	0.00	4.17	0.00	0.57	0.89	0.00
Cuculus canorus	**14.92**	0.00	0.00	4.17	0.00	3.79	0.79	0.00
Dendrocopos syriacus	0.00	0.00	0.00	0.00	0.00	0.00	1.90	0.00
Emberiza cia	0.00	0.00	0.00	0.00	0.00	0.00	**5.83**	0.00
Emberiza cirlus	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.00
Emberiza hortulana	1.67	0.00	0.00	7.14	0.00	9.16	9.13	0.00
Emberiza melanocephala	0.00	0.00	2.78	7.74	7.62	**13.64**	**16.32**	9.09
Eremophila alpestris	**13.17**	**16.67**	0.00	0.00	0.00	0.00	0.00	0.00
Falco tinnunculus	5.00	0.00	0.00	5.00	0.29	1.72	0.89	0.00
Galerida cristata	0.00	0.00	0.00	0.00	**12.78**	4.30	0.00	0.00
Garrulus glandarius	0.00	0.00	0.00	0.00	0.98	0.00	3.57	0.00
Lanius collurio	0.00	0.00	0.00	0.00	0.00	0.00	4.08	0.00
Lullula arborea	0.00	0.00	0.00	0.00	0.00	5.21	3.21	0.00
Luscinia megarhynchos	0.00	0.00	0.00	0.00	8.33	0.00	5.67	0.00

Table 3.8 Percent abundance of bird species in each bird assemblage (Cont'd). (codes starting with a letter stands for bird assemblages given in Figure 3.14).

Species	**Percent abundance of bird species in each bird assemblage** (species are listed alphabetically)							
	A11	**A12**	**A21**	**A22**	**B11**	**B12**	**B21**	**B222**
Melanocorypha bimaculata	0.00	0.00	**49.31**	3.57	0.00	8.53	0.00	0.00
Melanocorypha calandra	**5.00**	0.00	0.00	0.00	0.00	0.00	0.65	0.00
Merops apiaster	0.00	0.00	0.00	0.00	0.00	1.87	0.00	0.00
Miliaria calandra	0.00	0.00	2.78	**14.88**	0.00	4.76	6.49	0.00
Monticola saxatilis	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.00
Motacilla flava	0.00	0.00	0.00	3.57	0.00	0.00	0.00	0.00
Oenanthe finschii	0.00	**8.33**	0.00	0.00	0.00	0.00	0.00	0.00
Oenanthe hispanica	0.00	0.00	0.00	0.00	0.00	0.57	4.07	**9.09**
Oenanthe isabellina	0.00	0.00	0.00	**8.57**	**10.50**	1.14	0.00	0.00
Oenanthe oenanthe	10.00	**25.00**	2.78	0.00	0.98	7.96	0.00	0.00
Oriolus oriolus	0.00	0.00	0.00	0.00	3.77	0.00	4.90	0.00
Passer domesticus	0.00	0.00	0.00	0.00	**32.59**	1.52	0.00	0.00
Passer hispaniolensis	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.00
Perdix perdix	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.00
Petronia petronia	0.00	0.00	0.00	0.00	0.00	4.37	0.00	0.00
Phoenicurus ochruros	1.25	0.00	0.00	0.00	0.00	1.07	0.00	0.00
Pica pica	0.00	0.00	0.00	0.00	3.64	4.57	1.44	0.00
Pterocles orientalis	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.00
Rhodopechys sanguinea	0.00	**16.67**	0.00	0.00	0.00	0.00	0.00	0.00
Sitta neumayer	0.00	0.00	0.00	0.00	3.57	0.00	0.00	**51.52**
Streptopelia turtur	0.00	0.00	0.00	0.00	0.98	0.65	4.11	4.55
Sturnus vulgaris	0.00	0.00	0.00	0.00	0.00	0.00	2.86	0.00
Sylvia communis	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00
Sylvia curruca	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00
Turdus merula	0.00	0.00	0.00	0.00	0.00	0.57	**5.77**	0.00
Upupa epops	0.00	0.00	0.00	0.00	1.39	1.22	0.89	0.00

3.3.2.1.1 Steppe Bird Assemblages of Open, Homogenous Areas without Woodlands in Proximity

Skylark presence differentiates this group. It is one of the commonest bird in agricultural mosaics (Brotons *et al.* 2005), using different habitat types in Europe such as semi-natural steppes, cropped lowlands, set-asides, grasslands etc. (Fuller 2004), but it avoids shrubs, trees and forest-edges to reduce predation risk (Moller 1989, Fuller 2004) and prefers higher elevations and shorter swards in upland pastures of Bulgaria (Nikolov 2010).

21 species are recorded in bird assemblages of open, homogenous areas without woodlands in proximity (coded as A in Figure 3.14). The most abundant species are skylark and bimaculated lark. They are known as typical grassland species.

The sites supporting the positive group are open, homogenous areas without woodlands in proximity. The nearest neighbor analysis resulted with two parameters related with productivity important for discrimination of two types of communities: NDVI and precipitation in the driest period of the year. The significant differences of those sites from the negative group's sites are as follows:

- Higher elevation, lower mean temperatures, higher annual temperature range and precipitation in the warmest quarter.
- Higher NDVI, more homogenous with no or few shrubs and less old field patches, less habitat diversity and landscape diversity at different scales, mostly surrounded by other grassland patches, more distant to settlements, woodlands and trees.
- The main use of those sites is livestock grazing with lower densities in the past but high densities in current situation compared to other sites.

Two main bird assemblages of steppes can be seen in various plant community types as seen in graph below (Figure 3.15). Steppe bird assemblages of open, homogenous areas without woodlands in proximity are seen in all except gypsiferous steppes whereas steppe bird assemblages of heterogeneous areas with woodlands or settlements in proximity are seen in all types. The herbaceous vegetation close to natural state of steppes is represented more in the first one.

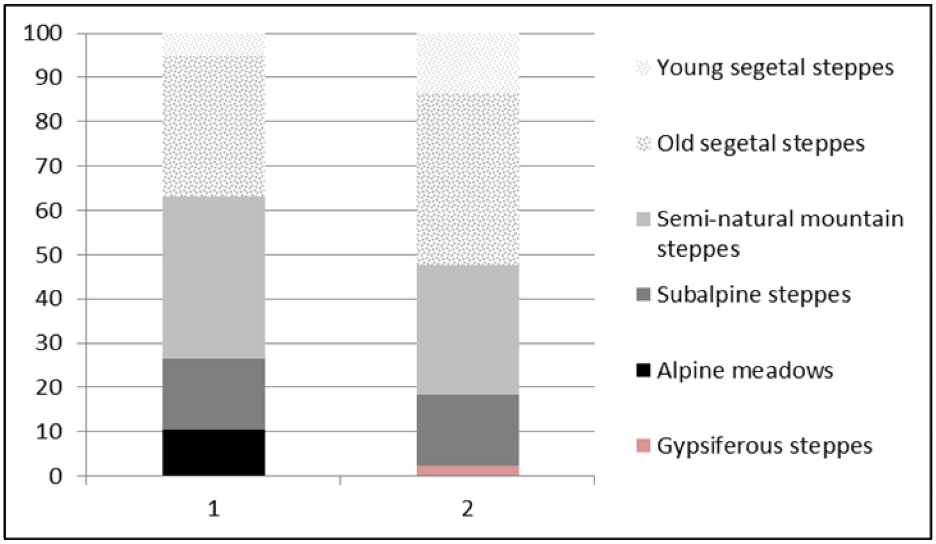


Figure 3.16 Percent occurrence of two main bird assemblages on different plant communities (1: Steppe bird assemblages of open, homogenous areas without woodlands in proximity, 2: Steppe bird assemblages of heterogeneous areas with woodlands or settlements in proximity)

At the second level the steppe bird communities of open, homogenous areas without woodlands in proximity are divided into two by bimaculated lark, shore lark (horned lark) and corn bunting. Shore lark (the positive indicator) is a typical grassland species (Trost 1972) inhabiting open country with low, sparse vegetation (Anglew 1986). Not sensitive to landscape features, shore larks prefer lower vegetation height and cover so benefit from grazing in general (Knick and Rottenberry 1995). Bimaculated lark is a steppe species breeding in stony plains, semi-desert like environments and mountainsides but it also uses arable lands at high elevations close to crop limit (Mullarney *et al.* 1999). Corn bunting can occur over a wide range of habitat conditions (Santos and Suares 2005) and little affected by landscape patterns (Reino *et al.* 2010). They benefit from arable lands around as feeding or nesting sites (Robinson *et al.* 2001). As a ground nesting species, corn bunting is a species associated with trees and tall shrubs (Nikolov 2010), breeding close to woodland, positively affected by woodland edges (Reino *et al.* 2010) similar to crested lark and tree pipit due to feeding opportunities (Moller 1989) although this situation is not confirmed in Turkey with detailed bird studies. The presence of first species in the first group implies steppes of open fields with less vegetation cover and height whereas bimaculated lark and corn bunting presence in the second group implies steppes close to trees and shrubs and arable lands. The nearest neighbor classification resulted in three environmental variables discriminating between steppe bird communities of high and montane zones are elevation, past livestock density dominated by sheep and soil depth. But other significant differences are low shrub density, low landscape diversity, and absence of features of human-altered environment. So the habitat preference of indicator species and habitats of the sites for birds are compatible although not perfectly matching.

High Mountain Homogenous Steppe bird Assemblages

This bird assemblage (coded as A1 in Figure 3.14) is separated with presence of shore lark; absence of bimaculated lark and corn bunting in most of the sites. 15 bird species are recorded in this assemblage in total. Skylark, common cuckoo, shore lark and northern wheatear are most abundant species.

The 11 sites of mostly alpine meadows, subalpine steppes and semi natural steppes support this bird assemblage. Those sites are good examples of homogenous herbaceous vegetation without shrubs or tees. The significant difference of those sites from montane steppe bird assemblages at 0.05 significance level are as follows: higher elevations i.e. above 2000m, colder and more humid climate, higher coverage by rocks or rocky outcrops, no other vegetation covers in proximity so the landscape diversity is lower at all scales and distance to other cover types are higher. Average maximum coverage of herbaceous vegetation is lower. The sites have never been used for crop production but used for livestock grazing: The past livestock grazing levels are lower in the highlands compared to other sites due to higher distance to settlements and larger grazing lands. However, current levels are similar or a bit higher compared to other sites: highlands are still grazed under transhumance whereas montane steppes are more often abandoned.

Among the steppe bird communities of highlands, the birds observed in one replicate is separated from the others with absence of skylark. It is the only site where tawny pipit is found in high numbers, and where Finsch's wheatear and crimson-winged finch are recorded. This replicate (61GW) is a rocky, grazed semi-natural steppe at 1972m.

Homogenous Montane Steppe Bird Assemblages

This assemblage (coded as A2 in Figure 3.14) is differentiated from the high elevation steppe bird assemblage with the presence of bimaculated lark and corn bunting at most of the sites. The most abundant bird species are skylark and bimaculated lark, followed by corn bunting, black-headed bunting, Isabelline's wheatear and linnet in lower abundances. 14 bird species are recorded in this assemblage in total.

The environmental properties significantly different between this group and high mountain bird assemblage sites are given before. Lower elevation and higher landscape diversity mark the differences. Shrub density varies between 0 and 3 among sites. The rock cover is still high.

The community is further divided into two by presence of bimaculated lark (coded as A21) and ortolan bunting (coded as A22). The group with bimaculated lark is composed of segetal steppes, mostly old segetal ones (75%). Bimaculated lark and skylark are the most abundant birds of six species of this group. The group with ortolan bunting is dominated by semi-natural steppes; old segetals are represented in 25%. Ortolan bunting is a farmland bird species inhabiting open farmlands with clear preference to arable lands with woody-vegetated elements, man-made woody, stony constructions creating heterogeneity (Vepsäläinen *et al.* 2005). Skylark and corn bunting are the most abundant species of 11 species of diverse habitat preferences such as water pipit, common quail, yellow wagtail, Isabelline's wheatear. This community is the closest to the other main bird community i.e. bird communities of other habitat preference. However, since there are only 4 replicates representing each assemblage, it is not possible to give statistical differences among two groups.

3.3.2.1.2 Steppe Bird Assemblages of Heterogeneous Areas with Woodlands or Settlements in Proximity

This bird assemblage (coded as B in Figure 3.14) is differentiated with the absence of skylark. The most abundant species of this group is black-headed bunting followed by ortolan bunting and house sparrow. All 56 species recorded during the surveys are found in the assemblage. Many of those species have diverse habitat preferences living both in steppes, human habitations, woodlands, rocky environments etc. The most abundant species are house sparrow, black-headed bunting, ortolan bunting and crested lark. Although some of those species can be considered steppe birds that need specific land features such as rocky outcrops or cliffs (like in the case of black-eared wheatear and rock nuthatch), most of the species are attracted by man-modified areas, human habitations or artifacts (examples are hooded crow, crested lark, house sparrow, starling, magpie). Other species are attracted to woody vegetation like forest steppe, tall bushy and scrub vegetation, forest edges, groves, river valleys, shrubs in steppes etc. Some examples of those species are ortolan bunting, black-headed bunting, blackbird and woodlark. Some such as quail are linked also to cereal crops.

44 replicates representing all plant community types support this bird assemblage. Semi-natural steppes and old segetal steppes dominate with 37 and 32 percentages, respectively. As indicated before, those replicates are in lower elevations. They have higher shrub density, woody vegetation, arable land or settlement in proximity, higher landscape diversity so both habitat diversity and species richness are higher.

This bird assemblage is divided into two groups based on wheatear, hooded crow, nightingale, blackbird and crested lark presence. The replicates of two groups differ in wood density in and around, which is explained below.

Bird Assemblages of Heterogeneous Steppes of Low Wood Density

This positive group (coded as B1 in Figure 3.14) is separated with the presence of wheatear, crested lark and absence of hooded crow, nightingale and blackbird. The first two species are open habitat species but can breed in stony human constructions (Arlt and Pärt 2007; Orbán 2004). Crested lark is also known for preference for human-disturbed sites rich in weed seeds (Orbán 2004). So the sites supporting this bird assemblage should encompass open habitats close to settlements but avoiding many trees because of higher predation risk of ground nests in steppes. The species list and most abundant species of this group are same with that of the main group.

The nearest neighbor classification found two variables to separate this group from its negative: distance to trees and homogeneity. The positive group is located where the nearest tree is 500m away at most. If the replicate itself is heterogeneous the distance to nearest tree can be as high as 1000m. The environmental differences of this group from bird assemblage of heterogeneous steppes of high wood density are wetter and colder, higher elevation in other words, less shrub density, more distant to settlements and trees as expected. But this group is not very close to settlements since proximity to villages means proximity to planted trees especially poplars. Because of this reason settlements are only seen from distance. But in many of the sites stony human constructions Landscape diversity is found to be significantly lower only at 2 km scale. The human habitats are seen from distant in most of the replicates.

This bird assemblage is represented in 28 replicates covered by all plant community types of the region except alpine meadows. Subalpine steppes, semi-natural steppes and old segetal steppes are represented in 25-36% of the replicates. The sites have similarities to the montane steppe bird assemblages.

The group is further divided into two groups with presence of crested lark and house sparrow in six of the replicates dividing the sites based on homogeneity and distance to settlements. The positive group (coded as B11) is composed of 19 species with high abundance of house sparrow, crested lark, Isabelline's wheatear, nightingale, black-headed bunting. The assemblage is seen at low wood density sites close to settlements. The negative group is seen at low wood density sites with diverse habitats. The abundant ones among 57 species are black-headed bunting, ortolan bunting, wheatear, bimaculated lark, rock sparrow, magpie, woodlark, showing that species of rocky outcrops, settlements, shrubby environments and steppes are all represented in the community.

Bird Assemblages of Heterogeneous Steppes of High Wood Density

The presence of hooded crow, nightingale and blackbird and absence of wheatear and crested lark separates this bird community (coded as B2 in Figure 3.14) from its positive (B1). The first three species are known to be associated with shrubs, trees or natural/man-made woodlands for breeding (Svennson 2009). 32 species are listed in this assemblage. The most abundant species are black-headed bunting, hooded crow and ortolan bunting. Preferentials are rock bunting, Isabelline wheatear, golden oriole, turtle dove.

The community is observed in 16 replicates covered by semi-natural and segetal steppes, old segetal ones constituting 44%. The environmental properties of those sites in comparison with its positive group are: warmer and drier, higher shrub density, higher landscape diversity at 2 km, quite close to settlements and trees with significance below 0.05 level. In addition the past livestock numbers are higher.

Two of the replicates supporting this bird assemblage is separated from the rest with high abundance of rock nuthatch. Presence of sedimentary rock body very close to the survey point caused this site to occur as an outlier.

3.3.2.2 Bird Assemblages Based on Bird Habitat Preference

The bird data is reorganized into steppe habitat use of the birds as indicated in Chapter II: Materials and Methods. DCA analysis is applied to the data and ordination of replicates on first two axes is given in Figure 3.16.

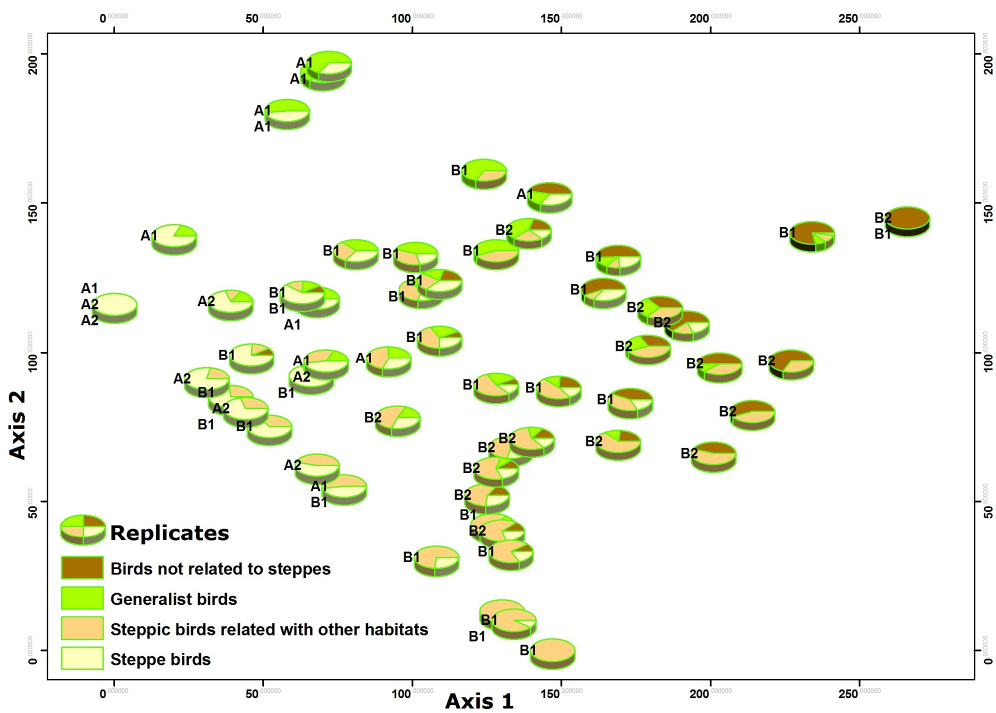


Figure 3.17 Ordination space of first two axes produced by bird data by habitat preferences. (The labels indicate TWINSPAN bird assemblages: A.1. High mountain homogenous steppe bird assemblages, A.2. Homogenous montane steppe bird assemblages, B.1. Bird assemblages of heterogeneous steppes of low wood density, B.2. Bird assemblages of heterogeneous steppes of high wood density)

High mountain homogeneous steppe bird assemblages (A1) and bird assemblages of heterogeneous steppes of low wood density (B1) had low scores on the ordination space and they both are dominated by steppe birds and birds using steppes but also related with other habitats. Towards the higher scores in axis 1, the abundance of steppic birds related with other habitats and bird not related with steppes increases as community shifts to bird assemblages of heterogeneous steppes of high wood density (B2). At the end of the first axis there are sites dominated by birds not related to steppes. Towards the end of the second axis both birds of homogeneous steppes are mixed with steppe birds and generalist birds. Finally in the middle of the space are different bird assemblages but mixture of steppe birds, steppic birds related with other habitats and generalist birds. The bird assemblages are rather mixed in habitat preference of the birds. So the bird assemblages give inferences abut habitat preference of species but still mixed in terms of birds of varying dependence to steppes.

3.3.2.3 Clustering of Sites Based on Bird Data

The results will be given with reference to TWINSPAN results for the ease of comparison. Two main groups and also three small groups like outliers are seen within 90% similarity limit (see Figure 3.17): Most of the replicates supporting "bird assemblages of open, homogenous areas without woods in proximity" are contained in single group.

The rest of the sites are contained in a single group that can be named as bird communities of other habitat preferences. The group is summarized below with bullet points:

- Site 37 is found to be the outlier with the only record of jackdaw.
- Replicates of 2SE, 41SO and site 50 makes a separate group due to presence of rock nuthatch similar to TWINSPAN analysis.
- Replicates 15SO, 42SO and 36SO make another group due to high abundance of house sparrow.
- A large group composed of 19 replicates represents bird assemblages of heterogeneous steppes with low wood density since it has 14 replicates of it but also has five replicates from the other groups.

- The other large group is composed mostly of replicates supporting bird assemblages of heterogeneous steppes with high wood density. Those sites are in diverse landscapes with settlements, arable lands and shrubby steppes.

The results of two clustering methods are similar at the coarse level. The rare records of species that are not actually rare in the study area determine the outliers and small groups. In terms of environmental determinants of the groups, the homogenous versus heterogeneous steppes are the basis of the main division. The factors of landscape diversity, distance to settlements and shrub density in or around are important for occurrence of specific bird community.

