ADAPTING AND TESTING A COMMUNITY CLASSIFICATION SYSTEM FOR MEDITERRANEAN TURKEY USING SATELLITE IMAGERY

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ABSTRACT

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Throughout the past century, vegetation scientists have been studying plant communities to develop classification standards for global mapping purposes. In Turkey, although there are several vegetation classification schemes in use by botanists, foresters or geographers, none is widely accepted by all for vegetation mapping.

In this study, a hierarchical, ecologically meaningful, physiognomic-floristic classification system was adapted and developed for terrestrial vegetation in Turkey. The system has eight hierarchical levels, with the alliance and the association as its lowest two floristic levels, and the classes are designed to be easily detected in the field or indirectly through remote sensing.

To test of its utility, a supervised vegetation classification of the whole Mediterranean Region of Turkey was carried out using Landsat ETM images. The accuracy of the classification ranged between 55% and 69% depending on the level of hierarchy. A further test for its ecological utility was carried out by comparing identified vegetation classes with breeding bird communities derived from data gathered through field observations at 193 ecological communities at 83 sites.

The proposed classification scheme has proven to be reasonably accurate when widely available satellite imagery is used and ecologically meaningful as shown by a high concordance with observed bird community patterns. It is suggested that this new system can be safely applied to other regions of Turkey for purposes of vegetation mapping, species habitat modeling, and nature conservation if proper image set and ancillary data is used.

Keywords: Vegetation, Plant Community, Classification, Remote Sensing, Mediterranean Region

ÖZ

BİR YAŞAMBİRLİĞİ SINIFLANDIRMA SİSTEMİNİN TÜRKİYE'YE UYARLANMASI VE UYDU GÖRÜNTÜLERİ İLE AKDENİZ BÖLGESİNDE TEST EDİLMESİ

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Geçtiğimiz yüzyılda bitki bilimciler bitki birliklerini çalışarak küresel yaygınlıkta kullanılabilecek bitki örtüsü sınıflandırma standartları geliştirmeye çalışmışlardır. Türkiye'de botanikçiler, ormancılar ve coğrafyacılar tarafından kullanılan farklı sınıflandırma sistemleri bulunmaktadır. Ancak bunların hiçbiri diğer gruplar tarafından da haritalama çalışmaları için yaygın bir şekilde kullanılmamaktadır ve ekolojik uygunlukları da test edilmemiştir.

Bu çalışmada, hiyerarşik, ekolojik açıdan anlamlı, fizyonomik-floristik bir sınıflandırma sistemi Türkiye'nin karasal bitki örtüsünün haritalanması için ele alınıp adapte edilmeye çalışılmıştır. Önerilen sistem 8 kategoriden oluşmaktadır ve bunların en alttaki iki tanesi floristik kategorilerdir. Sınıflar arazide kolaylıkla tespit edilebilecek ve uzaktan algılama ile de belirlenebilecek özelliktedir.

Sistemin test edilmesi için Landsat ETM'ler kullanılarak Akdeniz Bölgesi'nde bir sınıflandırma ve haritalama çalışması gerçekleştirilmiştir. Sınıflandırmanın doğruluğu hiyerarşi kategorisine göre 50% ile 70% arasında değişmektedir. Sınıflandırmanın ekolojik açından anlamlılığına da 83 alanda, 193 yaşambirliğinden yapılan üreyen kuş birliği örneklemesi ile bakılmıştır. Üreyen kuş birlikleri araziden tespit edilen bitki sınıfları ile karşılaştırılmıştır.

Önerilen sistemin uzaktan algılama ile uyumlu sonuçlar verdiği gözlenmiştir. Ayrıca kuş örneklemeleri de sistemin ekolojik açıdan anlamlı bir yapıya sahip olduğunu göstermiştir. Bu yeni sistem doğru uydu görüntüleri ve kaliteli verilerle birlikte Türkiye'nin diğer bölgelerinde de başarılı bir şekilde uygulanıp bitki örtüsü haritalaması, doğa koruma çalışmaları, doğal kaynak yönetimi ve habitat modellemesinde yaygın bir şekilde kullanılabilir.

Anahtar Kelimeler: Bitki Örtüsü, Bitki Yaşambirliği, Sınıflandırma, Uzaktan Algılama, Akdeniz Bölgesi

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ABBREVIATIONS

CI	Community of Individuals
BMU	Biodiversity Monitoring Unit
DCA	Detrended Correspondence Analysis
DCA	Detrended Correspondence Analysis
DECORONA	Detrended Correspondence Analysis
DEM	Digital Elevation Model
DHKD	Turkish Society for the Conservation of Nature
ETM	Enhanced Thematic Mapper
EU	European Union
EUNIS	European Union Natural Information System
FAO	Food and Agricultural Organization
FGDC	Federal Geographic Data Committee of US
FI	Focal Individuals
GAP	Gap Analysis Program
GIS	Geographical Information System
GPS	Geographical Positioning System
IC	Integrated Community Concept
METU	Middle East Technical University
NDVI	Normalized Difference Vegetation Index
NVCS	National Vegetation Classification Standard
TCS	Timed Species Counts
TEMA	Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitats
UNESCO	United Nations Educational, Scientific and Cultural Organization
WWF	Word Wide Fund for Nature

CHAPTER 1

INTRODUCTION

1.1. The concept of community

1.1.1. Definition

Ecologists have been giving a variety of meanings to community term and thus it has various definitions (Schooner 1986, Fauth *et al.* 1996, Rickleffs and Miller 2000), approaching the issue from different points. However, due to vagueness of the term, many ecologists have controversially called it "the problem of community" (Lortie *et al.* 2004, Austin 1999, Looijen and van Andel 1999). However, when all these definitions have been considered, besides raising different aspects of the community term, most of them commonly mention species assemblages and their interactions (Looijen and Andel 1999, Parker 2004).

Collection of these definitions is provided below. However, it is worthwhile to present here some definitions that have historical importance or prominence. Community is described as the associations of plants and animals occurring in a particular locality and dominated by one or more prominent species or by some physical characters (Slobodkin 1961, Shimwell 1971, Daubenmire 1968, Rickleffs and Miller 2000).

Although the early definitions emphasized the dominance concept, later definitions do not emphasize dominance. Community is described as an assemblage of species that co-occur in defined areas at certain times and that have the potential to interact with one another (Whittaker 1962, McPeek and Miller 1996).

Macfadyen (1963) suggested that the early conception of a community was an amalgam of ideas about co-occurrence, constancy, composition and interaction.

The various definitions of the community concept and the following questions are suggested for examining the differences in these definitions were presented below;

1. Are communities distinctive systems analogous to organisms?
2. Are communities groups of organisms/populations belonging to a single trophic level or to a single taxa, or are they made up of multiple trophic levels or taxa?
3. Is interaction among the species an important parameter?
4. Are communities spatially distinct entities?
5. Are environmental conditions or habitat features important in the identification of communities?
6. Is a distinctive community unit valid only for the plants from an analytical viewpoint?

Loojien and Andel (1999) collected definitions of the community concept from various textbooks and extended those with a selection from Shrader-Frechette and McCoy (1993):

1. An assemblage of populations of different species that occur together in space and time (Begon *et al.* 1996, also Hanson 1962, Diamond & Case 1986).
2. An assemblage of populations of plants, animals, bacteria, and fungi that live in an environment and interact with one another, forming together a distinctive living system with its own composition, structure, environmental relations, development and functions (Whittaker 1975, also Cowles 1901, Shelford 1963).
3. One or more populations with similar life habits and resource demands co-occurring in space and time (McNaughton & Wolf 1973, p. 550).
4. A group of interacting species that occur in the same area (Ricklefs 1973, also Collier *et al.* 1973, Pielou 1974).
5. Any assemblage of populations [of plants and animals] in a pre-described area or habitat (Krebs 1994, also Odum 1963, Williamson 1987).
6. Whatever lives in a habitat (lake, forest, sea floor) that some ecologists want to study (Cohen 1989, also Lederer 1984, Ehrlich & Roughgarden 1987).
7. A piece of vegetation which maintains a reasonable degree of homogeneity over an appreciable area and a reasonable permanence over a considerable time (Gleason 1939, also Curtis 1959).
8. An aggregation of living plants having mutual relations among themselves and to the environment (Colinvaux 1986).
9. An assemblage of organisms of different species (Jax *et al.* 1998, MacMahon *et al.* 1981, Allen & Hoekstra 1992, Mahner & Bunge 1997).
10. Groups of plants coexisting over short period of time in naturally circumscribed areas (McIntosh 1985).