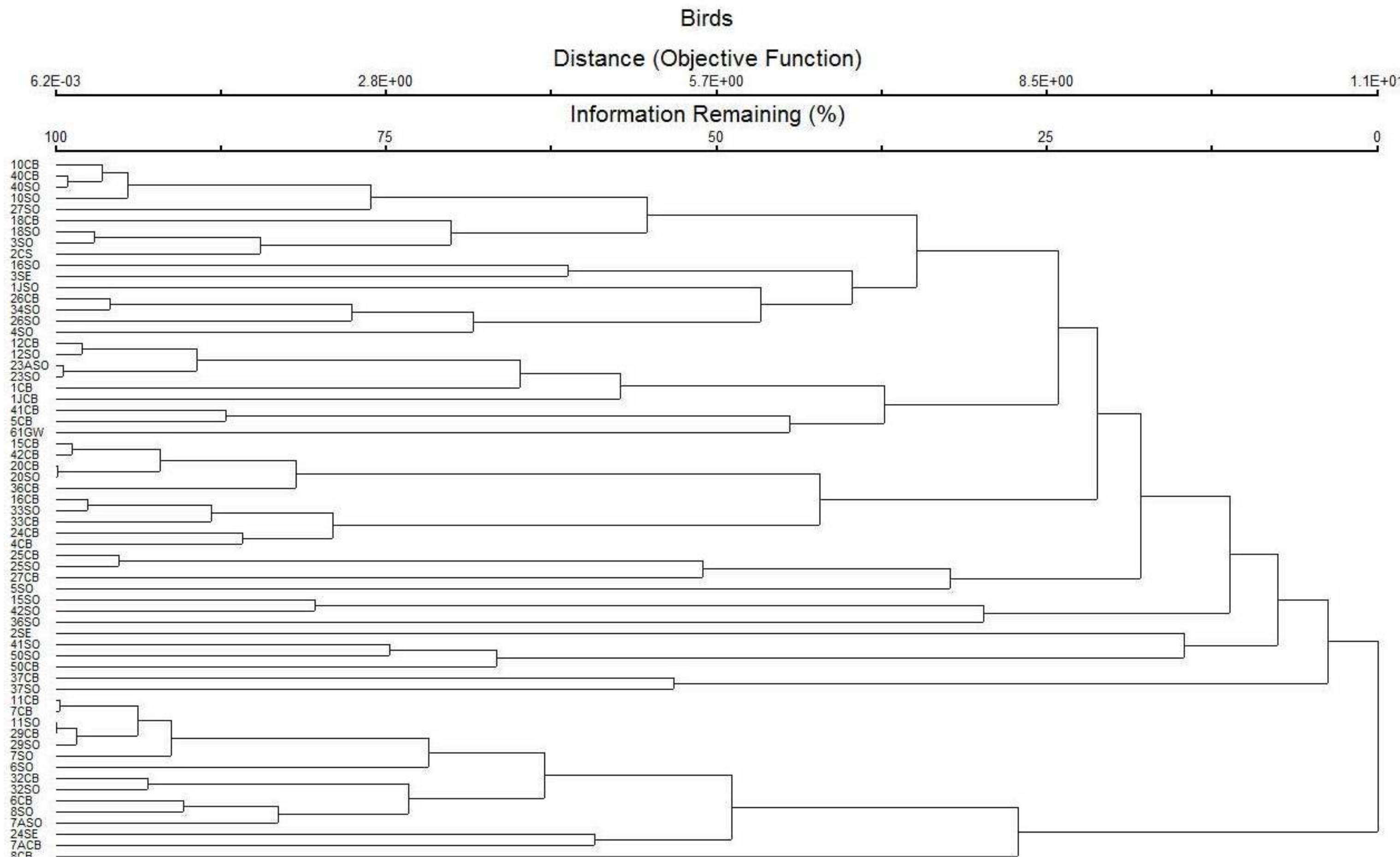


Figure 3.18 Dendogram of clustering bird data with Relative Sorensen (Bray-Curtis) distance and average group linkage.

3.3.2.4 CCA Analysis

The first CCA analysis done after removing the sites which do not have reliable land use information resulted with separation of replicates 36SO and 42SO from the rest with the first axis due to high number of house sparrows; site 37 with the third axis where six jackdaws recorded. All of the other sites are lined through the second axis because of this situation. After removal of bird data of those outliers, the second CCA analysis resulted in good overall dispersion of sites (Figure 3.18 and 3.19) with 16.9% total explanation of species data (see Table 3.9).

Table 3.9 Statistics of CCA Analysis based on bird and environmental data withouth two outliers

<table>
<tr><td>Total variance</td><td colspan="2">9.7878</td></tr>
<tr><td>Percent variance explained</td><td colspan="2">16.4</td></tr>
<tr><td>Eigenvalues</td><td colspan="2">0.659, 0.490, 0.459 (in axis order)</td></tr>
<tr><td colspan="3">Environmental variables with highest contribution to the axes
(Standardized canonical coefficients in parenthesis)</td></tr>
<tr><td>First axis</td><td>Second axis</td><td>Third axis</td></tr>
<tr><td>Distance to arable lands (0.679)</td><td>Past livestock density (0.332)</td><td>Distance to settlements (0.499)</td></tr>
<tr><td>Humidity (0.516)</td><td>Distance to trees (0.305)</td><td>Humidity (0.459)</td></tr>
<tr><td>Elevation (-0.572)</td><td>Shrub density (-0.379)</td><td>Current livestock density (-0.505)</td></tr>
<tr><td>Distance to settlements (-0.436)</td><td>Temperature annual range (-0.364)</td><td></td></tr>
</table>

The main axis is rather climatic but distance to arable lands and settlements contribute considerably to it. It reflects a sort of natural vs. human environments. The second axis is related with woody vegetation in and around the sites and past grazing level. The third axis with the least explanatory power is a mixture of various factors. As seen in Figure 3.18, the bird assemblages separated in the main axis as the bird assemblages of homogenous sites without woods in proximity are located in higher elevations and cold places, distant to settlements and trees. Whereas bird assemblages of heterogeneous sites are located in lower elevations, warmer places. The heterogeneous sites with low and high wood density are separated with shrub density as expected.

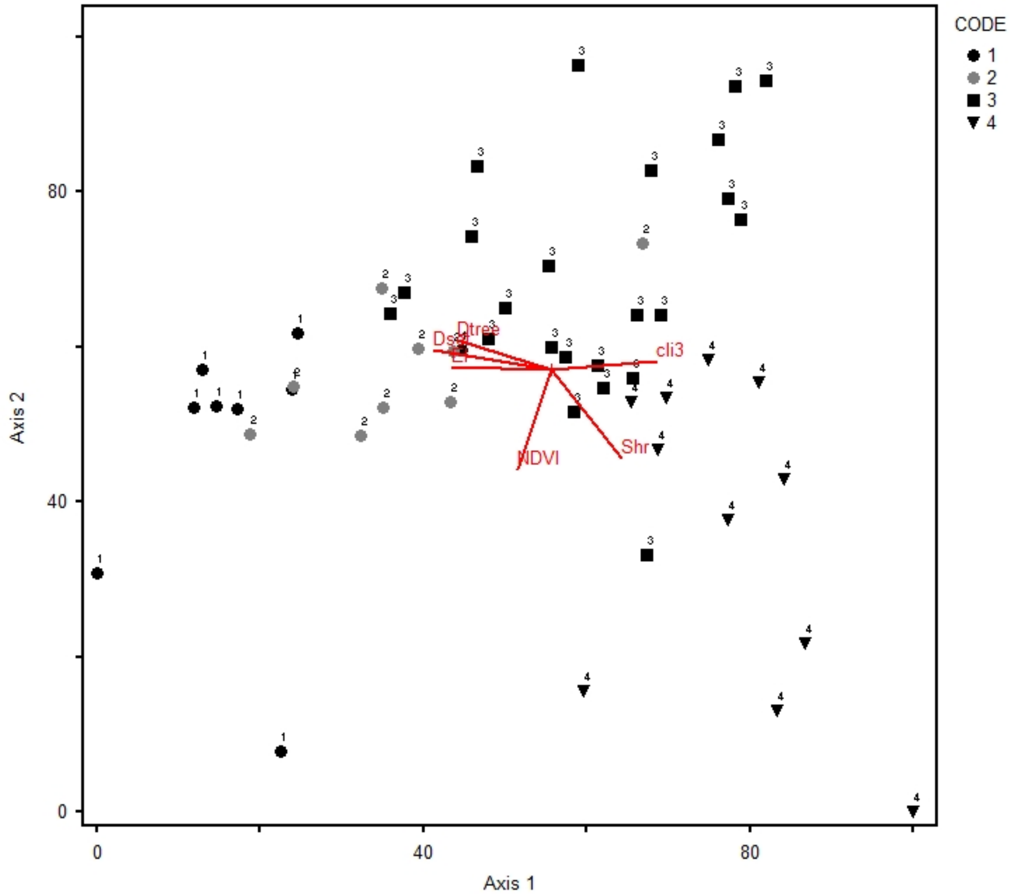


Figure 3.19 The ordination space of first two axes based on bird data and environmental data without two outliers (bird assemblages: 1: High mountain homogenous steppe bird assemblages, 2: Homogenous montane steppe bird assemblages, 3: bird assemblages of heterogeneous steppes of low wood density, 4: bird assemblages of heterogeneous steppes of high wood density; environmental variables: Dset: distance to settlements, Dtree: distance to trees, El: elevation, NDVI reflecting productivity, Shr: shrub density, cli3: climatic gradient)

The additional information obtained from third axis as seen Figure 3.20 are relatively higher grazing levels seen in homogenous steppes without woods in proximity, in general. But assemblages are not discriminated clearly with percent bare ground, arable land history or years since land abandonment.

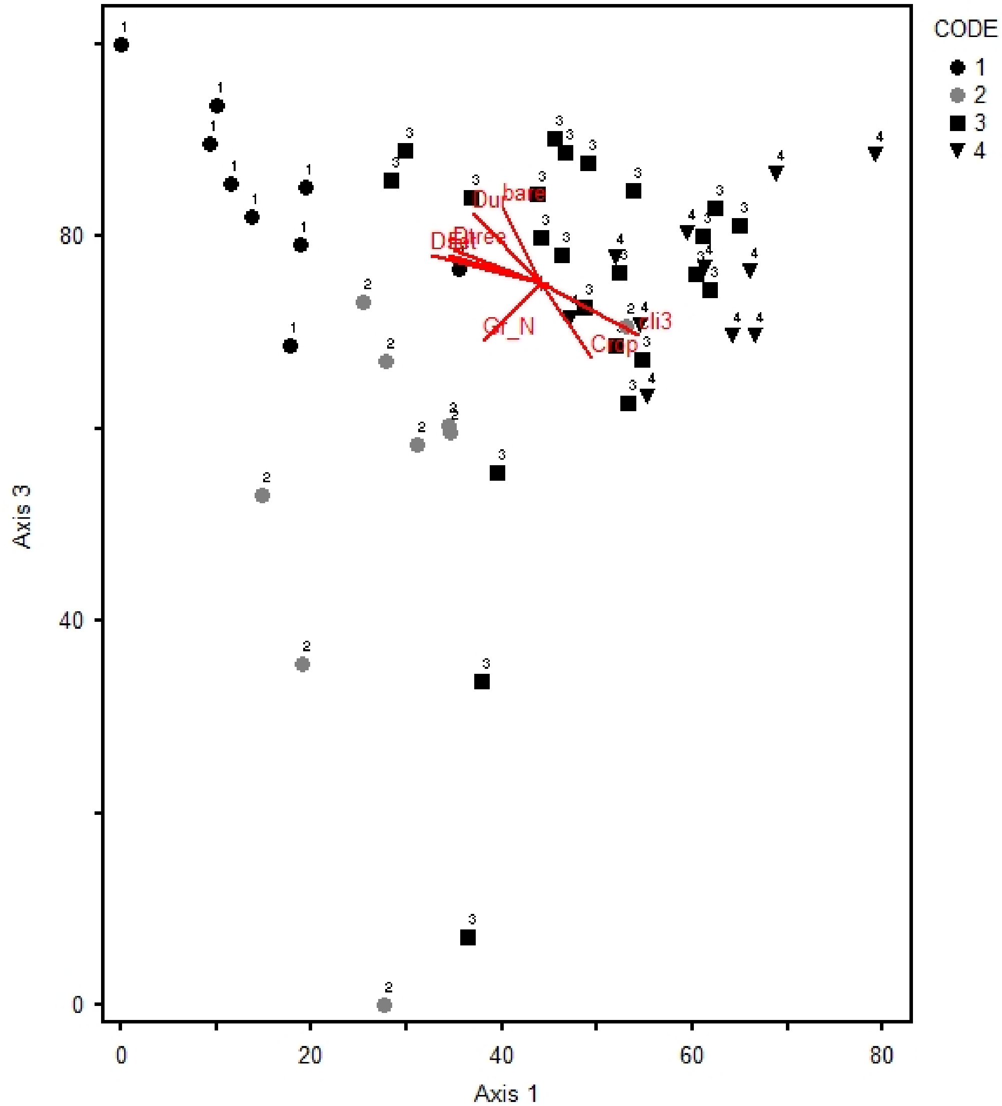


Figure 3.20 The ordination space of first and third axes based on bird and environmental data without two outliers (bird assemblages: 1: High mountain homogenous steppe bird assemblages, 2: Homogenous montane steppe bird assemblages, 3: bird assemblages of heterogeneous steppes of low wood density, 4: bird assemblages of heterogeneous steppes of high wood density; environmental variables: bare: percent of bare ground, dur: years since abandonment, Dset: distance to settlements, Dtree: distance to trees, Gr_N. current grazing levels, crop: arable history, cli3: climatic gradient)

3.3.3 Butterfly Assemblages of Steppes

One visit per site and weather conditions during the surveys resulted in less butterfly data than needed for proper analysis and comprehensive results. Therefore only the basic findings of the main analyses are given below.

The TWINSPAN analysis resulted with 3 levels of classification with 6 groups (Figure 3.20) by defining 532 pseudospecies. Due to limitations of data, the assemblages can not be defined properly. So they are not named but coded as indicated in below figure.

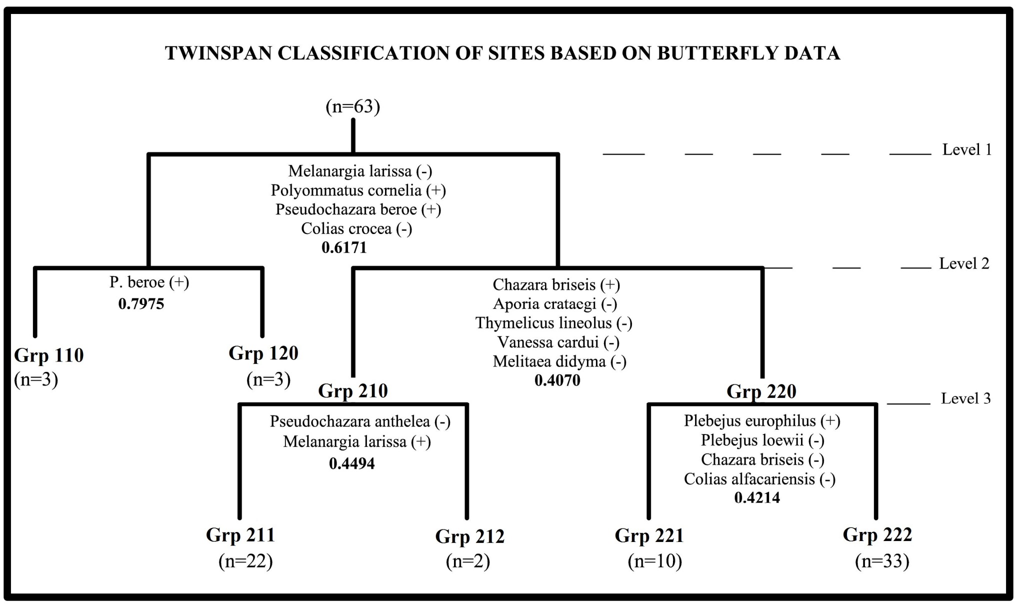


Figure 3.21 TWINSPAN classification based on butterfly data ("n" indicates the number of replicates belonging to each group. The eigenvalues of the divisions are indicated in each division, positive groups are at right side of each division)

Four indicator species determine the fist level division. Their larval foodplants are several species of legumes and grasses, not indicating specific plant species or genera. The positive indicators are observed in Yamadağ alpine meadows and subalpine steppes although known to be much widespread in the region in different habitats. The positive group (Grp 110 and Grp 120) has 6 species whereas negative group has all 93 species recorded during systematic surveys, although it is known from additional records that more species is found in both groups.

The positive group is represented in 6 replicates, 5 of which are alpine and subalpine vegetation whereas one of them, 41SO, is an old segetal steppe. Absence of any features attracting butterflies, cloudy and windy weather marked the records of positive group. According to Mann-Whitney test, elevation and distance to settlements are higher (with 0.95 significance level) whereas plant richness and landscape diversity at all scales are lower in the positive group. Those parameters cannot explain the first level division as indicator species are not restricted to those conditions or habitats. Deficient butterfly data is probably responsible for those results. It is perhaps much better to treat the group as an outlier caused by bias of the weather conditions.

The second level division is weaker with lower eigenvalues. Groups 210 and 220 are divided based on five indicator species with diverse larval food plants such as *Festuca* sp., shrubs of Rosaceae, *Phleum* sp., composites, members of Urticaceae and Boraginaceae, *Plantago lanceolata*, *Verbascum, Veronica.* Negative indicators are found in diverse habitats. Only the positive indicator *Chazara briseis* needs dry, stony, calcareous steppes specifically. So we can infer that second level division separates stony dry steppes form steppes of mixed habitats. But actually the maximum and minimum herbaceous coverage are significantly higher in the positive group according to Mann-Whitney test. In addition, positive group have higher percent slope, higher landscape diversity and closer to the settlements with 0.95 significance level. The groups starting with 21 are seen almost evenly among plant communities other than alpine steppes and gypsiferous steppes but the groups starting with 22 are more in semi-natural steppes and old segetal steppes.

Further details of the groups will not be discused. Although the first level seem to separate the high mountain sites and the second level divides the rest into homogenous steppes and heterogenous sites, the divisions are not clear. Overall, habitat preferences of the indicator species and the environmental properties of the groups determined are not compatible.

To overcome the limitations posed by the indicator species approach to insufficient data, clustering is performed. A cut at the level of 80% similarity resulted in 6 main groups as follows: groups 110 and 120 as a single group, group 212 together with site 33, 24CB and 41SO as a single group, group 211 represented as two separate groups and rest as a single group. Since few species are recorded in each site and the groups are formed based on one or two shared species, ecological interpretation of the results are limited and would be similar to that of TWINSPAN.

The CCA analysis resulted in 12.9% explanation of total variance in the species data. The eigenvalues of the axis are very low i.e. 0.465, 0.399 and 0.356, respectively. Both the percent variance explained and the eigenvalues are quite low. The basic outputs can be summarized as below:

- The environmental factors contributing most to the axes are elevation, landscape diversity at 500m, minimum herbaceous coverage, old cereal fields, the mean temperature of the warmest quarter and humidity.
- The groups coded as 110 and 120 which are mainly subalpine steppes are placed in the first two axis where elevation humidity and distance to settlements are high.
- The assemblages coded as 211 and 212 are seen where landscape diversity increases at 500m and 2 km. The assemblages coded as 221 and 222 are located in the origin.

3.4 Biodiversity

3.4.1 Plants

3.4.1.1 Plant Richness and Diversity on Sites

Observed plant richness and the results of rarefaction analyses given in Appendix D. However, it is important to remember that only plant species with more than 10% coverage were recorded.

The number of species with more than 10% coverage observed at each site varies between 6 and 18. The sites with the highest species richness are 3, 26, 40 in declining order. The sites with lowest richness are 29, 11, 8 and 61.

The results of rarefaction can provide a better ground for discussion since rarefaction estimates the richness based on a species accumulation curve. Before going into the details about the figures, first it is good to know that the results of Chao 1, Chao 2, Jackknife 1, Jackknife 2 and observed richness are highly correlated pairwise with $p \leq 0.001$ but r values vary between 0.51 and 0.95. The discussion will be based on interpretation of figures of Chao1 and Jackknife 1.

The richness based on Chao 1 varies between 55.5 (±49.9) and 7 (±1.87). The richest sites are 18, 2, 3 and 5, and the poorest sites are 29, 11, 8 and 61. The values have very high standard deviations which indicate that there is a high probability that the estimates are not accurate. On the other hand, the Jackknife 1 estimates vary between 27.5 (±3.23) and 7.9 (±1.31). The richest sites with the highest Jackknife 1 values are 3, 26, 18 and 40th sites. The poorest sites are 29, 11, 8 and 61st sites. The standard deviations this time are much lower, pointing to the validity these estimates.

The richest sites in terms of observed richness or richness based on Jackknife 1 are the same: 3, 26, 18 and 40. The first two sites are old segetal steppes whereas the other two are mixture of old segetal and semi-natural mountain steppes. They are marked with habitat heterogeneity caused by topography and mixture of land uses and also light grazing following abandonment of cultivation. Chao 1 estimated somewhat different sites as the richest: 18, 2, 3, 5. Both site 2 and 5 are semi-natural mountain steppes. Site 2 is a charcoal production site surrounded by oakland cut more than 20 years ago but never ploughed. The site 5 is again was never ploughed but was grazed in the past. The highest number of livestock grazing any of those sites was 1500.

The most species-poor sites were found to be same with different techniques: 29, 11, 8 and 61. Site 29 is the alpine meadow explained before. Site 11 is a subalpine steppe on scree. Sites 8 and 61 are semi-natural mountain steppes with rocky surface and lithosolic soil. None of the sites were cultivated in the past due to unsuitability of the soil and climate for agriculture. Instead, the sites have been grazed for a long time in declining livestock levels. All of the poorest sites are above 1800m. Since standard deviations for Jackknife 1 are quite small compared to those of Chao 1, and the estimates not so different from the observed richness, jackknife richness estimate will be used for further analyses.

The diversity figures are also given in Appendix D. The values for Shannon and Simpson Diversity indices are highly correlated ($r=0.948$, $p<0.001$) to each other and also to different richness measures ($p<0.023$). The most diverse sites are old segetal steppes at sites 10, 26, 40 and semi-natural mountain steppe of site 1. The least diverse sites are 29, 42, 4 and 41. The last three sites are classified as old segetal steppes although with less than 30 years of arable land history.

3.4.1.2 Factors Related with the Plant Richness and Diversity Patterns

The results of hierarchical partitioning of plant richness estimated with Jackknife 1 and plant diversity measured with Shannon's diversity index are given jointly Table 3.10. In addition, the percent distribution variance explained by each variable independently is provided in Figure 3.21.