Table 1: Community definitions' contents and dates

Year of Definition	Author	# of Definition	Interacting species	Assemblage of species	Spatially bounded	Temporally bounded	Habitat (resource & condition) bounded	Particular taxa	Vegetation	Dominance
1901	Cowles	2	X	X	X		X			
1939	Gleason	7			X	X			X	
1959	Curtis	7			X	X			X	
1961	Slobodkin	In the text		X	X		X			X
1962	Whittaker	In the text	X	X	X	X				
1962	Hanson	1		X	X	X				
1963	Shelford	2	X	X	X		X			
1963	Odum	5		X	X		X			
1968	Daubenmire	In the text		X	X		X			X
1971	Shimwell	In the text		X	X		X			X
1973	McNaughton & Wolf	3		X	X	X	X	X		
1973	Ricklefs	4	X	X	X					
1973	Collier *et al.*	4	X	X	X					
1974	Pielou	4	X	X	X					
1975	Whittaker	2	X	X	X		X			
1981	MacMahon *et al.*	9		X						
1984	Lederer	6		X			X			
1986	Diamond & Case	1		X	X	X				
1986	Colinvaux	8	X	X	X		X		X	
1987	Williamson	5		X	X		X			
1987	Ehrlich & Roughgarden	6		X			X			
1989	Cohen	6		X			X			
1992	Allen & Hoekstra	9		X						
1994	Krebs	5		X	X		X			
1996	Begon *et al.*	1		X	X	X				
1996	McPeek and Miller	In the text	X	X	X	X				
1997	Mahner & Bunge	9		X						
1998	Jax *et al.*	9		X						
Frequency			**9**	**26**	**21**	**8**	**14**	**1**	**3**	**3**

A high proportion of definitions approach the issue from different angles, showing the broadness of the issue which is the main reason of the vagueness of the community concept. Thus, it is not surprising that no agreed definition of an ecological community has arisen out of the debate about the nature of plant communities (McIntosh 1985; Keddy 1987). In fact, a diversity of opinions exists about the community concept (e.g. Wilson 1991, 1994; Keddy 1993; Dale 1994; Mirkin 1994; Grootjans et al. 1996; Looijen & van Andel 1999).

One of the issues that can be concluded from the above definitions and vagueness of the term is that community is interchangeably referred to include all of the living things in a particular area or according to species belonging to specific habitus or taxa. Both of them are used quite commonly in the literature. In order to come over this confusion, Looijen & Andel (1999) suggest using "community" when one refers to populations of the distinct taxa (i.e. birds, insects, plants etc.) and using "biocoenosis" when one refers to the biological component of the ecosystem (McNaughton & Wolf 1973). This idea is widely criticized by Parker (2001).

When all the definitions are examined from a practical viewpoint, the broadness of the content and scale appear to be the most problematic. However, most of the definitions emphasize: 1) species assemblages, 2) interactions, and 3) spatial distinctiveness. When the main subject of this study, standardized community classification, is considered these three aspects can be regarded as a starting point to develop a standard system.

Another important point to be raised from the above definitions and their contents is the necessity to discuss the problematic issues within the framework of their historical background, since traces of and old debate between Clements (1916, 1936) and Gleason (1926, 1939) is detectable throughout the definitions.

1.1.2. History, problems and recent developments in the community concept

Although, the ecological community concept can be traced back to Theophrastus (3rd A.D.) it will be appropriate to start an investigation of the subject from the late 19th century onward. One of the first scientists that has mentioned the necessity of a concept referring to biotic component of the ecosystem was Karl Möbius (1880) who has recognized the interaction of oysters with the algae, sponges, and oyster parasites. In addition to interaction of plants and animals, another idea behind the community concept is the conformity in the distribution of the species (see for references in Daubenmire 1968, page 5). In early 20th century research about the biological interactions and communities accelerated, especially in plant ecology (Clements 1916, 1939, Gleason 1926, 1936, Phillips 1931, Cowles 1899, 1911)

One of the most prominent debates in history of the community ecology is about the existence of a natural unit in the community level.

Although most scientists do not accept the holistic approach in community ecology, they have considered and used it for the ecosystem ecology (Odum 1969, Jordan 1981, McNoughton and Coughenhour 1981, Knight and Swaney 1981, Patten and Odum 1981, DeAngelis *et al*. 1986, Wilson 1976, 1980, Engleberg and Boyarsky 1979). This discussion is also related with the dichotomy in vegetation science, originating from the Clements and Gleason debate.

Frederic Clements was an influential plant ecologist who had gained an international reputation early in his career through two books that he has published: Research Methods in Ecology (1917) and Plant Succession (1916). By 1920, Clements was one of the most important ecologists in the United States (Hagen 1993). Clements has developed many quantitative field techniques including one of the most renowned, the "quadrat". He described ecology simply as "rational field physiology" and he was promoter of the holistic approach in the plant ecology. His studies on succession (Clements 1919, 1928) are of key importance in plant ecology. However he has extended his holistic approach into an organismic point of view of plant associations, in which he considered plant communities as entities that function like an individual plant or animal, "able to essentially reproduce its component parts" (1916). He called the plant communities as a "super-organism" and identified climax communities as discrete vegetation types of mature plant communities. He stated that "the whole is more than the sum of its parts" (Smuts 1926), which is an important analogy in ecology which is rejected by a few reductionists such as Gleason (1926, 1939) and Tansley (1935) in explanation of the nature's course. Due to Clements dominant scientific personality, it took a few decades before Gleason's theory to overcome the organismic community concept (Hagen 1993, Barbour et al. 1999, Ricklefs and Miller 2000, Nicolson and McIntosh 2002). According to Gleason (1926) the plant community is "scarcely even a vegetation unit but merely a coincidence".

Gleason's individualistic concept was extensively ignored till the 50s (McIntosh 1975, Barbour 1995, Nicolson 1990, Nicolson and McIntosh 2002). However, through new studies and techniques, such as gradient analysis, individualistic theory prevailed in the ecologic thought. In 1959, the Ecological Society of America awarded him the title of "eminent ecologist" due to his individualistic theory. However Gleason (1944) described his unpopular years as such: "To an ecologist, I was anathema. Not one believed my ideas; not one would even argue the matter… For ten years, or thereabout, I was an ecological outlaw, sometimes referred to as 'a good man gone wrong'."

Nicolson and McIntosh (2002) comment that "Gleason's individualistic concept has mainly been misconstrued as asserting that the community is a random collection of species and the species are responding solely to the physical or abiotic environment", which can be concluded as 1) ecological communities are random aggregations from the available species pool, and 2) relations among the species, due to environmental conditions and biotic interactions, are not important,

However, Nicolson and McIntosh (2002) state that misinterpretation of Gleason's individualistic theory also related to his misuse of some terms such as uniformality and randomness due to lack of his statistical background. Some of Gleason's quotations from his works were shown as proof to this argument. Although it is claimed that Gleason's individualistic concept suggest the unimportance of biotic interactions, his expression is controversial "… the dominant plant species which are distributed over the whole area of the community exert such a uniform effect on the other species that discrepancies in the physical environment are more or less smoothed out or obliterated" (Gleason, 1939).

As polarization of viewpoints between a well established paradigm and a contrary paradigm is common (Underwood 1986), the debate between Clements and Gleason was interpreted as whether discrete communities exist or not.

Actually, the issue is not the lack of community types; it is rather the continuity of the vegetation and the difficulty in separation of different types through clear boundaries. As Gleason (1926) stated in his influential paper: "No ecologist would refer the alluvial forests of the upper and lower Mississippi to the same associations, yet there is no place along their whole range one can logically draw a boundary between them. One association merges gradually into the next without any apparent transition."

Regarding the debate between individualistic and organismic concepts, the issue is not the existence or inexistence of communities; it is rather about how to perceive them from a scientific perspective. Even an amateur can differentiate the separate units in a continuum and describe the differences at a basic level (i.e. structural, dominance, coverage etc.). However, the main issue is in which perspective (i.e. holistic or individualistic, niche based or neutral), one tries to explain the differences.

Clements and Gleason were concerned mainly by the species composition. However during 1920s other ecologists were dealing with some other features of the communities such as the functional patterns within a community. Charles Elton had described the relationships between species according to feeding relationships and published one of the landmarks of modern ecology, "Animal Ecology" (1927). This was an important step in the characterization of communities since it adds another dimension to the floristic composition and abundance of the plant species. Later in the 1980s plant ecologists have developed astonishing concepts and theories about the functional patterns of the communities (Grime 1973, 1979, 1997, Tilman 1994, 1996, 1999), and questioned the roles of individual species within the ecosystem and their contribution to the ecosystem function.