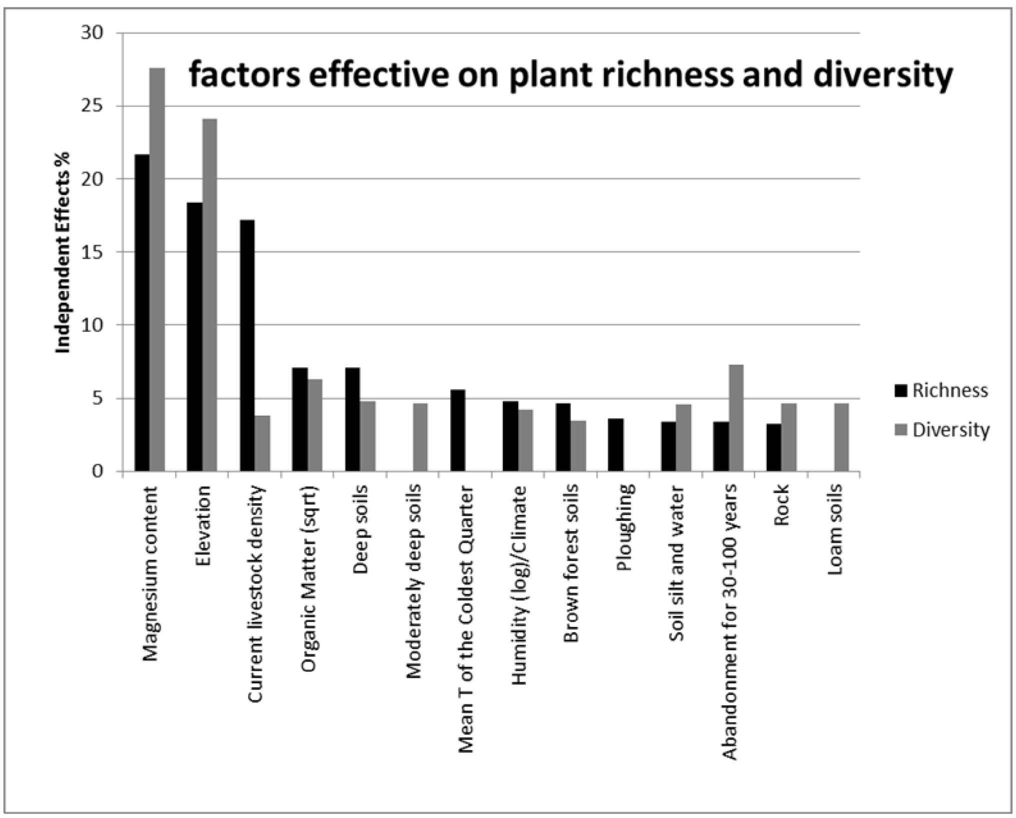


Figure 3.22 Distribution of percent variance explained by each variable independently (I) obtained by hierarchical partitioning of plant richness

The sum of *I*s is 0.81 for plant richness and 0.7143 for diversity. This value equals to goodness of fit measure of the full model minus the goodness of fit measure of the null model, so models for the plant richness better fitted than the diversity.

Table 3.10 The contribution of each variable to goodness of fit (as independent and joint effects) of all possible regression models explaining plant richness and diversity of the sites.

Variables	Independent effects (I) on richness	Independent effects (I)on diversity	Joint effects (J) on richness	Joint effects (J) on diversity	Total (Richness)	Total (diversity)
Magnesium content	0.18	0.21	0.82	0.79	1.00	1.00
Elevation	0.15	0.18	0.85	0.82	1.00	1.00
Current livestock density	0.14	0.03	0.67	0.07	0.81	0.10
Organic Matter (sqrt)	0.06	0.05	0.30	0.19	0.35	0.24
Deep soils	0.06	0.04	0.29	0.13	0.34	0.16
Moderately deep soils	-	0.04	-	0.11	-	0.15
Mean Temperature of the Coldest Quarter	0.05	-	0.17	-	0.22	-
Humidity (log) for richness/Climate composite for diversity	0.04	0.03	0.25	0.15	0.29	0.18
Brown forest soils	0.04	0.03	0.18	0.09	0.22	0.11
Ploughing	0.03	-	0.13	-	0.16	-
Soil silt and water	0.03	0.03	0.13	0.05	0.16	0.08
Land abandonment for 30-100 years	0.03	0.05	0.11	0.22	0.13	0.27
Rocks	0.03	0.03	0.09	0.12	0.11	0.16
Loam soils	-	0.03	-	0.12	-	0.15

According to the results, elevation and magnesium content are the main factors explaining plant richness and diversity of the sites with 15-20% independent effects. Among plant functional types, Mg is found to be correlated only with annual grasses (r=0.420, p=.019).

Magnesium is found to be the most important factor for the plant richness. Mg values range between 3.83 and 1617.4 ppm. Although there is not a correlation between soil Mg and plant richness or diversity on sites at 0.05 significance level, a close inspection on data reveals the relationship. When log(Mg) is plotted versus plant richness and diversity (Figure 3.22 and Figure 3.23), it is seen that after 1.81 threshold (65 ppm) starting with 2.25 (180 ppm), Mg is strongly related with diversity and richness (r= 0.635, p=0.003 for richness; r=0.463, p=0.04 for diversity). Those sites are marked with quite high values with one of four soil mineral parameters Ca, cation exchange capacity, N or P_2O_5. It is known that availability of Mg for plants depends on activity or proportion of Mg relative to soluble or exchangeable amounts of Potassium, Calcium, Sodium, Aluminum and Manganese (Mayland and Wilkinson 1989). So it is probable that the abundance of measured or non-measured other cations cause the four sites to impede the relationship.

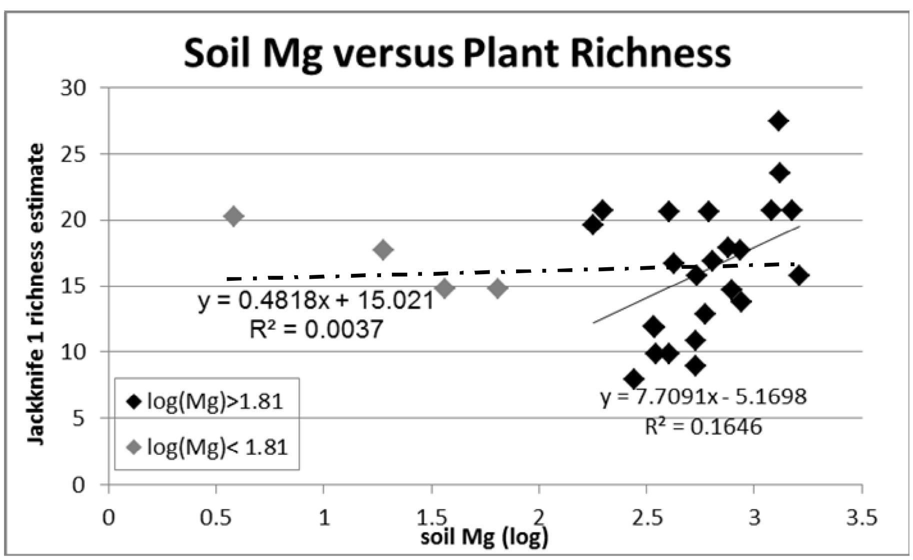


Figure 3.23 Relationship between soil Mg and plant richness (dashed line is the trendline for whole data whereas regular line is for log(Mg)>1.81)

Elevation is negatively correlated with richness and diversity (r>-0.4). As the elevation increases, annual grass and forb abundance decreases (r=-0.519, -0.444, respectively) and abundance of tragacanthic species and perennial grasses increases (r=0.494, r=0.427, respectively). However, no relationship has been found between perennial forbs and elevation which is the main plant functional type correlated with plant richness and diversity.

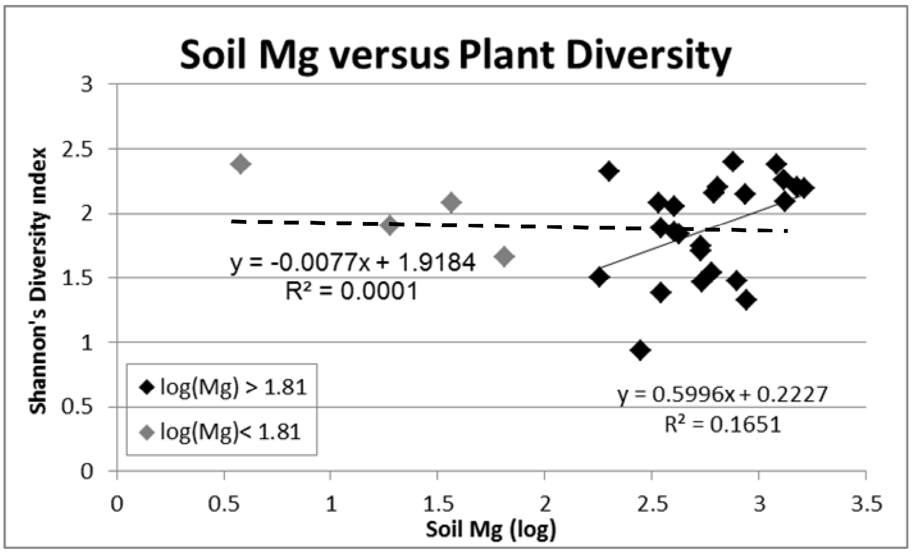


Figure 3.24 Relationship between soil Mg and plant diversity(dashed line is the trendline for whole data whereas regular line is for log(Mg)>1.81)

Current livestock density is the third important parameter for plant richness with 17.21% independent effect. But it does not have a similar effect for diversity with only 4% independent effect. The relationship between current grazing level with plant richness estimate (Jackknife 1) can be seen in Figure 3.24. There is an overall linear decrease with increasing livestock density. The decrease is lower for diversity. When a polynomial function is fitted, the lowest richness is observed in intermediate levels of livestock density, but those results cannot be used to support or contradict the intermediate disturbance theory. The reasons are that (i) the sites are environmentally different and as it is indicated before, other factors are playing role in diversity, and (ii) the whole range of livestock intensity is not represented well since the sites around 1000 or between 3000 and 6000 as livestock numbers not sampled enough as the fit implies in the graph.

Current grazing levels are found not to be related to abundance of decreaser, increaser or neutral species in response to grazing. Whereas old grazing level is found to be significantly related to decreaser plant abundance ($r=-0.290$, $p=0.035$).

Among the plant functional types and grazing levels, the only significant correlation is found between tragacanthic plant cover and past grazing level ($r=0.273$, $p=0.048$).

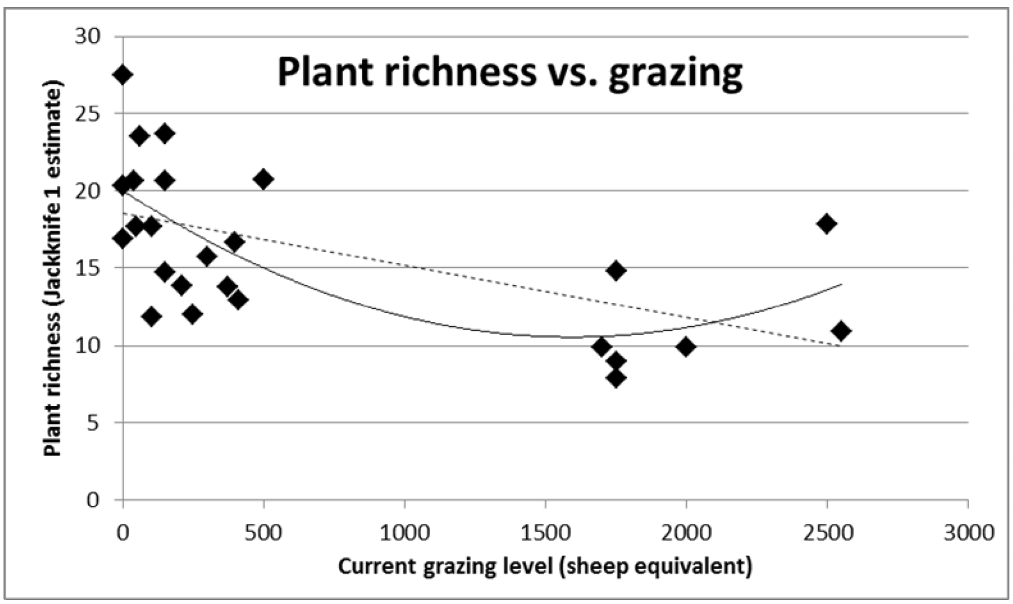


Figure 3.25 Graph showing plant richness versus current grazing levels on sites.

Cultivation abandonment for 30-100 years is important for diversity with 7% independent effect. Other parameters found to be important i.e. soil organic matter content, deep and moderately deep soils, mean temperature of the coldest quarter, humidity, climate PCA score, brown forest soils, ploughing, soil silt and water, old field for 30-100 years, rock presence and loam soils have less than 6% independent contribution to each explained variance. Soil depth is found to be negatively correlated with plant richness and diversity. In addition to independent effects, factors also contribute to joint effects. Among those, the same factors listed above have high joint contributions, except for humidity contributing more to joint effects.

In addition, there are many variables in correlation with richness of the sites, mostly due to multicollinearity:

- All Bioclim values were correlated with richness since all are produced with the input of digital elevation modeling.
- The landscape diversity measures are in correlation with the richness and diversity estimates. As the area of the landscape considered increases, so does the number of correlated diversity measures. This indicates that sites in a diverse landscape support higher biodiversity. Distance to grassland has a positive correlation with all of the measures whereas distance to arable lands shows negative correlation.
- Among the variables of less importance, temperature annual range (BIOCLIM 7) is negatively correlated with richness, whereas landscape diversity at 5km, soil Ca, salt and electrical conductivity are positively correlated with richness.
- P_2O_5 content is negatively correlated with observed richness and richness estimates ($r=-0.481$, $p=0.002$ for Jackknife 1). Nitrogen is only related to Chao estimates ($r=-0.588$, $p=0.035$).

In summary, low elevation dry sites of mostly old abandoned fields (most of them are old segetal steppes) with low grazing pressure and high landscape diversity support higher plant diversity. Such sites have higher Ca content, electrical conductivity, salt content, pH at saturation but lower organic matter and P_2O_5 content. A higher number of shrubs/trees is a reliable indicator of those sites. However, arable land history was not found to be correlated with the diversity measures.

Woody plant density in terms of shrubs and trees shows the most significant correlation with the biodiversity measures. The correlation with all measures are significant with r values ranging 0.58-0.75 and $p<0.001$. Shrub density is correlated with all climatic parameters, highest with mean temperature of the coldest quarter, arable land history of sites, negatively related to current grazing, all distance measures, soil organic matter and P_2O_5 amount; positively related to landscape diversity, soil Ca parameters. This shows that the density of shrubs and trees indicates a good combination of factors leading to high biodiversity at a site. When total cover of different plant functional types at a site is analyzed with observed richness, Jackknife 1 estimate and Shannon's diversity index pairwise, it is found that only perennial forb cover is correlated to all three biodiversity measures at 0.05 significance level. Spearman rank correlation resulted in 0.527, 0.469 and 0.474 r values for biodiversity measures, respectively.

3.4.2 Birds

3.4.2.1 Diversity and Richness Based on Bird Data

Observed richness of the sites varies between 13 and 2 with an average of 7.26 (±2.54) (See Appendix E). Rarefaction results are also provided in Appendix E. The results obtained by different methods (observed richness, Chao and Jackknife estimates) are all strongly correlated pairwise (all $p<0.001$, Spearman one-tailed test). However, since Chao 1 and Chao 2 estimates had quite high standard deviations, only the results pertaining to Jackknife 1 will be discussed.

The richest sites according to Jackknife 1 estimates, observed richness and most diverse sites according to Shannon's diversity index are the same: Sites 3, 1, 15 and 27. They represent the steppe bird assemblages of heterogeneous areas with woodlands in proximity. They support old segetal and semi-natural steppe vegetation. Simpson's diversity index found Site 4 as the fourth most diverse, a semi-natural steppe with bird assemblages of homogeneous montane steppes without woods in proximity. The common features of those rich and diverse sites are land abandonment, landscape diversity with settlements, arable lands, shrublands or orchards around. Species of various habitat preferences can co-occur in those sites such as species associated with trees, shrubs or woodlands like golden oriole, woodlark, nightingale, Levant sparrowhawk; steppe species like skylark, northern wheatear, bimaculated lark; species attracted by man-made features like house sparrow, a farmland species like corn bunting and hooded crow and a species of bare rocky terrain like rock sparrow.

The poorest site is 7A followed by 33, 20, 11 and 6 for observed richness but followed by 50 for Jackknife estimate. The least diverse site according to Simpson and Shannon's diversity indices is 7A followed by Site 36. The five sites support steppe bird assemblages of open, homogenous areas without woodlands in proximity either on high mountain or montane zone. They occur on three different vegetation types such as subalpine steppes, semi-natural mountain steppes and young segetal steppes. Site 50 and 36 support bird assemblage of heterogeneous areas with low wood density and occur on semi-natural steppe vegetation. Those sites are marked with low landscape diversity. They are either abandoned or not cultivated before. The poorest sites are in homogeneous landscapes without any shrubs such as rocky grazed steppes dominated by skylark, wheatear, shore lark or bimaculated lark. If there are shrubs thenthe sites are usually away from woodlands and arable lands. The common birds of those sites are rock dove, hooded crow, black-headed bunting, crested lark, house sparrow and starling. Site 36 has 7 species recorded so not poor in species richness but its diversity is low because of unevenness due to high number of house sparrows (51 individuals) recorded compared to abundances of other species.

Observed bird richness, jackknife 1 richness estimate and Shannon's diversity index are correlated with two bird functional groups: birds not related with steppes ($r=0.547$, $p=0001$) and steppic birds related with other habitats or needing different features such as rocks for breeding ($r=0.659$, $p<0.001$). Therefore, bird diversity and richness increases with addition of birds related with other habitat features but not steppes to the bird assemblage. Abundance of both bird functional groups are significantly negatively correlated with abundance of steppe birds at a site ($r=-0.382$, -0.472, respectively). If bird diversity is high at a site, it is in favor of birds not related with steppes.

3.4.2.2 Factors related with the Bird Richness and Diversity Patterns

The results of hierarchical partitioning for bird richness based on Jackknife 1 estimated and bird diversity based on Shannon's diversity index are given in Figure 3.25. The independent and joint effects of the factors are given in Table 3.11. The sum of *I*s is 0.8023 and 0.8075, respectively. This means that goodness of fit for all models for richness and diversity are close to each other.

According to the results, distance to woodlands and arable lands are two major factors effective on bird richness and diversity with 20-22% independent effects. Distance to woodlands is negatively correlated with birds not related with steppes ($r=-0.289$, $p=0.023$) and positively correlated with steppe birds ($r=0.258$, $p=0.043$). Elevation is found to be a third factor with 18-19.5% independent effect. It limits the former two factors and some bird species' distributions. It is negatively correlated with birds not related to steppes (-0.541, $p<0.001$) and positively correlated to generalist species ($r=0.251$, $p=0.049$). All those correlations are rather weak, but we can infer that the lower and closer to woodlands a site is, bird species not related to steppes increases which in turn leads to an increase in overall richness and diversity.

Other parameters found to be important are landscape diversity at the 500m and 2km scales, habitat heterogeneity, shrub/tree density, rock presence, current livestock number, land abandonment for 30-100 years, distance to settlements with trees, mixed crop production and land use, each with less than 8% independent contributions to explain richness or diversity. Their importance changes for richness and diversity.

The contribution of variables to joint effects follows similar trends. Exceptions are: Elevation has the highest joint effect. Similarly shrub/tree density, landscape diversity at 2km, distance to settlements with trees and previous mix crop production are more important with their contribution to joint effects to explain richness. In contrast, land abandonment for 30-100 years and homogeneity have less importance for their contribution to joint effects.

In addition, slope ($r=0.553$, $p=0.003$), distance to other grassland patches ($r=0.516$, $p=0.007$) and abandonment for 30-60 years ($r=0.410$ $p=0.038$) are found to be significant for bird richness.

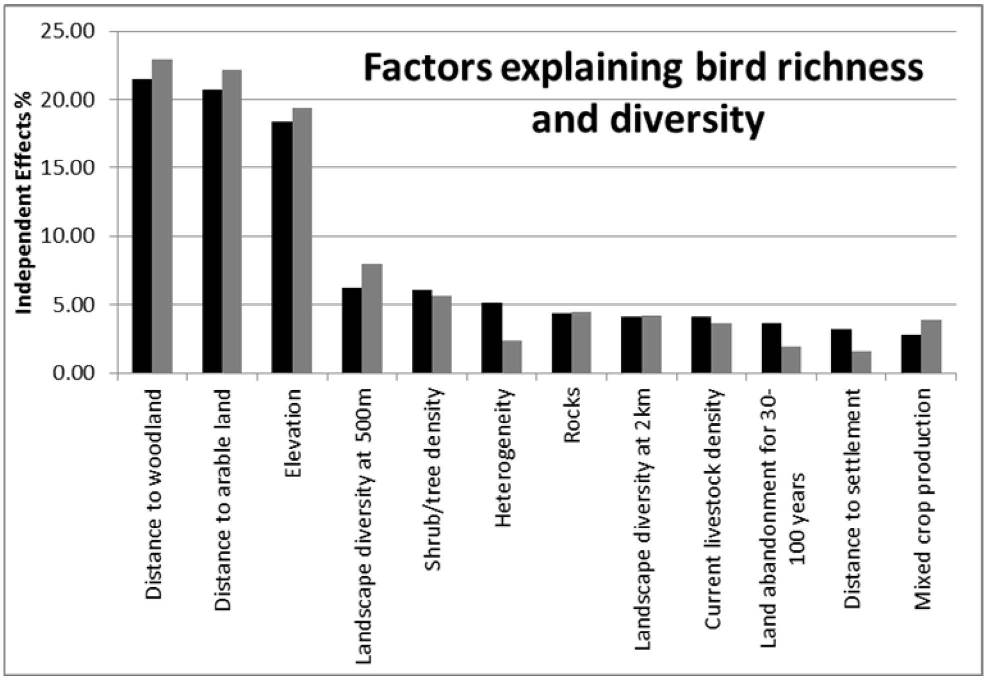


Figure 3.26 Distribution of percent variance explained by each variable independently (I) obtained by hierarchical partitioning of bird richness and diversity.