Another era in community ecology started with the availability of ordination techniques to analyze the species and environmental data. Ordination is a term used for the multivariate techniques to arrange sites according to an environmental gradient or species composition data (Digby and Kempton 1988, Austin 1990, Jongman et al. 1995). The term was introduced by Goddall (1954). The aim of the ordination is to summarize a large volume of complex, multi dimensional data into fewer dimensions by seeking patterns in the data set (Austin 1976, Goodall 1954, 1963, Dale 1975, Noy-Meir and Whittaker 1978). Early ordination techniques were not very helpful to evaluate the results satisfactorily or to differentiate whether variation was due to environmental factors or successional gradients (Bray *et al*. 1957, Brown and Curtis 1952, Curtis 1959, Curtis and McIntosh 1951). Clearer usage of the methodology was made possible by Peet and Loucks (1977), whose works played key role in realization of the continuum (Austin 1985). Whittaker (1956) explained the continuum feature of the vegetation as "Vegetation may be interpreted as a complex and largely continuous population pattern".

Since in all gradient analyses, plant species were found to be arranged independently in relation to each other (Whittaker 1951, 1953, 1956, 1977, Curtis 1959, McIntosh 1967, Peet 1981, Ter Braak and Prentice 1988, Austin 1985, Collins et al. 1993) gradient analyses by ordination techniques are accepted as one of the major empirical evidence for the Gleason's individualistic theory (Callaway 1997). Moreover, the continuum concept and Gleason's individualistic species assemblage concept were merged to form an individualistic-continuum concept by Goodall (1963). According to this concept, species distributions and abundances were determined by the environmental gradients whereas biotic interactions merely do not play any role. "Continuous species distributions along gradients may be expressed as Gaussian skewed, or bimodal curves, but are rarely attributed to any factor other than the physical environment and resource competition" (Callaway 1997). Although later studies empowered the idea of importance of the resource competition in explanation of the species distribution along a gradient in addition to abiotic factors (Grime 1973, Grace 1987, Keddy 1989, Pennings and Callaway 1992), the question of whether plant-plant interactions play considerable role in the community still remains suppressed in the individualistic-continuum concept. Callaway (1997) tried to integrate the direct and indirect plant interactions into the individualistic-continuum concept without damaging the central theme of the continuum concept.

Callaway (1997) claims that even Gleason believes that species distributions are affected by plant-plant interactions; e.g "…meeting with such strenuous competition from other plants that only a few individuals have a chance to grow" (Gleason and Cronquist 1964). Eliminating a species that is in direct relationship with other species does not mean that its beneficiary will be eliminated from a community, although, it should effect its beneficiaries abundance and distribution (Adler and Morris 1994, Wooton 1994, Callaway 1997, Inouye and Stinchcombe 2001). Callaway (1995, 1997) suggests that plant species are much more interconnected than current theories allow, and that the fundamental issue is not whether plant communities are individualistic or holistic, but that how much organisms in an area are interdependent (Callaway 1987, Lortie *et al*. 2004).

Consequently it can be claimed that, in the new millennium there are attempts to synthesize new community concepts in a more inclusive and less polarized way. Integrated Community (IC) concept was introduced by the Lortie et al. (2004), claiming that although there are defenders of the both the superorganism view of Clements and the individualistic concept of Gleason, none provides a fully satisfactory explanation for the modern ecologist (Lortie *et al*. 2004, Callaway 1997). Recent studies have also empirically demonstrated the importance of the facilitation (Bruno et al. 2003): "… current theory emphasizing competition or predation paints an incomplete, and in some cases misleading picture of our understanding of the structure and organization of ecological systems" (Bruno 2003). Thus it is suggested that facilitation has to be integrated to the current ecological theory (Bruno 2003). Lortie *et al*. 2004 claim to take this "one step further" in their paper to explain the Integrated

Community concept, and write "... submit that part of the solution to the old debate on individualistic versus organismal communities and recent experimental efforts to understand the relative importance of positive or negative interactions is to explicitly reconsider what most ecologists appear to have done implicitly; our formal conceptual theory of the fundamental nature of communities". One of the key features of the Integrated Community (IC) concept is that it rejects the strict individualistic community theory, and by this means suggests integrating facilitation and indirect effects to the formal community theory. According to Lortie *et al*. (2004) IC "proposes range from highly natural plant communities individualistic to highly interdependent depending on synergism among i)stochastic processes, ii) the abiotic tolerances of species, iii) positive and negative interactions among plants, and iv) indirect interactions within and between trophic levels". The IC concept proposes that all four processes can be important in determining the extant plant community at a given site but that the relative importance of each process will vary in space and time. The main processes or filters that structure a plant community has shown in the In the Figure 2. Each process/filter is represented by a pair of horizontal lines and the corresponding description is in bold italics adjacent to the symbol. Solid arrows depict the movement of species through the filters, and hatched lines illustrate where each process might influence the plant community.