Therefore, the most bird species-rich and diverse sites can be described as follows: Near woodland and arable land at low elevations, heterogeneous at local and landscape levels with high shrub/tree density. They tend to be sites with low current livestock density. Cultivation was abandoned at some of those sites for 30-100 years i.e. mostly old segetal steppes. Cultivation was mixed with cereals and legumes. They are found on high slopes which are abandoned earlier than flat land or mild slopes. Presence of rocky outcrops and proximity to settlements enhance especially the richness of such sites.

Table 3.11 The contribution of each variable to goodness of fit (as independent and joint effects) of all possible regression models explaining bird richness and diversity of the sites.

Variables	Independent effects (I) on richness	Independent effects (I)on diversity	Joint effects (J) on richness	Joint effects (J) on diversity	Total (Richness)	Total (diversity)
Distance to woodland	0.1721	0.1847	0.83	0.82	1.00	1.00
Distance to arable land	0.1661	0.1785	0.83	0.82	1.00	1.00
Elevation	0.1471	0.1566	0.85	0.84	1.00	1.00
Landscape diversity at 500m	0.0499	0.0643	0.17	0.22	0.22	0.28
Shrub/tree density	0.0490	0.0456	0.26	0.20	0.31	0.25
Heterogeneity	0.0410	0.0192	0.20	0.04	0.24	0.06
Rock	0.0349	0.0358	0.15	0.13	0.18	0.17
Landscape diversity at 2km	0.0329	0.0339	0.17	0.15	0.20	0.18
Current livestock density	0.0329	0.0289	0.16	0.10	0.19	0.13
Land abandonment for 30-100 years	0.0288	0.0156	0.11	0.01	0.14	0.02
Distance to settlement	0.0254	0.0129	0.14	0.02	0.17	0.04
Mixed crop production	0.0222	0.0315	0.09	0.12	0.11	0.15

3.4.3 Butterflies

3.4.3.1 Richness Based on Butterfly Data

The nature of butterfly data limits the ways richness and diversity can be estimated. Since there are no repeated surveys, rarefaction can not be done. Furthermore, when abundance data of transect counts and presence/absence data of general counts are combined, all data are needed to be converted into presence/absence format, thus losing abundance information. In addition, lack of any records for 19 transect counts prevents calculation of diversity indices. Therefore, the observed richness remains as the only richness measure for the sites. The observed richness obtained from general counts for the sites are given in Appendix F. The butterfly richness values vary between 1 and 25. The average is 11.21 (±7.1). High standard deviation means that number of species in each site varies a lot. The most species-rich sites are 3, 26, 20 and 25. They are mostly old segetal steppes. Those sites support the butterfly assemblage coded as 210 and differentiated with *Chazara briseis* in the TWINSPAN analyses. The sites are marked with butterfly attracting features (wind refugia, hilltopping sites, mudd-puddling areas), former mixed crop production, higher abundance of legumes in the vegetation, habitat heterogeneity, light grazing and high plant richness.

The poorest sites are 11, 6 and 29. They support butterfly assemblages coded as 110, 120 and 220. Sites have different vegetation types as subalpine steppe, semi-natural steppe and alpine meadow, respectively. The main reason for low number of butterfly species is cool weather during the surveys. In addition absence of any features attracting butterflies and low plant diversity are other probable reasons.

The findings are handicapped by no repetition through the season which is needed to include butterflies flying in a different period during the growing season. Therefore, they do not reflect the actual butterfly wealth of the region but provide a snapshot for comparison of sites.

3.4.3.2 Factors related with the Butterfly Richness Pattern

The results of hierarchical partitioning are given in Figure 3.26. The sum of *I*s is 0.8589. According to the results, the main factors contributing higher butterfly richness is distance to woodlands, distance to arable lands and elevation; each with more than 15% independent contribution to explained variance. Plant richness is another important factor with an I value of 10% and in positive correlation with butterfly richness (r=0.605, p=0.001). Presence of butterfly attracting feature at a site such as mud-puddling sites, hilltopping places, wind refuge etc had 7% independent contribution in explaining observed butterfly richness. The cultivation of both cereals and legumes in the past is found to be important for butterfly richness (r=0.457, p=0.019). The successional stages 30-100 years after land abandonment support higher butterfly richness. The factors with less than 4% independent contribution are landscape diversity at 500m and 2km, heterogeneity, past use as cereal field, and good weather conditions for butterfly watching. They indicate that abandoned fields in diverse landscapes and heterogeneous sites visited under proper conditions support higher number of butterfly species.

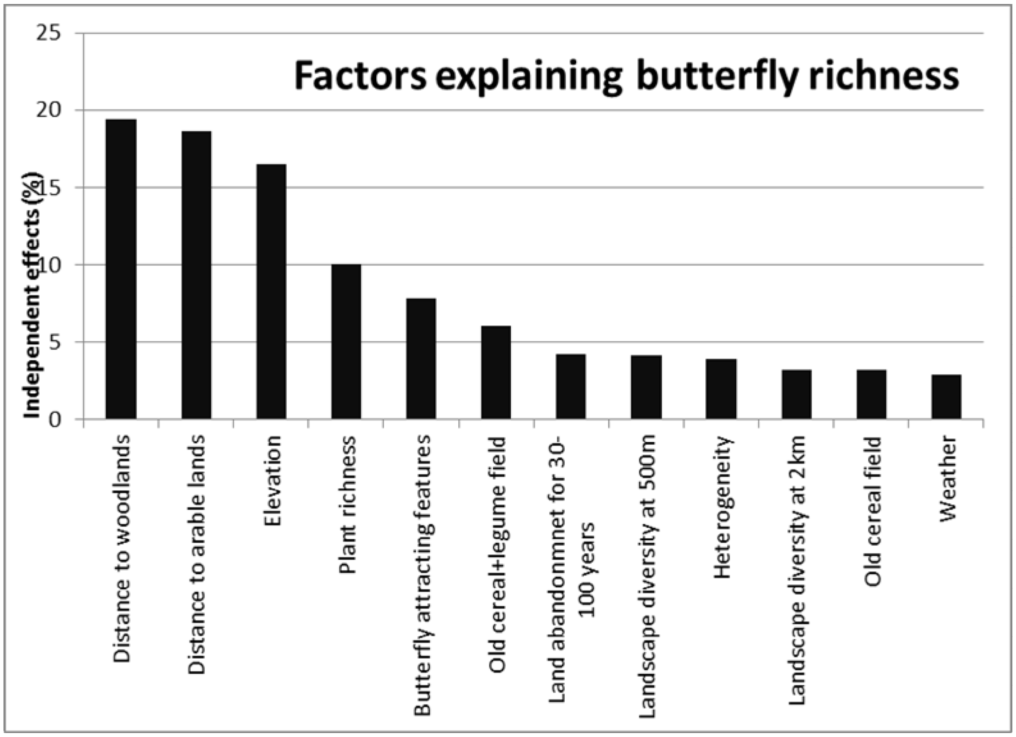


Figure 3.27 Distribution of percent variance explained by each variable independently (I) obtained by hierarchical partitioning of butterfly richness.

The richest sites in terms of butterflies can be described as follows: low-elevation steppes close to woodlands and arable lands that were once fields of mixed crops. They are usually located in moderate slopes and diverse landscapes. The factors listed are all correlated with butterfly richness with $p< 0.05$.

3.4.4 Relationship among Richness of Different Species Groups

The significant ($p<0.05$) relationships between richness for each species group as follows: The Jackknife estimates for plant and bird richness are weakly correlated ($r=0.367$) whereas observed butterfly richness and plant richness jackknife 1 estimate are highly correlated ($r=0.634$). Bird richness Jackknife1 estimate and butterfly observed richness are correlated, too ($r=0.518$). Diversity and richness values for specific to each species group are correlated to each other ($p<0.05$). All of those measures are correlated to shrub/tree density of a site (see Figure 3.27). This shows that shrub/tree density is a good overall indicator of diversity of a site.

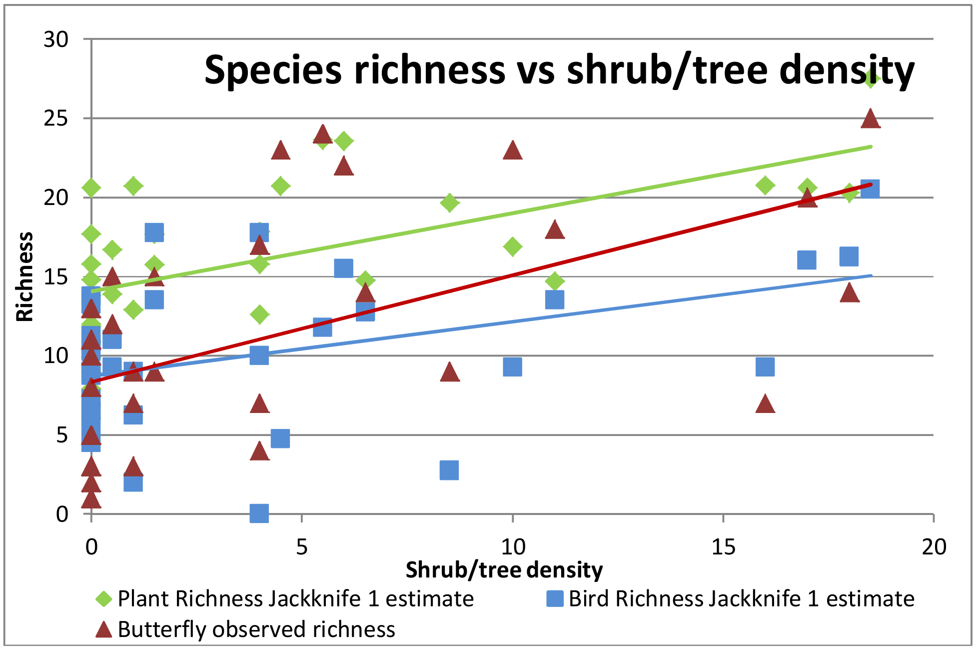


Figure 3.28 Shrub/tree density versus richness of each species group "Linear" represents fitted linear regression lines.

The correlation between richness/diversity measures among species groups are due to common prevailing factors: The main factor effective in all species groups is the elevation. It directly affects other determinants of climate and landscape diversity. In addition, current livestock level is one of the most important factors. Finally heterogeneity of the site and abandonment of cultivation for 30-100 years is effective on diversity and richness. The factors effective on plant richness and diversity also acts on butterflies since butterflies are directly linked to plant diversity. Most of above factors interact and determine shrub density of the region which is the best indicator of richness of a site.

Shannon and Simpson diversity values for birds and plants are correlated at for each species group (r=0.948 for plants; r=0.962 for birds; p<0.001). But values for birds and plants are not significantly related. As it is seen in Figure 3.28, Shannon diversity index values get much higher and variable values for plants whereas the values are much lower for birds. It is due to larger species pool and turnover rate of plants at regional scale.

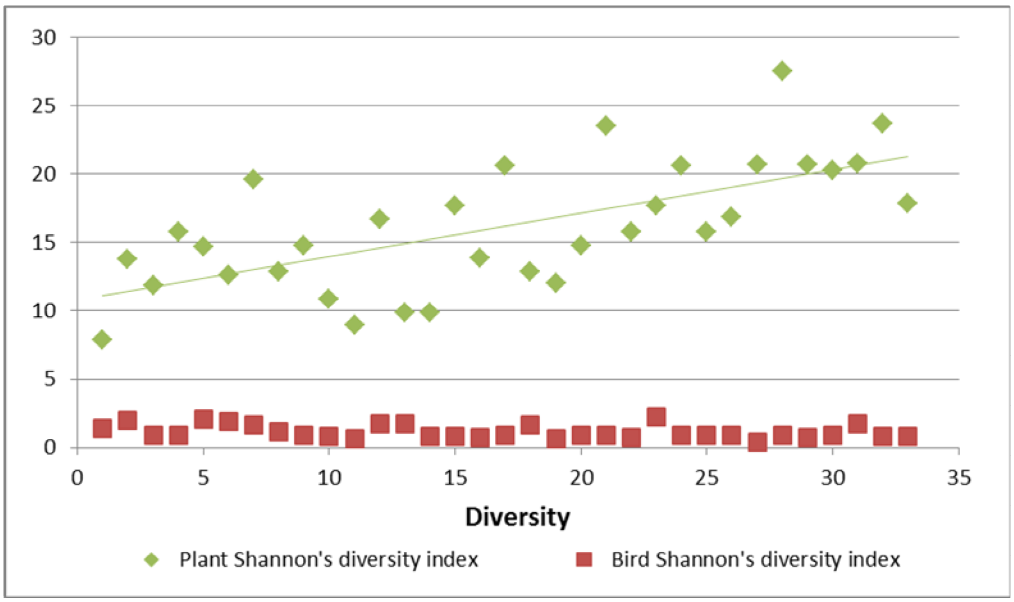


Figure 3.29 Shannon’s diversity index for birds and plants in sites ranked based on increasing plant diversity at the site level. Line represents fitted linear regression line.

CHAPTER IV

DISCUSSION

3.4. Data Collection Reconsidered

The size of under-researched Anatolian steppes, low number of qualified fieldworkers and deficient funds necessitated design of practical surveys for getting maximum reliable data within affordable effort. However, that necessity brought data limitations. Only plant species with more than 5% coverage in a plot were recorded; for birds, one visit per replicate took place. Since robust findings are obtained for region-scale study as presented in the previous chapter, data limitation did not complicate the interpretations about birds and plants, bearing in mind that more data would enable detailed findings and more comprehensive interpretations. One visit per site for butterfly data collection resulted in insufficient data to the degree that coherent results were not obtained, and the discussion of butterfly findings is minimal, too. Provided more funds and more high-quality fieldworkers, collection of data of all plants in plots, at least three repetitions of point counts for birds during at least one season, and long transect counts at fifteen day intervals, at least in one season, ideally in three seasons, for butterflies would result in a comprehensive dataset.

Completed with 32 sites with 64 replicates, number of survey sites limits the explanatory power of many tests such as regression-based tests and models such as generalized linear models or logistic regression. Those methods work best with normally distributed data from many sites as the number of sites should be five to ten times more than each the number of dependent variable. In addition to this constraint, multicollinearity imposed the use techniques other than regression.

Land use information was obtained from the villagers, but that resulted in coarse, rounded and fuzzy figures about livestock numbers and years since land abandonment. The history of sites can extend to hundreds of years back, and that information can be lost through generations, but clues like stony fences delimiting old arable lands, stone piles, a nearby shrubland can give a better understanding of the site. The results are compatible so it can be concluded that the resolution of data may be enough for this regional study but more detailed information would reveal better understanding of grassland dynamics. For example, the relation between years since land abandonment and diversity are vague, mostly due to imprecise figures used to indicate the duration.

3.5. Common Species, Assemblages, Richness and Diversity

3.5.1. Plants

Six different plant community types were identified at the end of study based on TWINSPAN analysis. Although the approach has similarities with the Braun-Blanquet method since both uses indicator species, the current study adopts a coarser and practical data collection method from a much larger region. However, some of the plant communities identified in this study are covered at the alliance or higher level in the known taxonomy of steppe vegetation, such as gypsiferous steppes in the alliance *Astragalo karamasici-Gypsophilion eriocalycis* Ketenoglu *et al* 1983 (Ketenoğlu *et al.* 2000).

Among the 6 plant communities defined, gypsiferous steppes and alpine meadows are different from the rest. Gypsiferous steppes developing on gypsum bedrock are well-known in Turkey to display distinctive vegetation (Ketenoğlu *et al.* 2000) and a flora rich in endemics (Akpulat and Çelik 2005). Alpine meadows are common alpine zones of Anatolian mountains such as the *Arabis androseca* and *Festuca ovina* association defined from Bolkar Mountains by Quezel in 1973 (Gemici 1994), or *Astragalo aurei-Festucion caucasicae* Hamzaoğlu 2006 found in Dumlu, Gavur and Palandöken Mountains in Erzurum (Hamzaoğlu 2006). Since such vegetation keeps green in the whole year, they are not treated as steppe. Subalpine steppes marked with an abundance of *Prangos platychlaena* and occurrence of plant species not found in the western part of the study area imply that Yamadağ represents a more easterly flora and delimits the Anatolian Diagonal; it is also similar to subalpine vegetation in Iran (Noroozi 2008).

Half of the survey sites were covered by semi-natural steppes, which are referred as victims of a recent destruction and degradation that took place in the 1950s and 1960s (Çetik 1985; Zohary 1973). Semi-natural steppes are represented with a high frequency and abundance of species characteristic to steppes, such as *Astragalus plumosus, Bromus tomentellus, Festuca valesiaca, Thymus sipyleus, T. migricus, Koeleria cristata, Salvia multicaulis* and *Stipa holosericea.* Quite few occurrences of overgrazing indicators such as *Gundelia tournefortii, Eryngium campestre, Euphorbia* sp. show that the steppes are recovering from the negative effects of overgrazing and that current grazing levels are not detrimental for steppes. A reminder of past overgrazing at those sites is the dominance of tragacanthic species. A few of those sites were abandoned arable lands. This indicated that recovery can take place in both overgrazed and ploughed sites. Semi-natural steppes can be further divided based on change in species composition due to soil properties, land use and heterogeneity of the sites.

Segetal steppes, covering large areas in the study region, and also in other mountainous parts of Turkey, are differentiated with annual indicator species, high coverage and richness of annuals, site-level heterogeneity and usually higher diversity than other steppe types. Medusahead *Taeniatherum caput-medusae,* the indicator species of segetal steppes, is found to be the commonest species. It is an annual grass known to be found in steppe, fallow fields, waste ground or roadsides in Turkey (Davis *et al.* 1986) but an exotic invasive species for arid and semi-arid plains of North America (Blank and Sforza 2007) Its high abundance and extensiveness shows the prevalence of segetal steppes in the region, especially in low mountain zones.

The young segetal steppes are dominated by annual grass and forbs with very few representatives of semi-natural steppes whereas perennial *Astragalus, Festuca, Stipa* and *Thymus* species are found in considerable abundance on old segetal steppes. Since they are older than 5 years, some of the pioneering species of Central Anatolia such as *Adonis aestivalis, Bifora radians, Wiedemannia orientalis* etc. are not recorded. Although it is not possible to delineate two with certain year period, the young segetal steppes are usually abandoned less than 30 years ago whereas older ones are generally abandoned more than 30 to 70 up to 100 years ago, with some older or younger exceptions. The subgroups of old and young segetal steppes show a gradient from segetal to semi-natural steppes based on the abundance of perennials, implying different successional stages or alternative states between semi-natural and young segetal steppes. The differentiation of plant communities based on plant functional types supports the division of semi-natural and segetal steppes based on annual versus perennial abundances. As the vegetation changes towards semi-natural steppe, first perennial forbs, then perennial grasses increase.

As mentioned in the first chapter, vegetation literature in Turkey separates plain steppes or low-mountain steppes as a distinctive type. But in this study such a group is not obtained. The reason is not having a survey site lower than 1200m and on a plain similar to Central Anatolian conditions.

3.5.2. Birds

Black-headed bunting and ortolan bunting are two commonest species of the standard surveys. Both species are attracted to woody elements. This indicates the shrubby nature of almost half of the steppes surveyed.

This study is first in attempting to define bird assemblages of steppes in Turkey. Based on TWINSPAN analyses, they are identified as that of open, homogeneous steppes without woodlands in proximity, on either very high elevation (i) or the montane zone (ii); bird assemblages of heterogeneous steppes with woodlands and settlements in proximity of low (iii) and high wood density (iv). The habitat preference of the indicator species and environmental differences between sites of different groups indicate that the classification is based mostly on birds avoiding or favoring heterogeneity at the landscape level, woody vegetation, arable lands or settlements nearby steppes. The bird assemblages are not clearly separated based on steppe-dependence of bird species. The bird assemblages of open, homogeneous steppes without woodlands and settlements in proximity especially on highlands are dominated by steppe birds but generalist species or steppe species needing specific features like rocky outcrops are abundant at some sites supporting this community. A different functional type approach i.e. species of forests/woodlands, arable lands, settlements and grasslands would give nuances about bird assemblages of steppes. Most of the species use habitat mosaics for feeding or breeding; for example, skylark uses other habitats as lower quality substitutes in accordance with compensation hypothesis whereas tawny pipit uses other habitats as supplements (Wolff 2005). Therefore, it is difficult to assign species to certain habitats most of the time.

The average bird species richness based on standard survey data is 7.26 (±2.54) for observed richness, 11.05 (±6.20) for Chao 1, and 10.05 (±4.53) for Jackknife 1 estimates. The average beta diversity of each site is 1.74 (±0.43) for Shannon's diversity index and 0.77 (±0.13) for Simpson's diversity index. Bird records have been collected before in the region for the Anatolian Diagonal Biodiversity Project with 30 minutes transect counts. There are 13 counts in habitats dominated by grasslands and close to the replicates. The observed richness was found to be between 7-15 with an average of 13.15 (Ambarlı 2009). Since the estimates for point counts and observed richness of 30' transect counts match, it is assumed that the estimates are acceptable.

3.5.3. Butterflies

One visit per site and bad weather conditions during some surveys resulted in underrepresentation of spring butterflies in the dataset and an overall incomplete data. As a snapshot of butterflies flying at that period, generalist species such as *Melanargia larissa, Colias crocea, Chazara briseis* and *Vanessa cardui* were commonest in the study area, most of which are members of Nymphalidae. Among 111 butterfly species identified, none of them were threatened and four of them were endemic. No representation of many threatened species flying in the region is due to survey methodology and inability of identification of most *Agrodietus* butterflies by observation.

Butterfly assemblages, identified by a 3-level TWINSPAN classification and 5 endpoints, cannot be clearly defined and named due to data limitations. The habitat preferences and distribution range of indicator species and the environmental properties of the sites they divide are not compatible to each other. There is an implication that the division will be based on butterflies flying in high elevation, habitat specialist species flying in dry stony environments and habitat generalist long-flying butterflies but the findings are not clear-cut. The data collection method used for butterflies does not enable us to have a reliable estimate of butterfly richness and diversity of sites.