The community problem is also associated with the characterization of communities. Hence, other than the discussions about the existence of communities there is another important problem to deal with, which is the characterization of the communities. In this respect, another important theory to include into the debate is the unified neutral theory of Hubbel (1979), which tries to provide a very simple and counter intuitive explanation of species diversity patterns (Hubbell, 2001). Neutral models view all species as equal (Hubbell 2001) and instead of focusing on differences between species that enable or allow them to coexist together it assumes that all species, i.e. trees in tropical forests or corals on a tropical reef, are alike (Whitfield 2002). Neutral theory explains the community by specifying speciation, dispersal, community size, birth and death of individuals (Whitfield 2002, McGill 2003). Based upon these criteria, assuming that individual organisms and species are ecologically identical, it generates species abundance distributions and species-area curves that are remarkably similar to natural ones (McGill, 2003).

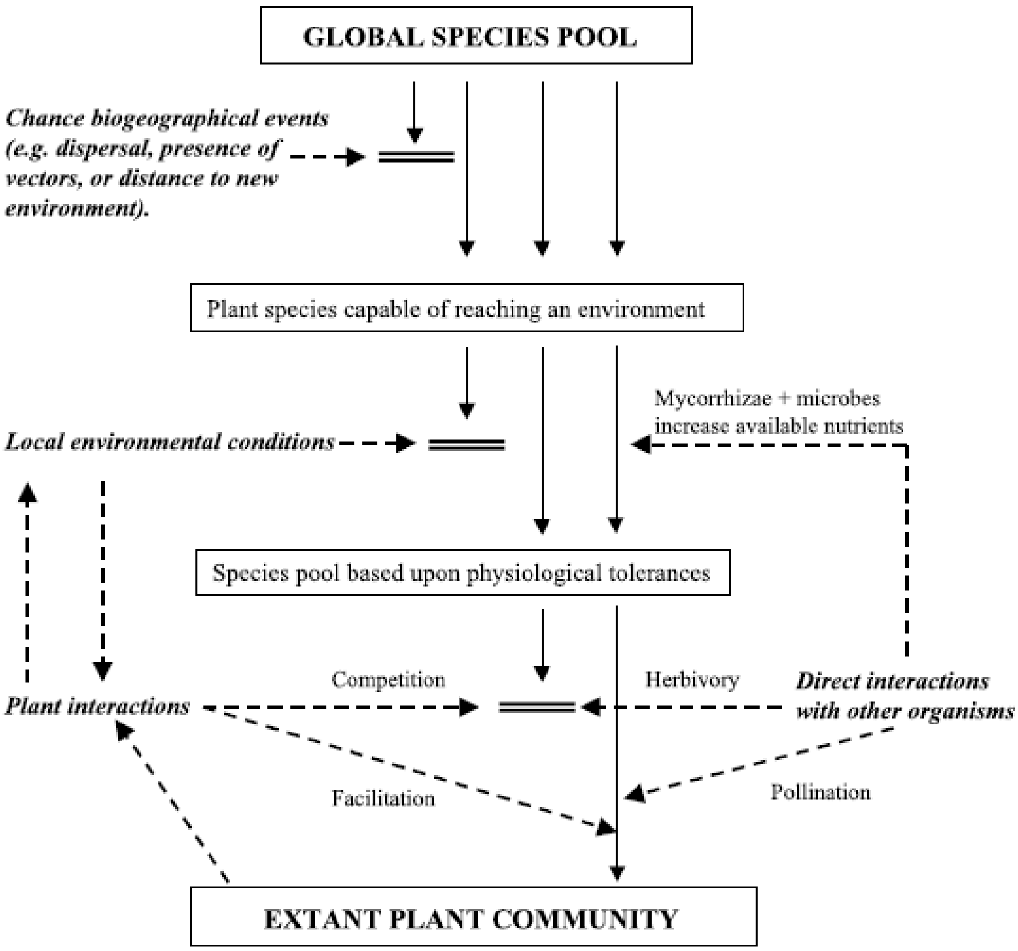

Figure 1: Integrated community concept and the main processes that structure a plant community. (Source: Lortie *et al*. 2004).