3.6. Factors Important for Richness and Diversity for Plants, Birds and Butterflies

The richest sites in terms of plant species are low elevation sites and with low livestock density. Magnesium content plays a significant role though it is not significantly or strongly correlated with richness or diversity. Climatically they are dry sites, experiencing relatively high temperatures in the coldest quarter of the year. The old fields, high landscape diversity support higher plant diversity. Those sites have higher Ca content, electrical conductivity, salt content, pH at saturation but lower organic matter and P_2O_5 content. The higher density of shrubs/trees is an indicator of such sites. Diversity results follow a similar pattern but current livestock density is less important; loam soil as a soil texture class is found to be important in explaining plant diversity.

The most plant species-rich sites are either some old segetal steppes or semi-natural steppes. The most species-poor sites are alpine meadows, some subalpine steppes and some semi-natural steppes. There is not a direct relationship between plant community type and the plant richness or diversity of a site. This is due to the difference in environmental factors determining the plant community and richness of a site. Although the elevation is an important factor determining both, Mg content and current grazing level determines the richness whereas bedrock and arable land history determines the type of the main communities.

The most bird species-rich and diverse sites are near woodlands and arable lands at low elevations, which are heterogeneous at both local and landscape levels with high shrub/tree density. They tend to be sites with low livestock density. Cultivation (usually mixed with cereals and legumes) was abandoned at some of those sites for 45-100 years. They are found on steep slopes which were abandoned earlier than flat land or milder slopes. Presence of rocky outcrops and proximity to settlements enhance especially the richness of such sites.

The richest and most diverse sites in terms of bird species support mostly the steppe bird assemblages of heterogeneous areas with woodlands or settlements in proximity. The poorest sites support mostly the steppe bird assemblages of open, homogenous areas without woodlands in proximity, and in minority, bird assemblages of heterogeneous areas with low wood density. So there is a relationship between bird assemblage type and bird species richness and diversity due to the common main actors such as distance to woodland and heterogeneity. However, as expected there is not a strong relationship between bird richness and plant community type of a site though there are some common environmental factors determining both.

The sites with a high number of butterfly species are located in lower elevations close to woodlands and arable lands. They are rich in plant species and have butterfly attracting features. They have heterogeneous habitat and experienced legume+cereal crop production in the past with have a higher abundance of legumes in the vegetation. The sites with the lowest number of butterfly species are plant species-poor sites without butterfly attracting features, most of which were too cold during the surveys.

Below discussed are the most important environmental, vegetation and land use parameters.

3.6.1. Elevation and Climate

Elevation, effective on several environmental variables, land use patterns, species and vegetation distributions, is found to be a major determinant of richness and diversity of plants, birds and butterflies. In addition, it is the main environmental factor determining alpine meadows and subalpine steppes, it divides the bird assemblages open, homogeneous steppes without woodland in proximity into highlands and montane, and it causes the first level division for butterfly assemblages. Moreover, together with humidity it is among the variables that have the highest contribution to explanation of variance in plant, bird and butterfly data in CCA.

The climatic variables used in this study are obtained from BIOCLIM models developed partly from digital elevation modeling, so the climatic variables and elevation are highly correlated. Therefore, climatic parameters accompany elevation in most of the results, but they have independent effects, too. The Thornthwaite precipitation effectiveness index reflecting humidity (the opposite of aridity) has a small contribution to explain plant richness and diversity. In addition, precipitation is one of determinants of first level division of bird assemblages. Mean temperature of the warmest quarter is important in explaining plant and butterfly data variances. Mean temperature of the coldest quarter had almost 5% independent contribution to explain plant richness. It is also an important parameter to explain the variance in plant data. Precipitation of the driest quarter is found to be important for the division of bird assemblages at different levels and in explaining variance in plant data. A composite parameter representing climate has minor importance <%5 for explaining butterfly richness.

3.6.2. Bedrock, Soil Nutrients and Productivity

Opposite to Tilman and the colleagues' findings (1996) no relationship has been found between productivity and richness or diversity. The major reason for this can be the data resolution: productivity measure is obtained from NDVI greenness index of Landsat images which have 900 m^2 pixel size, not from direct measurements on land. NDVI is claimed to be a valuable tool for estimating aboveground net primary production for studies at regional and global scales. However, Turner and colleagues (2005) claim that uncertainty and inherent errors of those methods for NPP prediction from standing crop are too high for site based studies in grasslands. In this study, NDVI is found to be important only for the first level division of bird assemblages. In addition, NDVI is found to be significantly correlated only with precipitation of the driest quarter and hydraulic conductivity of the soil, not with the soil nutrients. Therefore, it reflects water limitation for primary productivity. Because of the low spatial data resolution, it may not be a good indicator at site level and does not show correlations with other parameters (e.g. soil nutrients) as expected.

Mg, P and N are either important or correlated with plant richness or diversity. This relationship is negative for P and N as indicated by Critchley *et al.* 2002a,b: as the amount of soil nutrient decreases the diversity or richness increases. It is also negative for organic matter but positive for Mg due to magnesium's antagonistic effects (Proctor 1971).

Mg is known to be an essential nutrient since it is a constituent of chlorophyll, critical for absorption of light for photosynthesis. In addition, it is also used in functioning of ribosomes in protein synthesis and work as cofactor of many enzymes (Whitehead 2000). Its role in primary productivity is related to energy flow and biomass accumulation (Callahan and Kucera 1981). In temperate regions, 0.33% Mg in soil dry weight is the average which is equivalent to 3300 ppm (Brady and Weil 1999). The soil Mg in abandoned fields can vary between 1391.5 ppm in UK and 31460 ppm in in Spain (Van der Putten *et al.* 2000). The soil Mg in the survey sites range between 3.83 and 1617 ppm. Although a major cation for plants, Mg deficiency is rare in grasslands (Whitehead 2000). Magnesium gets attention as a limiting factor in serpentine soils by poor plant productivity, high rate of endemism and distinct vegetation types (Whittaker 1954) named as serpentine syndrome (Brady *et al.* 2005). In the study area Mg levels range a lot, and after logarithmic transformation it is seen that it has a relationship with plant richness and diversity. It is probably due to the element's antagonistic effects especially when Mg/Ca ratio is high in the soil: the effect on productivity is through its antagonistic behavior toward other elements in plants; depressing intake of Ca and elements such as Iron, Cobalt, Boron, Manganese, Phosphate and Sodium (Brady *et al.* 2005; Brooks and Yang 1984in Brady *et al.* 2005) and the toxicity should be applicable for most of the plants that are not adapted to serpentine on serpentine soils (Brooks 1987 in Brady *et al.* 2005). Although the soils of the survey sites are not classified as serpentine soils, high soil Mg does not act as a nutrient but a suppressing factor.

As the primary limiting resource affecting plant diversity (Critchley *et al.* 2002 a,b) nitrogen was negatively correlated only with Chao estimates. Chao estimates turned out with the highest values and standard deviations for richness. So probably the limiting effect of Nitrogen is better reflected in highly variable richness estimate. Among the other soil nutrient elements tested, P_2O_5 amount is found to be negatively correlated with all plant richness and diversity measures. Fynn and O'Connor (2005) state that not only N availability but also hierarchical interaction between N and P availability and their effect on primary production affects plant communities in South African mesic grasslands.

Organic matter is found to be an important soil variable affecting plant richness and diversity negatively, *contra* Janssens *et al.* 1998 and also explaining variance in plant data. As indicated in many studies, it should be due to its role in productivity (Tiessen *et al.* 1994; Campbell 1989). But that relationship cannot be proved through productivity in this study due to coarse estimation of productivity from satellite data.

Among the different soil classes sampled, brown forest soils are found to be important in supporting higher plant richness. Deep brown soils or brown forest soils may be supporting faster succession at a site as will be discussed later.

Soil depth is found to be negatively correlated with plant richness and diversity and variance in plant data. As the pool of soil resources for plant growth, it is positively correlated to aboveground plant biomass (Belcher *et al.* 1995) so negatively correlated with richness and diversity (Baer *et al.* 2003) which is in accordance with the findings. The limiting effect of soil depth as available soil resources is also important for succession in interaction with grazing and time (Fuhlendorf and Smeins 1998). One concern for soil depth data is its resolution:

Soil depth data was obtained from soil maps of the Ministry of Agriculture and Rural Affairs, which is quite coarse compared with the survey scale. On-site measurements would have provided much better understanding.

Soil parameters explaining variance in plant data are Soil water PCA (composed of field capacity, wilting point and saturation), soil texture as contents or classes, Ca PCA component (composed of salt content, pH at saturation, electrical conductivity, Ca content), and cation exchange capacity. Soil silt and water content has also small independent contributions to explain plant richness and diversity. Silt is well-known for its effect on species richness (Stohlgren *et al.* 1999). As a limiting factor for productivity, plant richness and diversity declines with an increase in soil water parameters, the field capacity, wilting point and saturation.

The is not an overall major impact of bedrock on richness, diversity and species composition. Two related findings are importance gypsum bedrock for differentiating gypsiferous steppes and importance of volcanic bedrock together with phytogeographical subdivision for subalpine steppes were explained before. Exposure of bedrock and presence of rocky outcrops has minor importance in explaining variance in plant and bird richness and diversity.

3.6.3. Vegetation Parameters: Cover, Height, Shrub/Tree Density and Plant Richness

Although many studies indicate the key role of vegetation structure in the form of sward height, percent bare ground and woody elements on grassland bird species habitat preference (Delgado and Moreira 2000; Moriera 2000; Benton *et al.* 2000; McCracken and Tallowin 2004; Chamberlain *et al.* 1999; Atkinson *et al.* 2004; Buckingam *et al.* 2006; Herkert 1994), the first two factors are found to be non-significant in our study. The possible reasons for this are the different ranges of vegetation height measured in studies, different data collection methods and precision. Some of cited studies took place in agricultural mosaics in which vegetation height of the survey sites varied a lot i.e. between 5 and 90 cm (Chamberlain *et al.* 1999) or in grasslands with very short vegetation and little variation (such as Winter et al. 2005 and Moriera 2010). The height is visually measured in this study as minimum and maximum heights (36 and 76 cm on average, respectively) with a difference of about 40 cm between the two extremes. The coarse estimation of the vegetation height and its wide range may result in finding no significant differences.

Shrub/tree density is the determinant of the second level division for bird assemblages, and an important parameter in explaining variance in bird data, including bird richness and diversity. It is known that many species, especially warblers, show close associations with shrubs (Santos 2000). Shrubs provide nesting and roosting sites for birds that do not use homogenous vast steppes. Tree cover has a negative effect on most of the grassland-specialist birds (Cunningham and Johnson 2006) due to higher risk of predation for species such as calandra larks (Reino *et al.* 2010; Moriera 1999). Therefore, it is reasonable to find shrub cover as the splitter of the bird community.

From butterfly's point of view, shrubs themselves may be adult or larval foodplants. In addition, shrubs provide a utility resource for roosting and mating locations for some butterflies (Dennis 2004).

Shrub density is a good overall indicator of richness and diversity of a site as it is correlated with richness and diversity of all three species groups on sites. It is also correlated with most of the environmental factors, acting like a composite factor that indicates most of the environmental parameters. The joint effect of environmental and land use activities on biodiversity appears to be reflected in a single factor: shrub/tree density of the site which can be the result of three different and sometimes contradicting factors: (i) encroachment of grazing-resistant shrubs in case of overgrazing, especially in fire-prone grasslands (Van Auken 2000; Brown and Archer 1999) (ii) revegetation of abandoned lands below tree line accompanied by low grazing or no grazing (*et al.* 2007) (iii) remnants of previous vegetation indicating proper conditions for plant growth. Shrub presence may reflect the degree of recovery of steppes from overuse and their successional status. In a review about land abandonment, McDonald and colleagues (2000) state that in the early stages of abandonment biodiversity is likely to decrease, in the medium stage with considerable scrub cover biodiversity tend to increase but later, as woody canopy closes, biodiversity decreases again. The findings of this study are in parallel with that statement.

Butterfly richness is found to be related to plant richness of the sites. Many studies show that plant and butterfly diversity are correlated (e.g. Cremene *et al.* 2005; Erhardt and Thomas 1991; Rosin *et al.* 2001) since butterflies use many plants as nectar sources and specifically select certain foodplants for egg laying. The findings support this explanation even though the butterfly data is quite limited. In addition, plant assemblages and butterfly assemblages are more or less matching, split in a similar way. There are similar findings indicating strong correlation between grassland type and butterfly richness and composition (Collinge *et al.* 2003; Erhardt 1985) Finally, percent herbaceous cover is found to be slightly important for division of butterfly communities. It is known that butterfly species such as *Plebeijus argus*, *Polyommatus coridon* and many other blues prefer habitats with bare grounds to lay eggs on plants at the margins between vegetation and bare ground (Bourn and Thomas 1993; Krauss *et al.* 2005).

3.6.4. Landscape Diversity and Local Heterogeneity

Landscape diversity of survey sites at the 500m and 2 km scales are important for explaining bird and butterfly richness and diversity, and also observed variance in butterfly data. Diversity at the 500m scale had a higher impact on richness and diversity measures. The findings are in accordance with previous studies stating the importance of small and large scale landscape heterogeneity (Nikolov 2010; Davis *et al.* 2007; Krauss *et al.* 2003). Plant richness is not found to be correlated with landscape diversity or distance to other vegetation types, similar to the findings of Krauss and colleagues (2004) and Bruun (2000). But it is important to keep in mind that very few studies target the relationship between landscape diversity and plant richness, the results are not consistent to each other and not adequate for a generalization (Krauss *et al.* 2004).

Parameters related with distance to woodlands, arable lands and trees or settlements are also important for birds and butterflies. Distance to arable lands, settlements and trees are important in explaining variance in bird data. Distance to arable lands and woodlands are two major factors with highest independent contributions in explaining bird and butterfly richness and diversity. Arable lands provide foraging opportunities for the birds through compensation or supplementation mechanisms (Wolff 2005; Brotons *et al.* 2005). Woodlands provide nesting and feeding sites and preferred by different species. Therefore, as expected, the sites close to those two land cover types are richer. However, the situation is rather complicated for steppe birds, especially for ground-nesting birds: Some species, like crested lark, tree pipit, and corn bunting can breed close to woodland with partially covered nests to benefit from feeding opportunities whereas other species such as skylark breed away from trees at distances of 50m or more with open nests to avoid nest predation mostly by corvids (Moller 1989). In a study on the response of farmland birds, most of which are in our species list, to forest plantation edges Reino and colleagues (2009) found that bird diversity of overall, woodland, farmland and ground-nesting species declined away from the edges; widespread, woodland species and overall species richness had positive responses to edges whereas some steppe-species had negative responses. Woodlands or shrublands contribute to butterfly richness by housing species that cannot be seen in homogenous steppes such as *Favonius quercus* and *Satyrium* species.

Agricultural lands replace natural or semi-natural vegetation on the land, destroy tha natural flora butterflies dependent on and replace them with monocultures most of the time. But flower-rich field margins are known to attract butterflies (Settele *et al.* 2009). Proximity to arable land may indicate high habitat diversity due to complex land use activities. Although landscape diversity should have been found significant in that situation, it may not be working for butterflies due to butterfly use of flower-rich field margins and small patches.

Distance to trees and homogeneity are two environmental factors that separate bird assemblages of heterogeneous steppes into those with low or high wood density. Trees are defined here as tall woody plants that are suitable for bird nesting. Although proximity to woodland and shrub/tree density is lower at sites with skylark, there is no clear-cut criterion. Heterogeneity at both site and landscape levels is another good parameter for the division.

Habitat heterogeneity is found to be important for discriminating some vegetation subgroups, some butterfly assemblages, and two bird assemblages of heterogeneous steppes. In addition heterogeneity has a considerable effect in explaining bird and butterfly richness and bird diversity. As indicated in Tews *et al.* 2004, there is a positive relationship between habitat heterogeneity and animal species diversity since structurally complex habitats provide more niches and diverse ways of resource use; this is also true for plants (Bazzaz 1975).

Distance to settlements is found to be important for discriminating some bird assemblages since some bird species such as house sparrow favor man-made constructions or modified environments for breeding and nesting. Collinge (2003) states that urban gradient is important for birds. The settlements in our study are usually groups of farm buildings or small villages so an urban gradient probably does not exist. Such human structures create nesting sites and feeding opportunities such as ruderal vegetation on neglected land in the vicinity of farm buildings providing food sources for granivorous birds (Fuller *et al.* 2004).

Habitat features important for butterflies such as mud-puddling sites, hilltopping places or wind refuges are named as butterfly attracting features in this study, and presence of such features are found to be important for explaining butterfly richness of sites. Although many studies emphasize the importance of such features for butterfly habitat (Rosin *et al.* 2011; Dover *et al.* 1997), our finding may be biased since only one visit were made to sites, but wherever a site had attracting features it had higher species richness and abundance.

3.6.5. Land Use Factors Effective on Steppe Diversity

Land use activities are highly correlated with elevation and climate, but on their own they have important effects on richness, biodiversity and species composition.

3.4.4.1 Grazing

Livestock grazing levels declined in the study area in parallel with emigration and farm abandonment. Current grazing levels are on average 1/7th (range is from ½ to 1/100) of the past levels, which were typically called as "overgrazing" by villagers. Current and past grazing levels are in negative linear relationship with all the biodiversity measures. As livestock density in terms of dry sheep equivalent decreases, diversity or richness of species groups increase. Current grazing level is an important parameter for explaining variance in plant and bird data, and the third most important factor for explaining plant richness and diversity. However, it has less importance in explaining bird diversity and richness, and no importance in explaining butterfly richness. It is more important for richness than diversity. This means that once a species is able to get established under a certain level of grazing, its abundance is less affected from grazing.

The application of intermediate disturbance theory to the results and building a discussion over intermediate disturbance theory would be inconvenient. The reasons are that (i) the sites are environmentally different and as it is indicated before, factors other than grazing are playing a role in diversity (ii) the whole range of livestock intensity is not represented well since the sites having around 1000 or between 3000 and 6000 livestock were not sampled enough.

For the relation between grazing level and plant richness, Fırıncıoğlu and colleagues (2009) state similar findings for plants with an exclosure study in a *Festuca-Thymus* steppe: grazing exclosure increased richness. Similarly Louhaichi and colleagues (2012) found lower diversity, biomass and cover in arid steppe of Syria due to short term sheep grazing. Studies in grasslands of Europe and North America (Belsky 1992; Noy-Meir 1995; Enyedi *et al.* 2008) came to similar conclusions. In this study the grazing was researched in environmentally different sites. But an overall negative effect of grazing is seen. The reason for the negative effect can be due to soil and climatic conditions limiting the community through productivity more than grazing (Bakker *et al.* 2006) and grazing may have an additive negative effect. Past overgrazing experience can contribute to this as steppes still in recovery may not be able to resist grazing even at low levels.

Number of forb species and overall richness are found to be correlated in our study, but opposed to Fırıncıoğlu *et al.* 2010 and Fırıncıoğlu *et al.* 2007, no relationship has been found between forb and grass cover and grazing . It is known that grazing favors annuals over perennials (Diaz *et al.* 2007) and there are studies emphasizing increase in annual forbs in response to grazing (Hayes and Holl 2002; Towne *et al.* 2005). In this study no relationship has been found between grazing levels and annual forbs, annual grasses or annuals overall. However, there are sites with a vegetation similar to that of old segetal steppes that have not been ploughed but grazed heavily. For example, the site at Hezanlı Mountain is differentiated from the rest of the semi-natural montane steppes with a high abundance of *Bromus tectorum.* In addition many perennial grass species are absent or low in coverage, and tragacanthic plants are dominant. This vegetation composition may be due to a history of overgrazing. Moreover, the high nitrogen detected in the soil is probably due to grazing and contributes to higher forb abundance. Similarly some old segetal steppes abandoned 30-80 years ago but grazed afterwards heavily still have a high coverage of annuals.

The main difference of such sites from closest group of sites is much higher past livestock levels. The reason for finding no significant relationship between such sites and the closest group of sites is perhaps low number of sites in this condition. Further research is needed whether the observed high abundance of annual grasses but not forbs at those sites is a direct effect of grazing.

In this study, shrub/tree density is found to be negatively related with grazing level. Fırıncıoğlu and colleagues (2009) found significant negative relationship between grazing and shrub cover where *Genista* is the dominant shrub. Although *Genista* is not a common shrub in the study area, shrub intensity but not cover is found to be significant. The finding is consistent with the well-known fact that grazing suppresses shrubs and trees.

Grazing affects bird populations by causing changes in vegetation structure, food resources and predation pressure (Vickery *et al.* 2001). In this study, minor negative effect of current grazing level was evident on bird richness and diversity. Batary *et al.* 2007 reports that grazing generally has negative effects on bird richness and abundance, but findings about grassland birds are inconsistent: Kamp and colleagues (2009) state that some grazing-dependent steppe birds of high conservation concern benefitted from intensive grazing; Nikolov (2010) found that extensively grazed pastures supported higher structural complexity of vegetation cover and higher bird-species richness and diversity compared with abandoned ones; Batary and colleagues (2007) state that true grassland birds benefit from extensive grazing whereas non-grassland birds are not affected. It is known that birds favoring sparse vegetation benefit from grazing due to lower vegetation height and patchiness (Agnew *et al.* 1986). Because of different effects on species of different habitat choice, it is understandable that grazing levels do not have a major impact on birds overall.

Impact of grazing on vegetation composition and structure affects butterflies in various ways (Vogel *et al.* 2007). Overgrazing on host plant may have detrimental effects, but cessation of grazing may make the host plant unsuitable, e.g. too tall for ovipositioning such as *Hespera comma* in United Kingdom (Thomas *et al.* 1986; Vogel *et al.* 1997). Keeping vegetation at desired height may be beneficial for some butterfly populations or some species may be negatively affected from grazing overall. In this study, grazing did not affect butterfly richness of diversity directly but through plant richness and diversity, since past or current grazing level was not found to be an important factor in hierarchical partitioning analysis but was correlated with biodiversity measures. Quantitative data about whole plant species or nectar source at a site and a complete butterfly fauna data would give more information.

The livestock numbers of the past were found to be non-significant for diversity, richness and most of the species assemblages. This indicates that in most of the sites the signs of overgrazing disappeared and the steppes have recovered. Past livestock numbers was found to be a significant factor only for tragacanthic cover (similar to Fırıncıoğlu *et al.* 2010) and in discrimination of bird assemblages of high mountain homogeneous steppes and homogeneous montane steppes, and explaining variance in bird data. The presence of tragacanthic species and lower abundance of decreasers indicate effects of past overgrazing on vegetation but it does not have a direct impact on current diversity or richness.