Whitfield (2002) says that "the troubling thing for most ecologist is that neutral simulations can produce ecosystems that look just like the real thing" and he uses quotation of the J. Levine of the UK Natural Environment Research Council's Center for Population Biology at Silwood Park: "Neutrality starts with the assumptions that are clearly wrong, but produces patterns that match what we see in nature". Even Hubbell admits that "I'm very puzzled by how well it's worked, and I was really unprepared for how theoretically rich in questions it was".

However, limitations of the neutral theory are summarized as follows (Whitfield 2002):

1. It only applies within one level of the food-web; it might explain the diversity of trees or herbivorous insects but not the effects of them on each other,

2. Hubbel (2001) says that the theory works better on plants and microbes than animals. It explains the community structure better where different species overlap and exploit resource,
3. It collapses at small or large spatial scales (Condit et al. 2002),

The niche concept is accepted as one of the fundamental concepts in ecology (Alford 1986), hence in the 1990s it was accepted as the central organizing aspect of the modern ecology (Cherrett 1989, Real and Brown 1991, Real and Levin 1991, Leibold 1995). In contrast to the neutral theory, niche based theories, which can be said to be traditional models, try to explain the species' pattern of distribution, abundance and coexistence according to their features. Its basic approach is based upon the assumption that each species is adopted to exploit a particular niche (Whitfield 2002) through evolutionary processes and ecological interactions. Although it is claimed that niche based theories successfully produce a good description of the natural world (Chave *et al.* 2002), Hubbel implies that it has to be much more complex than the neutral models to achieve superior results (Whitfield 2002).

Another debate about the identification or characterization of the community is between Loojien & van Andel and Parker. Their discussion solely based on narrowing the community concept into species-individuals which is supposed to be the smallest unit in community ecology (Looijen & van Andel 1999, 2002, Parker 2001, 2004, Chave *et al*. 2000). They claim that if we try to address the community problem in an inclusive way it ends up with all species and all the interactions that means covering the whole biosphere which practically does not take us to any point. Hence, they provide another concept which is exclusive, "Community of individuals" (CI) (Looijen & van Andel 1999, 2002) and "Focal Individual (FI)" (Parker 2001, 2004). First Looijen and Andel (1999) have suggested their theory in a paper addressing the conceptual problems and definitions of the community ecology. It is likely that Parker (2001) has developed his controversial theory of FI while criticizing the CI theory.

Looijen and van Andel (1999) claims that "As far as the concept of ecological communities, is concerned, there is an ongoing debate whether communities exist and if so, what might be their nature, without offering any new perspectives (e.g. Wilson 1991, Keddy 1993, Mirkin 1994, Palmer & White 1994, Wilson 1994)" and they address the problems in community concept, that their new concept suggest solution, as follows:

1. Problem of ambiguity: Community term is being used for various kinds of living things at various levels of organization which is called as biocoenosis (*sensu* McNaughton and Wolf 1973) according to Loortie and van Andel (1999). They suggest community term for a single taxonomic phylum or class (i.e. plants, birds, insects etc.),
2. Problem of boundary: Communities are discrete, spatially and structurally distinct units,
3. Problem of heterogeneity: Communities are too heterogeneous with respect to species composition,

"Community of Individuals" is defined as the set of individuals of two or more species of plants, or birds, etc., which occur in the intersection of the areas occupied by populations of these species. This definition taxonomically narrows the community concept (i.e. as mentioned in the first item above) and conceives only certain groups of individuals of populations of different species as a community (Looijen and van Andel 1999).