3.4.4.2 Agricultural Abandonment and Succession on Abandoned Lands

Vegetation Succession

The design of this research is not suitable to reveal the successional stages since difference in vegetation can also be due to different environmental conditions and land use practices on sites other than land abandonment. Young segetal, old segetal and semi-natural steppes are not clearly defined successional stages of a single site since they are observed in environmentally different localities. However, the results can help inferences about succession of abandoned lands in the study area.

Abandonment for 0-30 years and 30-100 years support different plant communities, namely young and old segetal steppes, with some exceptions. There are no sites known to be abandoned earlier than 110 years ago so it is not possible to comment on older sites. Studies show that if not managed, secondary grasslands developed after forest destruction return to the shrubland condition within 15-30 years in China (Zhang 2005) and within 33 years in Oklahoma with the annual stage lasting a maximum of 13 years after soil disturbance or land abandonment in USA (McLendon and Redente 1990; Booth 1941; Hobbs and Huenneke 1992; Collins and Adams 1983). Annuals disappear after 25 years and replaced completely by bunchgrasses in Kansas and

Oklahoma (Booth 1941). Compared to those findings, succession proceeds slower in the study area.

There are also examples of faster succession rates: Four sites of old segetal steppe type are reported to be abandoned only 6 to 20 years ago and two of the semi-natural steppes were old fields abandoned 30 years ago. There are two possible explanations of this discrepancy: either the steppes experienced accelerated succession or the information about land use is wrong. The common features of those two sites are development over deep brown soils or brown forest soils, a sharp a decline in grazing intensity, high landscape diversity at both 500m and 2 km scales, and especially being very close to woodlands.

Cramer and colleagues (2007) claim that the period of succession to historical state is highly variable but if traditional non-intensive agriculture has taken place in small farms during a short period, if the regional species pool is capable of dispersal and competition with agricultural legacy, and if environmental conditions are suitable for recovery, then succession to historical state takes 20-30 years. In the case of a long agricultural history with intensive applications making current soil status quite different from its historical status, if soil seed bank is impoverished, and if distance to natural vegetation is far and seed dispersal is limited, succession takes much longer time. Cramer and colleagues (2007) give examples from temperate regions of North America and Central Europe as vegetation is dominated by mid-successional tree species with high levels of species richness. Lesschen and colleagues (2008) state that soil and vegetation recovery after land abandonment takes 45 years but is faster on lime than on marl in the semi-arid environment of southeastern Spain. Based on Cramer and colleagues' (2007) generalizations, proximity to woodland, brown forest soils and volcanic bedrock may have supported faster succession rates. For the opposite case, a long history of agriculture and impoverishment of soil especially soil erosion can be the reason for slower observed succession.

Since there are divergent examples of the relationship between the successional stage and the period of years since abandonment, the latter parameter is probably not the only determinant of the successional stage of a site. In addition, overgrazing in the past may result in the dominance of annuals, and although never ploughed sites may be covered with a vegetation similar to old segetal steppes.

Agricultural Abandonment and Past Agricultural Activities

Land abandonment process in the study area is similar to European experience (Cramer *et al.* 2007) but with different intensities. Following the agricultural mechanization and labor migration speeding up after 1950s, land abandonment has taken place due to the driving force of global agricultural policies. Starting from marginal lands i.e. slopes distant to settlements, most of the cereal lands were gradually abandoned. Land abandonment took place until 5 years ago in the survey sites, with a peak about 40 years ago. This created old fields of different ages, so different successional stages are observed at sites. Productive, flat lands on low mountains are still cultivated. Below 1400m, all land is either cultivated or abandoned recently and turned into young segetal steppes.

Arable land history is the main factor discriminating semi-natural montane steppes and segetal steppes. Years since abandonment is the main determinant of old or young segetal steppes, an important parameter in explaining variance in plant data, plant, butterfly richness and bird richness and diversity. Especially abandonment for 30-100 years is found to be important for richness and diversity for all species groups. Similar studies accept old field or old successional stage to occur between 10-50 years after abandonment. Therefore, the attribute "old depends on the context. This study names the "old successional stage" as one that is reached 30-100 years after abandonment. In most other environments, that period is long enough for shrubland development as will be discussed in the next section.

Burke and colleagues (1995) found that 50 years after agricultural activity is an adequate time for the recovery of soil nutrients and active organic matter. Siemann and colleagues (1999) found arthropod and plant richness increase with successional age during 15-54 years in USA. In a study on calcareous grasslands of Swiss mountains, Balmer and Erhadt (2000) found that old fallow lands (10 years old) had the highest butterfly richness. Pöyry and colleagues (2005) claim that some butterfly species have preferences to certain successional stages.

Many studies in Europe indicate a decline in plant and butterfly diversity with land abandonment (Tasser and Tappeiner 2002; Dullinger *et al.* 2003) but those studies include shrublands as the final stage developed after abandonment compared to our survey sites with less than 10% shrub cover.

Abandonment of grazing is generally followed by an increase in woody vegetation cover. Birds associated with scrub and woodland vegetation benefit from land abandonment (Preiss *et al.* 1997, MacDonald *et al.* 2000, Suárez-Seoane *et al.* 2002b, Verhulst *et al.* 2004, Vallecillo *et al.* 2008), while those tied to open habitats are negatively affected (Nikolov 2010). Therefore, it is reasonable that succession has an effect on bird communities. The findings of this study indicates moderate negative correlation between shrub density and current grazing level but not with past grazing level in accordance with the literature cited above.

Kamp and colleagues (2011) state that abandoned fields of 5-18 years are among most important habitats for steppe bird species in Kazakhstan. Santos (2000) found that bird richness increases with succession and the species composition changes as larks are replaced first by warblers, then by thushes as the dominant bird family, the density of passerines increases, the proportion of passerines feeding on the ground or in the air decreases while the proportion of passerines feeding on vegetation increases, passerines nesting on the ground decreases but passerines nesting in shrubs increases. Many studies that took place in pastures showed that shrubby pastures had more bird diversity than shrubless ones, similar to the findings of this study (Nikolov 2010; Vallecilo *et al.* 2008; Tubelis and Cavalcanti 2000). So land abandonment for 30-100 years favors shrubby steppe and affects vegetation structure favoring bird richness and diversity.

The type of crop cultivated during arable land use is found to have a minor role in explaining variance in plant data, butterfly richness and bird richness, and to a lesser extent, bird diversity. This is reasonable since most of the blue butterflies flying in the region use members of Fabaceae as host plants although butterflies usually do not use the crop plant as a major source. However, a diverse cultivation history is thought to favor legume diversity. Critchley and Fowbert (2000) state that lands with a mixed agricultural past can succeed to grassland faster, whereas cereal fields stay longer in early successional stages. Parallel to this finding, mixed-crop lands have a flora more similar to that of semi-natural mountain steppes.

3.7. Conservation Implications

The conservation recommendations about steppes of the study area or steppes of Anatolia in general are given below as bullet points.

- Different factors act on diversity, richness and composition of different species groups living in steppes. Elevation, arable land history and current grazing levels are important for plants whereas distance to woodlands and arable lands, local- or landscape-level heterogeneity are important for birds. Those factors should be considered in planning and designing conservation of steppes. Different plant communities, bird and butterfly assemblages should be represented; conservation-priority species should be included and important factors such as grazing levels should be considered in management plans.
- Although steppes cover large areas of Turkey, there is not any single protected area designated as a representative of the steppe ecosystem. Although sites for protecting wetlands or wildlife may have considerable area covered by steppes, there is no action planned or implemented for steppe conservation. Protected areas with different plant communities like gypsiferous, halophilous, semi-natural steppes of plains, mountains in different ecoregions should be established to represent steppes in the protected area network.
- For bird and butterfly-rich steppes, it is important to maintain the landscape mosaic with a combination of arable lands, woodlands, grasslands of different seral stages, and with local heterogeneity. Conservation actions targeting steppes in general, or certain species in particular, should consider both the land to be conserved and the landscape around it. Human activities are important for maintaining biodiversity for example maintaining landscape mosaics. Both complete abandonment of agriculture and intensive agriculture in vast areas will have negative effects on biodiversity. Support for nature-friendly family-level agriculture through incentives would favor biodiversity.
- The steppes on the Anatolian Diagonal are extraordinarily rich in plants, birds and butterflies, harboring many endangered species or species that are quite low in numbers elsewhere. This study does not target planning for species-level conservation, but it is necessary to emphasize that species action plans are needed to prevent human activities harming populations of

endangered species and to sustain long term viability of those species. Implementation of such action plans is crucial, at least in prevention of habitat-destroying activities that potentially affect populations of endangered species.

- Steppes and woodlands are in continuous interaction throughout the history of Anatolia. Dominant vegetation continuously shifted between steppes and woodlands in response to climate and human activities. Introgression of Irano-Turanian steppe vegetation into Anatolia and speciation on the diverse landscape resulted in species-rich steppes. However, currently steppes are under the threat of unnatural forest revegetation although those sites have been steppes for a very long time and harbor steppe-adapted rare species. Afforestation has potential for both positive and negative impacts on steppes. Afforestation of recently destroyed woodlands supports the integrity of the woodland system, thereby enhancing landscape heterogeneity around steppes. In contrast, afforestation of long-term steppes, especially the ones that cannot support woody vegetation anymore because of altered soil properties or current climatic conditions, will only result in the destruction of steppes. The idea that "it will be forest anyway given enough time" is not a reason for afforestation since natural processes taking place in much lower speed rate let species and populations adapt to new conditions or find refugia. Otherwise, destruction of populations of important species takes place. At least a literature survey on the sites to be planted with trees would reveal the importance of many sites for biodiversity. The afforestation actions can be planned in this way for all sites, independent of land ownership. Again, at least a literature survey should be an obligation prior to afforestation.
- The livestock grazing level is critical for steppe biodiversity. The findings indicate that as grazing level decreases, richness and diversity of plants increase. However, as known from many experiences in Europe and America, termination of grazing will favor shrubs, and if the climate allows, steppes will turn into woodlands with time. Therefore, low-intensity extensive grazing may be needed to maintain steppe cover and habitat heterogeneity. Research is needed to find out the figures for the appropriate "low level" of grazing.
- Grasslands are dynamic systems in space and time at various scales. Any "static" conservation action would have negative effects. All conservation

actions should be based on continuation of land use at low levels for "steppe biodiversity", monitoring the effects in a regular way and revising management plans. Maintenance of grazing or small-scale local farming will have positive effects, but habitat-destroying activities like mining and large-scale conversion of natural ecosystems should not be allowed before being carefully evaluated. The effects of those activities should be monitored as learning and early-warning mechanisms.

- From individual perception to institutional or administrative responsibilities, steppe is ignored as a "value" or a "conservation object". Conservationists should try to change this perception at different levels of organizations. The General Directorate of Nature Conservation and Natural Parks is a unit under the "Ministry of Forestry and Hydrological Affairs" which does not cover steppes in name or in practice. Although there are sub departments for wetlands and vulnerable ecosystems, steppes are not explicitly covered. The Ministry of Agriculture and Rural Affairs is the responsible organization for the sustainable use of steppes as rangelands. However, its works are based on productivity and no biodiversity-targeted action or planning has taken place so far apart from some new pilot studies. Ideally both ministries should have units responsible for conservation and sustainable use of steppes working in collaborative way.

CHAPTER V

CONCLUSION

Richer and more close to semi-natural conditions compared to dry grasslands of Europe and North America; steppes of Turkey deserve much attention from research, sustainable use and conservation points of view. This study is the first in revealing important findings about factors affecting species assemblages and biodiversity in Anatolian steppes at regional scale.

Generated and maintained in semi-natural condition by man for thousands of years in a speciation center where steppes of the study area are extraordinarily rich for herbaceous plants and harbor threatened grassland birds and butterflies of Europe. Although experienced overuse in the history, steppes usually experienced small-scale, usually family-level, farming practices widespread in montane zone of the study area that allowed for existence of both grazed large grassland patches on highlands or rocky substrates and landscape mosaic composed of woodlands, arable lands, human constructions and grazed grasslands at montane zone. Following fates similar to grasslands worldwide in terms of overuse with high stocking, conversion to arable land and finally land abandonment; study area inhabits different seral stages of different steppe communities. Cultivation abandonment and decrease or abandonment of grazing in once-overgrazed sites allowed a recovery for those sites. So that high diversity has survived in diverse semi-natural habitats and different species assemblages composed of species of different habitat preferences can be seen.

Six main plant communities and four main bird assemblages of the steppes, identified and examined with multivariate techniques for the first time for steppes of Anatolia, showed that the factors governing species composition and richness patterns of species groups differ and additionally they differ among species groups. The major determinants are gypsum bedrock, elevation, arable land history for plant communities whereas they are landscape and local heterogeneity and woody elements for bird assemblages. The major determinants of richness and diversity are soil Magnesium, elevation, current grazing level for plants; proximity to woodlands and arable lands and elevation for birds and butterflies. Among those, factors deserving special attention are Magnesium's major positive effect on richness although serpentine is not the case; importance of segetal communities as richest sites are usually abandoned lands for 30-100 years; not humped-back but negative linear relationship between current grazing level and richness and diversity; importance of landscape and local diversity, refuges and woody elements of steppes for birds and butterflies. Shrub/tree density on steppes with less than 10% woody coverage substitutes diversity and richness figures of all species groups so an overall good indicator of steppe biodiversity status indicating recovery level, successive status or maintenance of good soil conditions of the steppes.

It has already been late to start to conserve steppes of Anatolia. So researching, planning, implementing and monitoring for conservation actions should take place as soon as possible. Perceiving steppes as dynamic systems, interacting with various factors especially responding to changes in climate and land use would be the fruitful approach in designing management and conservation tools for steppes. Targeting conservation priority species, encompassing different species assemblages of steppes and gradients of factors important for species assemblage and biodiversity, considering landscape and local heterogeneity and sustaining conservation through land management would be basic steps to take for planning the conservation of steppes.

Afforestation campaign is filling the "emptiness" of steppes as acres are ploughed without being aware of destroying steppe biodiversity. Careful planning of afforestation for the success of afforestation, sustaining wildlife and steppe biodiversity is needed but most importantly, work on perception of steppes as a value to conserve from individual to organizational level is needed.

This research can be interpreted as first step to understand steppe biodiversity at the site and landscape scales. A wide range of environmental conditions were sampled at a few survey sites. More work is needed as a follow-up for better understanding of the steppe ecology and biodiversity. Among the data used for such analysis, reliability of land use data is critical. For at least each ecosection identified in this study, follow-up studies surveying many sites in each ecosection with different land use activities would reveal valuable detailed information. Forest steppes should also be sampled as complementary information. Links with information from forest-steppe zone samples will fill some gaps in our knowledge, e.g. whether some steppe plant assemblages are remnants of ground cover of forest steppes, how long such elements can stay after the destruction of the tree component, how much sites close to forest-steppes share similar herbaceous vegetation components, etc.

How to manage the land to support biodiversity is a vital question that needs to be answered. Although this research gives some inferences, detailed local experimental or monitoring studies must be undertaken to learn what to do on land. Especially grazing levels supporting biodiversity should be the target of research all around the steppes of Turkey.

Abandoned land succession is a subject that has been heavily researched in US and Europe but not in Turkey. This study provided first findings about biodiversity of abandoned lands, but intensive surveys and monitoring is needed to further understand those dynamics.

Long term monitoring and experimentation are the keys for understanding grassland dynamics, how to use this natural resource and how to conserve in the long term. The American literature is based mostly on studies taken place in Konza Prairie and Kansas Long term Ecological Research (LTER) stations (Knapp *et al.* 1998). Similar establishments are necessary and need to be settled urgently in Turkey to understand the steppe dynamics here, effect of land uses or abandonment and possible impacts of climate change on steppes.

Steppes of Turkey can be imagined as vast ocean to discover. Starting from a realistic and recent map of steppes based on RS and GIS techniques, a wide range of subjects such as possible impacts of climate change, Carbon sequestration, microbial activities, invertebrate diversity and their effect on biodiversity are awaiting to be researched.

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APPENDIX A

PLANT LIST

Table A.1 Alphabetical list of plant species recorded during surveys

Scientific Name	**Endemism (END)**	**Plant Family**	**Plant Functional Type***	**Response to Grazing**
Acantholimon caryophyllaceum BOISS.		Plumbaginaceae	TRG	invader
Acantholimon reflexifolium BOKHARI	E	Plumbaginaceae	PF	invader
Acantholimon venustum BOISS.		Plumbaginaceae	TRG	invader
Acanthus dioscoridis L	E	Acanthaceae	TRG	invader
Achillea biebersteinii AFAN.		Asteraceae	PF	invader
Achillea millefolium L.		Asteraceae	PF	invader
Achillea wilhelmsii C. KOCH		Asteraceae	PF	invader
Aegilops triuncialis L.		Poaceae	AG	invader
Aegilops umbellulata ZHUKOVSKY		Poaceae	AG	invader
Alkanna megacarpa DC.	E	Boraginaceae	PF	invader
Alyssum desertorum STAPF.		Brassicaceae	AF	invader
Anthemis aciphylla BOISS.		Asteraceae	PF	invader
Anthemis pungens YAVIN	E	Asteraceae	AF	invader
Arenaria acerosa BOISS.	E	Caryophyllaceae	PF	invader
Arenaria cucubaloides SMITH		Caryophyllaceae	PF	invader
Arenaria ledebouriana FENZL.	E	Caryophyllaceae	PF	invader
Artemisia spicigera C. KOCH		Compositae	PF	invader
Asphodeline tenuior (FISCHER) LEDEP.		Liliaceae	PF	invader
Astragalus ancistrocarpus BOISS. ET HAUSSKN.		Fabaceae	PF	invader
Astragalus barbarae BORNM.	E	Fabaceae	PF	invader
Astragalus chthonocephalus BOISS. &	E	Fabaceae	TRG	invader
Astragalus condensatus LEDEB.	E	Fabaceae	TRG	invader

*Plant functional types: TRG: tragacanthic sp., AG: annual grass, AF: annual forb, PG: perennial grass, PF: perennial forb, SHR: shrub or tree

Table A.1. Alphabetical list of plant species recorded during surveys (cont'd)

Scientific Name	Endemism (END)	Plant Family	Plant Functional Type*	Response to Grazing
Astragalus cymbibracteatus HUB.-MOR.	E	Fabaceae	TRG	invader
Astragalus gummifer LAB.		Fabaceae	TRG	invader
Astragalus kurdicus BOISS.		Fabaceae	TRG	invader
Astragalus lamarckii BOISS.	E	Fabaceae	TRG	invader
Astragalus microcephalus WILLD.		Fabaceae	TRG	invader
Astragalus plumosus WILLD.	E	Fabaceae	TRG	invader
Astragalus pycnocephalus FISCHER		Fabaceae	TRG	invader
Astragalus xylobasis FREYN ET BORNM.	E	Fabaceae	PF	invader
Berberis crataegina DC.		Berberidaceae	SHR	invader
Bromus cappadocicus BOISS. ET BAL.		Poaceae	PG	increaser
Bromus danthoniae TRIN.		Poaceae	AG	invader
Bromus japonicus THUNB.		Poaceae	AG	invader
Bromus tectorum L.		Poaceae	AG	invader
Bromus tomentellus BOISS.		Poaceae	PG	decreaser
Centaurea solstitialis L.		Asteraceae	AF	invader
Centaurea virgata LAM.		Asteraceae	PF	invader
Chardinia orientalis (L.) O. KUNTZE		Asteraceae	AF	invader
Cicer incisum (WILLD.) K. MALY		Fabaceae	PF	invader
Convolvulus assyricus GRISEB.	E	Convolvulaceae	PF	invader
Convolvulus compactus BOISS.		Convolvulaceae	PF	invader
Coronilla orientalis MILLER		Fabaceae	PF	increaser
Coronilla varia L.		Fabaceae	PF	increaser
Cotoneaster nummularia FISCH. ET MEY.		Rosaceae	SHR	invader
Crataegus orientalis PALLAS EX BIEB.		Rosaceae	SHR	invader
Crataegus x bornmuelleri ZABEL	E	Rosaceae	SHR	invader
Crepis foetida L.		Asteraceae	AF	invader
Crepis sancta (L.) BABCOCK		Asteraceae	AF	invader
Cynodon dactylon (L.)		Poaceae	PG	increaser
Dactylis glomerata L.		Poaceae	PG	Decreaser
Daphne oleoides SCHREBER		Thymelaeaceae	PF	invader
Daucus carota L.		Apiaceae	PF	invader
Dorycnium pentaphyllum SCOP		Fabaceae	PF	increaser
Ebenus laguroides BOISS.	E	Fabaceae	PF	Increaser
Ebenus macrophylla JAUB. ET SPACH	E	Fabaceae	PF	increaser

*Plant functional types: TRG: tragacanthic sp., AG: annual grass, AF: annual forb, PG: perennial grass, PF: perennial forb, SHR: shrub or tree

Table A.1. Alphabetical list of plant species recorded during surveys (cont'd)

Scientific Name	Endemism (END)	Plant Family	Plant Functional Type*	Response to Grazing
Elymus hispidus (OPIZ) MELDERIS		Poaceae	PG	decreaser
Elymus lazicus (BOISS.) MELDERIS	E	Poaceae	PG	decreaser
Elymus repens (L.) GOULD		Poaceae	PG	decreaser
Eryngium campestre L.		Euphorbiaceae	PF	invader
Euphorbia macroclada BOISS.		Apiaceae	PF	invader
Euphorbia petrophila C. A. MEYER		Euphorbiaceae	PF	invader
Festuca callieri (HACKEL EX ST.-YVES) F.		Poaceae	PG	increaser
Festuca glaucispicula MARKGR.-DANNANB.	E	Poaceae	PG	increaser
Festuca longipanicula MARKGR.-DANNENB.	E	Poaceae	PG	increaser
Festuca pinifolia (HACKEL EX BOISS.)		Poaceae	PG	increaser
Festuca valesiaca SCHLEICHER EX		Poaceae	PG	increaser
Fumana procumbens (DUN.) GREN. ET		Cistaceae	PF	invader
Galium incanum SM.		Rubiaceae	PF	invader
Galium verum L.		Rubiaceae	PF	invader
Genista albida WILLD.		Fabaceae	PF	invader
Globularia trichosantha FISCH. ET MEY.		Globulariaceae	PF	increaser
Gundelia tournefortii L.		Asteraceae	PF	invader
Gypsophila parva BARK.	E	Caryophyllaceae	AF	invader
Gypsophila turcica HAMZAOGLU	E	Caryophyllaceae	PF	invader
Hedysarum pestalozzae BOISS.	E	Fabaceae	PF	increaser
Hedysarum pycnostachyum HEDGE ET	E	Fabaceae	PF	increaser
Hedysarum varium WILLD.		Fabaceae	PF	decreaser
Helianthemum canum (L.) BAUMG.		Cistaceae	PF	invader
Helianthemum ledifolium (L.) MILLER		Cistaceae	PF	invader
Helianthemum salicifolium (L.) MILLER		Cistaceae	AF	invader
Helichrysum arenarium (L.)MOENCH		Asteraceae	PF	invader
Helichrysum pallasii (SPRENGEL) LEDEB.		Asteraceae	AF	invader
Hordeum bulbosum L.		Poaceae	PF	decreaser
Hypericum scabrum L.		Guttiferae	PF	invader
Juniperus communis L.		Cupressaceae	SHR	invader
Juniperus excelsa BIEB.		Cupressaceae	SHR	invader
Juniperus oxycedrus L.		Cupressaceae	SHR	invader
Koeleria cristata (L.) PERS.		Poaceae	PG	decreaser
Krascheninnikovia ceratoides (L.)		Chenopodiaceae	PF	invader
Legousia speculum-veneris (L.) CHAIX		Campanulaceae	AF	invader

*Plant functional types: TRG: tragacanthic sp., AG: annual grass, AF: annual forb, PG: perennial grass, PF: perennial forb, SHR: shrub or tree

Table A.1. Alphabetical list of plant species recorded during surveys (cont'd)

Scientific Name	Endemism (END)	Plant Family	Plant Functional Type*	Response to Grazing
Leymus cappadocicus (BOISS. ET BAL.)		Poaceae	PG	decreaser
Linum austriacum L.		Linaceae	PF	invader
Linum flavum L.		Linaceae	PF	invader
Lotus gebelia VENT.		Fabaceae	PF	decreaser
Malus sp.		Rosaceae	SHR	decreaser
Marrubium astracanicum JACQ.		Lamiaceae	PF	invader
Marrubium globosum MONTBRET ET	E	Lamiaceae	PF	invader
Medicago rigidula (L.) ALL.		Fabaceae	AF	invader
Medicago x varia MARTYN		Fabaceae	PF	decreaser
Minuartia hamata (HAUSSKN.) MATTF.		Caryophyllaceae	AF	invader
Minuartia hybrida (VILL.) SCHISCHK.		Caryophyllaceae	AF	invader
Minuartia juniperina (L.) MARIE ET		Caryophyllaceae	PF	invader
Nepeta nuda L.		Lamiaceae	PF	invader
Odontites aucheri BOISS.		Scrophulariaceae	AF	invader
Onobrychis armena BOISS. ET HUET		Fabaceae	PF	decreaser
Onosma bornmuelleri HAUSSKN.	E	Fabaceae	PF	invader
Onobrychis fallax FREYN ET SINT.	E	Fabaceae	PF	decreaser
Onobrychis sulphurea BOISS. ET BAL.	E	Fabaceae	PF	decreaser
Onosma sintenisii HAUSSKN. EX BORNM	E	Boraginaceae	PF	decreaser
Papaver argemone L.		Papaveraceae	AF	invader
Papaver dubium L.		Papaveraceae	AF	invader
Petrorhagia cretica (L.) BALL ET		Caryophyllaceae	AF	invader
Phleum exaratum HOCHST. EX GRISEB.		Poaceae	AG	invader
Phlomis kurdica RECH. FILL.		Lamiaceae	PF	invader
Phlomis linearis BOISS. ET BAL.	E	Lamiaceae	PF	invader
Phlomis oppositiflora BOISS. ET	E	Lamiaceae	PF	invader
Phlomis physocalyx HUB.-MOR.	E	Lamiaceae	PF	invader
Phlomis rigida LABILL.		Lamiaceae	PF	invader
Phlomis sieheana RECH. FIL.	E	Lamiaceae	PF	invader
Pilosella hoppeana (SCHULTES) C. H. ET		Asteraceae	PF	invader
Poa sterilis BIEB.		Poaceae	PG	various
Polygala anatolica BOISS. ET HELDR.		Polygalaceae	PF	invader
Polygonum sp.	?	Polygonaceae	PF	?
Potentilla recta L.		Rosaceae	PF	invader
Prangos platychlaena BOISS. EX	E	Apiaceae	PF	Invader
Quercus pubescens WILLD.		Fagaceae	SHR	decreaser

*Plant functional types: TRG: tragacanthic sp., AG: annual grass, AF: annual forb, PG: perennial grass, PF: perennial forb, SHR: shrub or tree

Table A.1. Alphabetical list of plant species recorded during surveys (cont'd)

Scientific Name	**Endemism (END)**	**Plant Family**	**Plant Functional Type***	**Response to Grazing**
Reseda lutea L.		Resedaceae	PF	invader
Rosa canina L.		Rosaceae	SHR	invader
Salvia caespitosa MONTBRET ET AUCHER	E	Lamiaceae	PF	invader
Salvia cryptantha MONTBRET ET AUCHER	E	Lamiaceae	PF	invader
Salvia multicaulis VAHL		Lamiaceae	PF	invader
Sanguisorba minor SCOP.		Rosaceae	PF	decreaser
Scirpoides holoschoenus (L.) SOJAK		Cyperaceae	PG	invader
Scutellaria orientalis L.		Lamiaceae	PF	invader
Silene oligotricha HUB.-MOR.	E	Caryophyllaceae	PF	invader
Silene supina BIEB.		Caryophyllaceae	PF	invader
Stachys lavandulifolia VAHL		Lamiaceae	PF	invader
Stipa ehrenbergiana TRIN. ET RUPR.		Poaceae	PG	increaser
Stipa holosericea TRIN.		Poaceae	PG	increaser
Stipa lessingiana TRIN. ET RUPR.		Poaceae	PG	increaser
Taeniatherum caput-medusae (L.)		Poaceae	AG	invader
Tanacetum cadmeum (BOISS.)	E	Asteraceae	PF	invader
Telephium imperati L.		Caryophyllaceae	PF	invader
Teucrium chamaedrys L.		Lamiaceae	PF	increaser
Teucrium polium L.		Lamiaceae	PF	increaser
Thymus haussknechtii VELEN.	E	Lamiaceae	PF	invader
Thymus kotschyanus BOISS. ET HOHEN.		Lamiaceae	PF	invader
Thymus migricus KLOKOV ET DES.-		Lamiaceae	PF	invader
Thymus pubescens BOISS. ET KOTSCHY		Lamiaceae	PF	invader
Thymus sipyleus BOISS.		Lamiaceae	PF	invader
Thymus spathulifolius HAUSSKN. ET VELEN.	E	Lamiaceae	PF	invader
Trifolium campestre SCHREB.		Fabaceae	AF	invader
Trifolium hirtum ALL.		Fabaceae	AF	invader
Trifolium lucanicum GASP.		Fabaceae	AF	invader
Trifolium pannonicum JACQ.		Fabaceae	AF	invader
Trifolium pauciflorum D'URV.		Fabaceae	PF	decreaser
Trigonella fischeriana SER.		Fabaceae	AF	invader
Trigonella spruneriana BOISS		Fabaceae	AF	invader
Verbascum sp.		Scrophullariaceae	PF	invader
Veronica multifida L.		Scrophullariaceae	PF	decreaser
Vicia cracca ROTH		Fabaceae	AF	invader
Vicia villosa ROTH		Fabaceae	PF	invader

*Plant functional types: TRG: tragacanthic sp., AG: annual grass, AF: annual forb, PG: perennial grass, PF: perennial forb, SHR: shrub or tree

Table A.1. Alphabetical list of plant species recorded during surveys (cont'd)

Scientific Name	**Endemism (END)**	**Plant Family**	**Plant Functional Type***	**Response to Grazing**
Xeranthemum annuum L.		Asteraceae	AF	invader
Ziziphora clinopodioides LAM.		Lamiaceae	PF	invader

*Plant functional types: TRG: tragacanthic sp., AG: annual grass, AF: annual forb, PG: perennial grass, PF: perennial forb, SHR: shrub or tree

APPENDIX B

BIRD LIST

Table A.2 Alphabetical list of bird species recorded during standart surveys

Scientific Name	**English Name**	**s recorded in Standard surveys**	**Relation with steppe habitats***
Accipiter brevipes	Levant Sparrowhawk	1	0
Acrocephalus arundinaceus	Great Reed Warbler	1	1
Alauda arvensis	Skylark	54	4
Alectoris chukar	Chukar	7	2
Anthus campestris	Tawny Pipit	15	4
Anthus spinoletta	Water Pipit	1	2
Athena noctua	Little Owl	1	1
Buteo rufinus	Long-legged Buzzard	2	4
Calandrella brachydactyla	Short-toed Lark	1	2.5
Carduelis cannabina	Linnet	28	0
Carduelis carduelis	Goldfinch	1	2
Carpospiza brachydactyla	Pale Rock Sparrow	2	0
Cettia cetti	Cetti's Warbler	3	0
Clamator glandarius	Great Spotted Cuckoo	1	0
Columba livia	Rock Dove	10	0
Columba palumbus	Wood Pigeon	3	0
Corvus cornix	Hooded Crow	13	4
Corvus monedula	Jackdaw	1	2
Coturnix coturnix	Quail	4	1.5
Cuculus canorus	Cuckoo	17	0
Dendrocopos syriacus	Syrian Woodpecker	3	2

*0: birds not related with steppes, 1: generalist species, 2: steppic birds needing other habitats or features for breeding 3&4: steppe birds

Table A.2. Alphabetical list of bird species recorded during standart surveys (cont'd)

Scientific Name	**English Name**	**Individuals recorded in Standard surveys**	**Relation with steppe habitats***
Emberiza cia	Rock Bunting	8	0
Emberiza cirlus	Cirl Bunting	1	2
Emberiza hortulana	Ortolan	36	2.5
Emberiza melanocephala	Black-headed Bunting	51	1
Eremophila alpestris	Shore Lark	13	2
Falco tinnunculus	Kestrel	9	4
Galerida cristata	Crested Lark	12	0
Garrulus glandarius	Jay	5	0
Hirundo rupestris	Crag Martin	2	0
Lanius collurio	Red-backed Shrike	5	2.5
Lullula arborea	Woodlark	11	0
Luscinia megarhynchos	Nightingale	13	0
Melanocorypha bimaculata	Bimaculated Lark	28	4
Melanocorypha calandra	Calandra Lark	3	4
Merops apiaster	Bee-eater	4	0
Miliaria calandra	Corn Bunting	21	4
Monticola saxatilis	Rock Thrush	1	0
Motacilla flava	Yellow Wagtail	1	1
Oenanthe finschii	Finsch's Wheatear	1	1.5
Oenanthe hispanica	Black-eared Wheatear	7	1.5
Oenanthe isabellina	Isabellina Wheatear	9	4
Oenanthe oenanthe	Northern Wheatear	27	3
Oriolus oriolus	Golden Oriole	8	0
Passer domesticus	House Sparrow	69	0
Passer hispaniolensis	Spanish Sparrow	1	0
Perdix perdix	Grey Partridge	1	4
Petronia petronia	Rock Sparrow	11	2
Phoenicurus ochruros	Black Redstart	3	1
Pica pica	Magpie	16	1
Pterocles orientalis	Black-bellied Sandgrouse	1	4
Rhodopechys sanguinea	Crimson-winged Finch	2	2.5
Sitta neumayer	Rock Nuthatch	4	0
Streptopelia turtur	Turtle Dove	7	0
Sturnus vulgaris	Starling	6	0
Sylvia communis	Whitethroat	1	1.5
Sylvia curruca	Lesser Whitethroat	2	0
Turdus merula	Blackbird	8	0
Upupa epops	Hoopoe	4	1.5

APPENDIX C

BUTTERFLY LIST

Table A.3 Alphabetical list of butterfly species recorded in surveys

Species Name	Butterfly Family	No. of records
Aglais urticae	Nmyphalidae	4
Apharitis (Cigaritis) acamas	Lycaenidae	2
Aporia crataegi	Pieridae	28
Argynnis aglaja	Nmyphalidae	2
Argynnis niobe	Nmyphalidae	14
Argynnis pandora	Nmyphalidae	27
Aricia (Plebeius) agestis	Lycaenidae	4
Brenthis hecate	Nmyphalidae	7
Brintesia circe	Nmyphalidae	8
Callophrys rubi	Lycaenidae	4
Carcharodus alceae	Hesperidae	1
Carcharodus lavatherae	Hesperidae	5
Carcharodus orientalis	Hesperidae	3
Carcharodus stauderi	Hesperidae	2
Chazara bischoffii	Nmyphalidae	4
Chazara briseis	Nmyphalidae	39
Chazara persephone	Nmyphalidae	2
Chilades (Lachides) galba	Lycaenidae	1
Chilades trochylus	Lycaenidae	2
Coenonympha pamphilus	Nmyphalidae	9
Coenonympha saadi	Nmyphalidae	1
Colias alfacariensis	Pieridae	23
Colias aurorina	Pieridae	2
Colias crocea	Pieridae	45
Cupido osiris	Lycaenidae	22
Erynnis marloyi	Hesperidae	5
Erynnis tages	Hesperidae	1

Table A.3. Alphabetical List of Butterfly species recorded in surveys (cont'd)

Species Name	Butterfly Family	No. of records
Euchloe ausonia	Pieridae	5
Euphydryas aurinia	Nmyphalidae	2
Favonius quercus	Lycaenidae	1
Glaucopsyche alexis	Lycaenidae	4
Glaucopsyche asteraea	Lycaenidae	4
Hipparchia pellucida	Nmyphalidae	2
Hyponephele lupina	Nmyphalidae	22
Hyponephele lycaon	Nmyphalidae	6
Iphiclides podalirius	Papillonidiae	3
Issoria lathonia	Nmyphalidae	16
Kirinia roxelana	Nmyphalidae	1
Krinia (Esperarge) climene	Nmyphalidae	11
Lampides boeticus	Lycaenidae	12
Lasiommata megera	Nmyphalidae	2
Leptidea duponcheli	Pieridae	6
Libythea celtis	Nmyphalidae	2
Limenitis reducta	Nmyphalidae	1
Lycaena alciphron	Lycaenidae	8
Lycaena asabinus	Lycaenidae	1
Lycaena phlaeas	Lycaenidae	7
Lycaena thersamon	Lycaenidae	3
Lycaena tityrus	Lycaenidae	6
Maniola jurtina	Nmyphalidae	4
Maniola telmessia	Nmyphalidae	1
Melanargia larissa	Nmyphalidae	69
Melitaea cinxia	Nmyphalidae	8
Melitaea didyma	Nmyphalidae	20
Melitaea telona	Nmyphalidae	5
Muschampia poggei	Hesperidae	3
Muschampia proteides	Hesperidae	1
Muschampia tesellum	Hesperidae	2
Papilio alexanor	Papillonidiae	5
Papilio machaon	Papillonidiae	3
Pararge aegeria	Nmyphalidae	1
Pieris brassicae	Pieridae	8
Pieris ergane	Pieridae	10
Pieris napi	Pieridae	1
Pieris rapae	Pieridae	2
Plebejus alcedo	Lycaenidae	1
Plebejus anteros	Lycaenidae	3

Table A.3. Alphabetical list of butterfly species recorded in surveys (cont'd)

Species Name	Butterfly Family	No. of records
Plebejus argus	Lycaenidae	2
Plebejus eurypilus	Lycaenidae	15
Plebejus idas	Lycaenidae	4
Plebejus loewii	Lycaenidae	22
Plebejus sephirus	Lycaenidae	19
Polygonia c-album	Nmyphalidae	1
Polyommatus admetus	Lycaenidae	9
Polyommatus aedon	Lycaenidae	4
Polyommatus amandus	Lycaenidae	10
Polyommatus bellargus	Lycaenidae	7
Polyommatus cornelia	Lycaenidae	9
Polyommatus daphnis	Lycaenidae	8
Polyommatus icarus	Lycaenidae	18
Polyommatus menalcas	Lycaenidae	3
Polyommatus ossmar	Lycaenidae	1
Polyommatus poseidon	Lycaenidae	2
Polyommatus semiargus	Lycaenidae	6
Polyommatus thersites	Lycaenidae	9
Pontia edusa	Pieridae	25
Proterebia afer	Nmyphalidae	2
Pseudochazara anthelea	Nmyphalidae	17
Pseudochazara beroe	Nmyphalidae	6
Pseudochazara geyeri	Nmyphalidae	3
Pseudochazara mamurra	Nmyphalidae	3
Pseudochazara mniszechii	Nmyphalidae	6
Pseudochazara pelopea	Nmyphalidae	1
Pseudophilotes vicrama	Lycaenidae	5
Pyrgus armoricanus	Hesperidae	1
Pyrgus cinarae	Hesperidae	8
Pyrgus serratulae	Hesperidae	1
Pyrgus sidae	Hesperidae	2
Satyrium abdominalis	Lycaenidae	13
Satyrium ilicis	Lycaenidae	3
Satyrium spini	Lycaenidae	4
Satyrus amasinus	Nmyphalidae	17
Satyrus favonius	Nmyphalidae	2
Spialia orbifer	Hesperidae	15
Spialia phlomidis	Hesperidae	6
Thymelicus lineolus	Hesperidae	29
Thymelicus sylvestris	Hesperidae	15

Table A.3. Alphabetical list of butterfly species recorded in surveys (cont'd)

Species Name	Butterfly Family	No. of records
Turanana endymion	Lycaenidae	5
Vanessa atalanta	Nmyphalidae	1
Vanessa cardui	Nmyphalidae	35
Zerynthia deyrollei	Papillonidiae	1

APPENDIX D

PLANT RICHNESS OF THE SITES

Table A.4 Plant richness and diversity of the sites

Sites	# Plots	Observed Richness	Chao 1 Mean	Chao 1 SD (analytical)	Chao 2 Mean	Chao 2 SD (analytical)	Jackknife 1 Mean	Jackknife 1 SD (analytical)	Jackknife 2 Mean	Shannon'S Diversity Index	Simpson's Diversity Index
1	10	14	20.13	6.08	20.13	6.08	20.3	1.92	23.06	2.375	0.8858
1J	20	10	22.5	17.14	22.5	17.14	14.75	2.34	18.4	2.085	0.8555
2	20	13	45	39.6	45	39.6	20.6	2.54	26.95	2.153	0.8388
3	20	18	43	24.24	43	24.24	27.5	3.23	34.79	2.257	0.8336
4	20	11	15.17	4.88	15.17	4.88	15.75	1.89	17.69	1.463	0.6386
5	20	13	41	21.28	39.6	20.23	20.6	2.54	27.8	2.055	0.8247
6	20	12	12	0.09	12	0.09	12	0	7.74	2.082	0.8333
7A	20	15	30	13.63	29.25	12.96	20.7	2	26.1	2.206	0.8457
7	20	12	20	11.66	20	11.66	15.8	1.74	18.55	2.141	0.8542
8	20	8	9	1.87	9	1.87	9.9	1.31	9.99	1.882	0.8235
10	20	15	16.5	2.29	16.5	2.29	17.85	1.56	17.99	2.401	0.8896
11	20	8	8.25	0.73	8.25	0.73	8.95	0.95	8.14	1.746	0.7837
12	20	11	19	11.66	19	11.66	14.8	1.74	17.55	1.658	0.7376
15	20	12	20	11.66	20	11.66	15.8	1.74	18.55	2.197	0.8677
16	20	9	11	3.74	11	3.74	10.9	1.31	11.85	1.711	0.7751
18	20	14	55.5	49.09	55.5	49.09	23.55	2.57	30.8	2.093	0.8052
20	20	15	24	10.17	24	10.17	20.7	2.43	24.39	2.32	0.8727
23	20	12	21	10.17	21	10.17	17.7	2	21.39	1.907	0.8049
24	20	9	10.5	2.29	10.5	2.29	11.85	2.85	11.99	1.378	0.6903
25	20	15	15.4	0.87	15.4	0.87	16.9	1.31	14.44	2.205	0.8709
26	20	17	21.08	4.05	21.08	4.05	23.65	2.08	24.83	2.387	0.8737
27	20	12	21	10.17	21	10.17	17.7	2	21.39	2.143	0.8558

Table A.5. Plant richness and diversity of the sites (cont'd)

Sites	# Plots	Observed Richness	Chao 1 Mean	Chao 1 SD (analytical)	Chao 2 Mean	Chao 2 SD (analytical)	Jackknife 1 Mean	Jackknife 1 SD (analytical)	Jackknife 2 Mean	Shannon'S Diversity Index	Simpson's Diversity Index
29	20	6	7	1.87	7	1.87	7.9	1.31	7.99	0.932	0.4557
32	20	11	26	13.57	25.25	12.9	16.7	2.43	22.1	1.835	0.794
33	20	11	11.25	0.73	11.24	0.7	12.9	1.31	12.14	1.544	0.6311
34*	10	9	13	5.29	13	5.29	12.6	1.99	14.38	1.484	0.689
36	20	12	12.67	1.31	12.67	1.31	13.9	1.31	13.14	2.035	0.8218
37	20	11	11.67	1.31	11.67	1.31	12.9	1.31	12.14	2.063	0.852
40	20	16	19.13	3.66	19.13	3.66	20.75	1.89	21.84	2.375	0.8833
41	20	9	18	10.17	18	10.17	14.7	2.43	18.39	1.473	0.6749
42	20	10	14	5.29	14	5.29	13.8	1.74	15.69	1.326	0.6309
50	20	13	37.5	31.11	37.5	31.11	19.65	2.49	25.1	1.506	0.6198
61	20	8	10	3.74	10	3.74	9.9	1.31	10.85	1.858	0.8213

APPENDIX E

BIRD RICHNESS OF THE SITES

Table A.5 Bird richness and diversity of the sites

Sites	Observed Richness	Chao 1 Mean	Chao 1 SD (analytical)	Chao 2 Mean	Chao 2 SD (analytical)	Jackknife 1 Mean	Jackknife 1 SD (analytical)	Jackknife 2 Mean	Shannon'S Diversity Index	Simpson's Diversity Index
1	11	14.6	3.85	17.13	6.08	16.25	2.56	18.42	2.339	0.8984
1J	10	10.13	1.77	12.13	3.66	12.75	2.84	13.92	2.085	0.845
2	10	22.25	13.15	26	16.49	16	3.24	19.33	2.154	0.8622
3	13	23.67	10.27	29.67	14.84	20.5	3.57	24.5	2.458	0.905
4	9	11.67	3.49	15	6.48	13.5	1.94	15.5	2.119	0.8711
5	9	10.67	3.49	32.5	31.11	13.25	1.89	16.42	2.061	0.8533
6	4	3.5	1.32	5	3.74	4.5	0.87	5.17	1.149	0.6173
7A	2	2	0.01	2	0.23	2	0	1.33	0.611	0.42
7	5	9.5	7.19	9.5	7.19	7.25	1.44	8.42	1.494	0.75
8	5	5.5	1.32	6	1.87	6.5	0.87	6.83	1.512	0.7653
10	7	15	11.66	9.67	3.49	10	1.22	11	1.778	0.8047
11	4	6	3.74	5	1.87	5.5	0.87	5.83	1.213	0.6562
12	8	10.5	2.29	9.9	1.46	11.25	0.75	11.08	2.007	0.8581
15	11	29	23.62	31.25	20.19	17.75	3.09	21.58	2.213	0.8719
16	6	6.67	1.31	10	5.29	9	2.12	10.33	1.696	0.8
18	10	14.13	3.66	14.6	3.85	15.5	2.6	16.83	2.112	0.8526
20	4	4.17	0.54	4.17	0.54	4.75	0.75	4.25	1.352	0.7347
23	7	8.5	1.03	8.9	1.46	10.25	0.75	10.08	1.827	0.821
24	8	15	11.66	14.5	7.64	10.75	1.44	13.25	1.979	0.8472
25	7	7.5	1.03	8.13	1.77	9.25	1.44	9.42	1.885	0.8402
26	8	10.67	3.49	12.17	4.88	11.75	1.44	13.25	1.841	0.7969

Table A.5. Bird richness and diversity of the sites (cont'd)

Sites	Observed Richness	Chao 1 Mean	Chao 1 SD (analytical)	Chao 2 Mean	Chao 2 SD (analytical)	Jackknife 1 Mean	Jackknife 1 SD (analytical)	Jackknife 2 Mean	Shannon'S Diversity Index	Simpson's Diversity Index
27	11	15.5	4.8	31.25	20.19	17.75	1.44	21.58	2.181	0.855
29	5	7	3.74	5.67	1.31	6.5	1.5	6.5	1.413	0.7219
32	7	16	11.66	10	2.65	11	1.22	11.67	1.73	0.7857
33	4	7	4.34	8.5	7.19	6.25	0.75	7.42	1.154	0.6122
34*	7	-	-	-	-	-	-	-	1.906	0.8438
36	7	9.25	3.4	8.13	1.77	9.25	0.75	9.42	0.741	0.3076
37	7	14	11.66	10	5.29	9	1.22	10.33	1.589	0.7424
40	6	8.5	2.29	8.13	1.77	9.25	1.44	9.42	1.72	0.8099
41	9	17	11.66	15	6.48	13.5	1.94	15.5	2.059	0.8587
42	10	11.6	2.16	12.5	2.96	13.75	1.44	14.58	1.93	0.7847
50	6	2	0.15	2.5	1.32	2.75	0.75	2.92	1.611	0.7751
61	6	5.25	0.73	12.5	7.58	8.75	2.84	11.25	1.684	0.7969

*Site 34 did not have a replicate. So the rarefaction was not applied.

APPENDIX F

BUTTERFLY RICHNESS OF THE SITES

Table A.6 Observed richness of butterflies on sites

Sites	Observed Richness
1	14
1J	14
2	20
3	25
4	15
5	10
6	1
7A	3
7	5
8	3
10	17
11	1
12	11
15	7
16	8
18	22
20	23
23	13
24	11
25	23
26	24
27	9
29	2
32	15
33	7
34*	4
36	12
37	9
40	7
41	18
42	3
50	9
61	5

APPENDIX G

SOIL DATA

T.C.
TARIM VE KÖYİŞLERİ BAKANLIĞI
TARIMSAL ARAŞTIRMALAR GENELMÜDÜRLÜĞÜ
TOPRAK GÜBRE VE SU KAYNAKLARI MERKEZ ARAŞTIRMA ENSTİTÜSÜ MÜDÜRLÜĞÜ
PK 5, 06172 Yenimahalle-Ankara
Tel: 0312-315 65 61-65 Faks. 0312-315 29 31

TOPRAK KALİTE ve VERİMLİLİK LABORATUVARI ANALİZ RAPORU
Analysis Report of Soil Quality and Fertility Laboratory

İstek Kayıt No / Tarihi	:28.06.2011-0833-11
Rapor No	:224
Rapor Tarihi	:08.07.2011
Örneği Gönderenin Adı ve Adresi	:Didem AMBARLI Ortadoğu Teknik Üniversitesi Biyoloji Bölümü Biyolojik Çeşitlik Ve Koruma Lab.NO=105 ANKARA

Toprak Örneğinin Kime Ait Olduğu ve Örneğin Alındığı Yerin Diğer Özellikleri	Örnek veya Parsel No	Lab.No	Kalsiyum (Ca) %	Magnezyum (ppm)	Su ile Doymuşluk %	Bünye Sınıfı	EC dS/m	Toplam Tuz %	Su ile Doymuş Toprakta pH	Kireç ($CaCO_3$) %	Aktif Kireç %	Bitkilere Yarayışlı Besin Maddeleri (kg/da) Fosfor (P_2O_5)	Bitkilere Yarayışlı Besin Maddeleri (kg/da) Potasyum (K_2O)	Organik Madde %	Toplam Azot N, %	Organik Karbon %	Verilmesi Gereken Saf Bitki Besin Maddesi (kg/da) Azot (N)	Verilmesi Gereken Saf Bitki Besin Maddesi (kg/da) Fosfor (P_2O_5)	Verilmesi Gereken Saf Bitki Besin Maddesi (kg/da) Potasyum (K_2O)
Didem AMBARLI -ODTÜ Biyoloji Bölümü 1-CB		4807	1,50	3,836	44	L	0,798	0,022	7,81	5,59		2,17	26,21	1,53		0,89			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 5-CB		4808	0,72	404,3	64	CL	0,880	0,036	7,25	1,17		2,64	89,27	2,38	0,2373	1,38			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 6-CB		4809	1,16	339,7	59	CL	0,835	0,032	7,89	29,82		3,57	74,18	3,76	0,2887	2,18			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 8-CB		4810	0,92	349,4	43	L	0,643	0,018	8,00	30,03		3,34	52,61	1,95		1,13			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 10-CB		4811	0,74	756,4	62	CL	0,877	0,035	6,50	-		14,44	112,48	2,69		1,56			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 15-CB		4812	1,36	536,6	58	CL	1,079	0,040	7,73	4,92		1,40	50,13	1,11		0,64			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 20-CB		4813	1,12	198,9	57	CL	0,924	0,034	7,64	55,25		2,17	119,56	1,10		0,64			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 24-CB		4814	0,41	346,7	80	C	0,306	0,016	5,97	-		4,04	89,27	5,83		3,38			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 27-CB		4815	0,84	860,6	46	L	0,816	0,024	8,05	24,51		0,62	50,13	0,63	0,1335	0,37			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 33-CB		4816	1,41	596,5	63	CL	1,069	0,043	7,40	0,67		3,96	92,44	1,72	0,1675	1,00			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 41-CB		4817	1,04	787,4	58	CL	0,902	0,033	7,89	18,25		4,73	95,65	1,85		1,07			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 42-CB		4818	0,45	872,1	43	L	0,727	0,020	7,06	0,39		3,80	36,34	1,11		0,64			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 50-CB		4819	1,02	179,9	51	CL	0,746	0,024	7,90	18,18		1,94	43,01	1,96	0,1103	1,14			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 4-S0		4820	0,46	538,8	47	L	0,653	0,020	6,68	-		1,86	60,32	2,05	0,0989	1,19			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 5-S0		4821	0,83	1324	71	C	0,843	0,038	8,14	54,54		0,93	77,10	1,29		0,75			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 6-SO		4822	1,08	1132	63	CL	1,022	0,041	7,81	4,67		1,79	102,24	3,15	0,1991	1,83			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 8-SO		4823	1,16	355,1	59	CL	0,796	0,030	7,82	2,26		4,35	116,00	2,60		1,51			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 11-SO		4824	0,68	536,9	83	C	0,601	0,032	6,48	-		5,28	109,02	7,91		4,59			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 12-SO		4825	0,15	64,66	66	CL	0,116	0,005	5,89	-		3,57	45,34	4,47		2,59			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 16-SO		4826	0,71	1617	53	CL	0,857	0,029	6,47	-		6,44	34,21	1,19		0,69			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 18-SO		4827	0,66	1326	41	L	0,684	0,018	6,71	-		3,49	22,50	0,64	0,0078	0,37			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 23-SO		4828	0,58	19,03	58	CL	0,453	0,017	6,40	-		12,45	83,08	2,76		1,60			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 25-SO		4829	1,06	642,1	57	CL	1,018	0,037	7,45	1,56		3,57	109,02	1,46	0,0986	0,85			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 29-SO		4830	0,58	278,6	83	C	0,326	0,017	6,09	-		8,46	92,44	6,95	0,3585	4,03			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 32-SO		4831	1,43	421,9	56	CL	1,006	0,036	7,89	12,45		2,64	83,08	0,54		0,31			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 40-SO		4832	1,22	1203	71	C	1,016	0,046	7,13	0,88		1,32	89,27	2,68	0,2185	1,55			

APPENDIX G (Cont'd)

Toprak Örneğinin Kime Ait Olduğu ve Örneğin Alındığı Yerin Diğer Özellikleri	Örnek veya Parsel No	Lab.No	Kalsiyum (Ca) %	Magnezyum (ppm)	Su ile Doymuşluk %	Bünye Sınıfı	EC dS/m	Toplam Tuz %	Su ile Doymuş Toprakta pH	Kireç ($CaCO_3$) %	Aktif Kireç %	Bitkilere Yarayışlı Besin Maddeleri (kg/da)		Organik Madde %	Toplam Azot N, %	Organik Karbon %	Verilmesi Gereken Saf Bitki Besin Maddesi (kg/da)		
												Fosfor (P_2O_5)	Potasyum (K_2O)				Azot (N)	Fosfor (P_2O_5)	Potasyum (K_2O)
Didem AMBARLI -ODTÜ Biyoloji Bölümü 2-CS		4833	1,20	613	66	CL	0,888	0,038	7,91	22,99		1,01	65,72	1,45		0,84			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 3-SE		4834	0,83	1303	49	L	0,880	0,028	7,79	1,56		2,48	77,10	0,74		0,43			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 7A-SO		4835	0,81	1506	57	CL	0,954	0,035	6,83	-		3,49	36,34	1,52	0,1546	0,88			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 61-HW		4836	1,38	402,6	59	CL	0,887	0,033	7,81	12,70		8,31	92,44	3,52	0,3022	2,04			
Didem AMBARLI -ODTÜ Biyoloji Bölümü 1J-SO		4837	4,42	36,84	53	CL	1,270	0,043	7,51	3,11		0,39	18,99	1,05	0,0470	0,61			

Analiz Sorumlusu
Vecihe İNCİRKUŞ
Uzman Kimya Mühendisi

Laboratuvar Sorumlusu
Dr. Mustafa USUL
Ziraat Yüksek Mühendisi

Dağıtım:

Analizi yapılan numune tarafımızdan alınmamıştır. Numunenin alınış şeklinden laboratuvarımız sorumlu değildir.
Bu rapor, TGSKMAE'nin yazılı izni olmadan kısmen kopyalanıp çoğaltılamaz. İmzasız ve mühürsüz raporlar geçersizdir.
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APPENDIX G (Cont'd)

Table A.7 Soil Data (Cont'd)

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GIDA, TARIM VE HAYVANCILIK BAKANLIĞI
Toprak - Gübre ve Su Kaynakları Merkez Araştırma Enstitüsü Müdürlüğü
PK 5, 06172 Yenimahalle-Ankara
Tel: 0312-315 65 61-65 Faks. 0312-315 29 31

SULAMA-TOPRAK FİZİĞİ VE TUZLULUK LABORATUVARI
Irrigation-Soil Physics and Salinity Laboratory

İstek Kayıt No / Tarihi	11-0833/28.06.2011
Rapor No	46
Rapor Tarihi	12.09.2011

Lab No	Kireç ($CaCO_3$) (%)	Organik madde (%)	Yapılan Uygulama	Konu	Kum	Silt	Kil	Bünye	Tarla Kapasitesi	Solma Noktası	Hacim Ağırlığı	Hidrolik İletkenlik	KDK
					%	%	%		%	%	(g/cm^3)	(cm/h)	me/100 g
4807				1-CB	75,2	19,1	5,7	**SL**	16,09	10,24	1,35	1,99	37,09
4808				5-CB	39,1	22,8	38,1	**CL**	28,39	17,97	1,09	0,73	32,09
4809	28,82		Kireçli	6-CB	52,1	30,3	17,6	**SL**	26,71	16,23	1,15	1,82	34,34
4809			Kireç giderilmiş	6-CB	44,7	34,0	21,3	**L**					
4810	30,03		Kireçli	8-CB	52,4	26,9	20,7	**SCL**	20,99	10,57	1,34	0,66	20,15
4810			Kireç giderilmiş	8-CB	30,8	35,0	34,2	**CL**					
4811				10-CB	37,5	43,5	19,0	**L**	29,28	15,93	1,34	0,32	34,71
4812				15-CB	45,0	26,3	28,7	**CL**	29,83	19,18	1,17	0,48	41,98
4813	55,25		Kireçli	20-CB	46,2	24,9	28,9	**SCL**	20,43	14,64	1,14	0,82	21,04
4813			Kireç giderilmiş	20-CB	15,4	30,3	54,3	**C**					
4814		5,83	Organik madde giderilmemiş	24-CB	38,2	42,3	19,5	**L**	40,97	21,43	0,89	1,49	25,38
4815			Organik madde giderilmiş	24-CB	24,8	38,0	37,2	**CL**					
4815	24,51		Kireçli	27-CB	51,2	26,4	22,4	**SCL**	19,55	11,72	1,31	1,68	20,43
4815			Kireç giderilmiş	27-CB	52,3	31,4	16,3	**SL**					

Analiz sonuçları yukarıda belirtilen numune(ler) için geçerlidir.

Bu rapor, TGSKMAE'nin yazılı izni olmadan kısmen kopyalanıp çoğaltılamaz. İmzasız ve mühürsüz raporlar geçersizdir.

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APPENDIX G (Cont'd)

T.C.
GIDA, TARIM VE HAYVANCILIK BAKANLIĞI
Toprak - Gübre ve Su Kaynakları Merkez Araştırma Enstitüsü Müdürlüğü
PK 5, 06172 Yenimahalle-Ankara
Tel: 0312-315 65 61-65 Faks. 0312-315 29 31

Lab No	Kireç ($CaCO_3$) (%)	Organik madde (%)	Yapılan Uygulama	Konu	Kum	Silt	Kil	Bünye	Tarla Kapasitesi	Solma Noktası	Hacim Ağırlığı	Hidrolik İletkenlik	KDK
					%	%	%		%	%	(g/cm^3)	(cm/h)	me/100 g
4834				3-SE	54,8	17,2	28,0	**SCL**	25,19	16,33	0,98	2,76	34,64
4835				7A-SO	26,3	33,5	40,2	**C**	36,37	15,31	0,98	2,39	17,94
4836				61-HW	38,8	28,8	32,4	**CL**	32,39	20,39	1,04	1,07	42,83
4837			Jips giderilmiş	1J-SO	28,3	32,2	39,5	**CL**	39,91	14,50	1,18	0,25	45,83

CURRICULUM VITAE

PERSONAL INFORMATION

Family name **:** AMBARLI

First names **:** Didem

Date of birth **:** 08.07.1979

Place of Birth **:** Germany

Nationality **:** Turkish

Civil status **:** Married

E-mail **:** didemcakar@gmail.com

EDUCATION

Institution	*Date from - Date to*	*Degree(s) or Diploma(s) obtained:*
METU Biology department	2005-June 2012	Ph.D.
METU Biology department	2002-2005	M.Sc.
METU Biology department	1997-2002	B.S.

EXPERTISE AND RESEARCH INTERESTS

- Plant Ecology
- Vegetation dynamics
- Grassland Ecology
- Conservation Biology
- Biodiversity and nature conservation

LANGUAGE SKILLS

competence indicated on a scale of 1 to 5 (1 - excellent; 5 - basic)

Language	*Reading*	*Speaking*	*Writing*
Turkish	1	1	1
English	1	2	2
Spanish	5	5	0

TECHNICAL SKILLS

- Planning and implementing biodiversity survey and analysis techniques,
- Research design from population to community levels
- Field survey and data collection techniques on plants, birds and butterflies
- Analysis of diversity and richness measures,
- Multivatiate analyses to reveal biodiversity, environment and land use relationships,
- Systematic conservation planning and regional conservation prioritization techniques,
- Vegetation mapping techniques,
- Teaching assistanship.

COMPUTER SKILLS

- MS Office (Word, PowerPoint, Excel)
- Remote sensing and GIS softwares: MapINFO, TNTmips, ArcGIS
- Statistics softwares: PC-ORD, ESTIMATES, NTSYS, MVSP, RAMAS GIS, RAMAS ECOLAB, R-Studio
- Site selection softwares: Marxan, SITES

OTHER SKILLS

- Butterfly wacthing
- Mountaineering
- Photography
- Driving licence , advance four-wheel drive at all conditions

MEMBERSHIP

- Society for Conservation Biology
- European Dry Grassland Group and two working groups of it:
    - Working Group on Mediterranean Dry Grasslands
    - South-East European Dry Grassland Group (SEEDGG)
- Nature Research Society (Turkey)
- Nature Conservation Centre (Turkey)

PROFESSINAL EXPERIENCE

- **2009-2011:** Project manager of Black Sea Region Systematic Conservation Planning (Nature Conservation Center)
- **2009-2011:** Nature Conservation expert of "Developing a basis for the active conservation of Turkey's butterflies" project (Nature Conservation Center)
- **2010-2011:** Project manager of "Facilitating Effective Legal Protection of Turkey's Rich Butterfly Fauna" project (Nature Conservation Center)
- **2007-2009:** Project manager of Anatolian Diagonal Biodiversity Project (Nature Conservation Center)
- **2004-2008:** Research assitant of a TUBİTAK-funded project:
- **2002-2006:** Research assitant (Middile East Technical University, Department of Biological Sciences)

RELEVANT PUBLICATIONS

Zeydanlı,U.S., Turak,A.S., Balkız,Ö., Özüt,D., Welch,H., Karaçetin,E., Ambarlı,D., Ertürk,A., Durmuş,M., Bilgin,C.C. 2011. Identification of Prime Butterfly Areas in Turkey Using Systematic Conservation Planning: Challenges and Opportunities. *Biological Conservation* 150 (1): 86-93.

Doğan, M., Akaydın, G., Çakaroğulları (Ambarlı) D. 2007. Infrageneric Grouping of Turkish *Acantholimon* Boiss. (Plumbaginaceae) Assessed by Numerical Taxonomy. Advances in Biological Research 1 (3-4): 85-91.

Çakaroğulları (Ambarlı), D. 2005. The Population Biology of a Narrow Endemic, *Centaurea tchihatcheffii* Fisch. & Mey. (Compositae). METU M.Sc. Thesis, Ankara.

INTERNATIONAL CONFERENCES

Ambarlı, D., Bilgin, C.C. 2012. Effects of livestock grazing and environmental variables on the diversity of Anatolian steppes. The 9th European Dry Grassland Meeting: Dry Grasslands of Europe: Grazing and Ecosystem Services. 19-23 May 2012.

Ergüner Baytok, Y., Yıldırım, A., Ambarlı, D. Bilgin, C.C., Vural, M. 2009. Population Viability Analysis for a highly threatened annual endemic plant, *Centaurea tchihatcheffii.* 94th ESA Annual Meeting 2-7 Ağustos 2009, New Mexico. Oral presentation.

Ambarlı.D. 2008. Production of sustainable land use plans by application of systematic conservation planing at the local level. International Workshop of NGO Perspectives on Mitigation Strategies and Monitoring Approaches of Land Degradation and Desertification, 15-17 November 2008, Istanbul, Turkey. Oral presentation.

Ambarlı (Çakaroğulları), D. Bilgin, C. Vural, M. 2006. Defining Threats and Conservation Approaches Based on the Population Biology of a Threatened Endemic Knapweed in Central Turkey. First European Congress of Conservation Biology. 22-26 August 2006, Eger, Hungary. Poster Presentation.

NATIONAL CONFERENCES AND MEETINGS

Ambarlı,D., Turak, A., Zeydanlı, U., Vural, M. 2010. Comparison of hotspots versus systematic conservation planning approaches for *In-Situ* conservation of widespread versus restricted species: examples form Anatolian Diagonal

Hotspot. 20th National Biology Congress with international participation. 21-25 June, Denizli/Turkey. Presentations Book. Pp. 90-91.

Ambarlı (Çakaroğulları), D., Bilgin, C., Vural, M. 2006. Use of ecological information in conservation of *Centaurea tchihatcheffii* Fisch & May. 18th National Biology Congress. 26-30 June 2006. Aydin/Turkey.

SCHOLARSHIPS AND AWARDS

- 2012. The Best Talk Award for the young scientists of the 9th European Dry Grassland Meeting in Prespa, Greece, 19-23 May 2012.
- 2011. Turan Demirarslan Grassland Research Scholarship (The Turkish Foundation for Combating Soil Erosion, for Restoration and Protection of Natural Habitats)
- 2010-2011. Rufford Small Grants Foundation Fund
- 1999-2002. Scientist support for Natural Sciences- The Scientific and Technological Research Council of Turkey (TUBITAK)