In the below diagram Community of Individuals concept is explained diagrammatically. Each of the numbered areas has different species composition and therefore accepted as different type of communities. Areas 1, 3, 17 and 19 contain individuals of one species and therefore they are not accepted as (multi-species) community (A:Area, P:Population, S:Species)

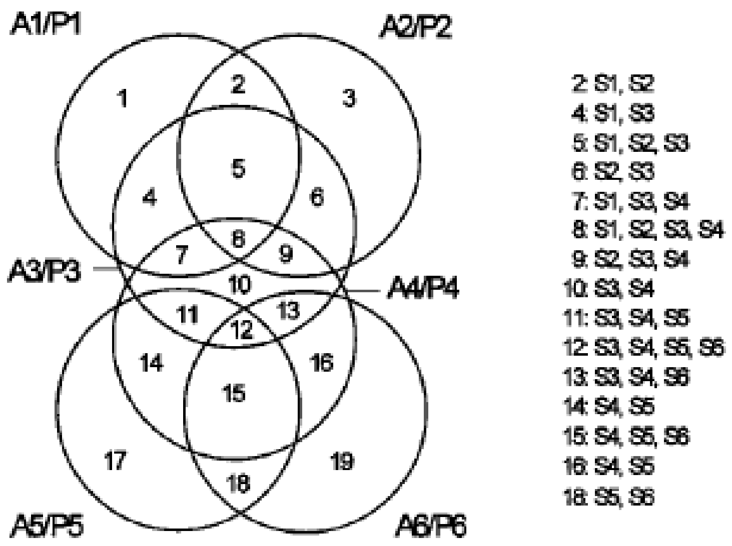

Figure 2: Community of individuals (Source: Looijen and van Andel, 1999).

Parker (2001) criticizes the new concept as "…belief in distinct communities can result in extreme and rather peculiar approaches to determining their boundaries". Parker (2001) summarizes criticism against CI as 1) highly scale limited, excessively narrow and confining, 2) creating all sorts of scale problems and conflicts with respect to the question of which individuals are to be counted as community members, 3) inapplicable in situations where species richness is high and/or population density is low, 4) providing too static picture of communities, 5) unjustly not encompassing many concepts that have been developed for the community level, and 6) containing hidden assumptions that are not met by natural systems.

Parker's (2001) controversial community concept FI suggests an alternative, which is based on the direct and indirect biotic interactions and suggests two basic features for his concept: 1) Communities are continuous in space and time (Brand and Parker 1995) 2) Processes underlie composition and dynamics (Pickett *et al.* 1992). According to Parker (2001), "the community of this individual is all other individuals with which it interacts".

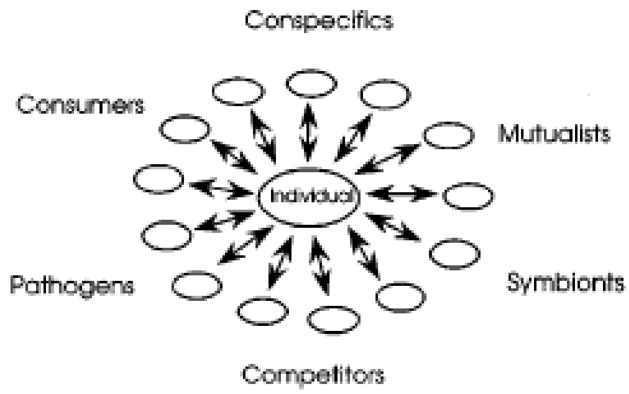

Figure 3: Web of interactions of a focal individual (Source: Parker 2001).

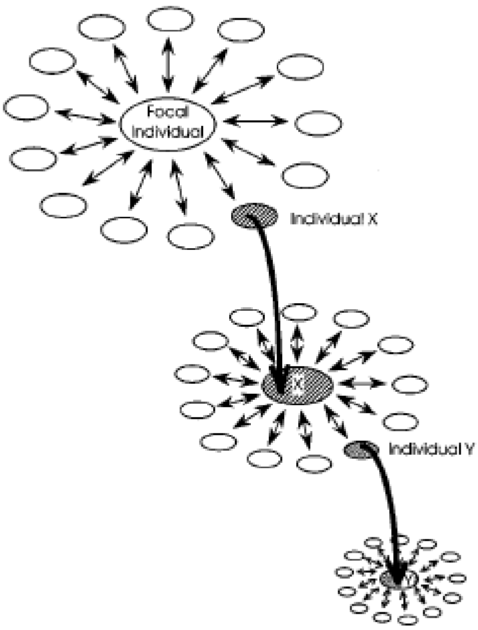

Figure 4: Three individuals and their unique web of interactions are represented (Source: Parker 2001)

Individual Y interacts indirectly with the focal individual while individual X interacts directly.

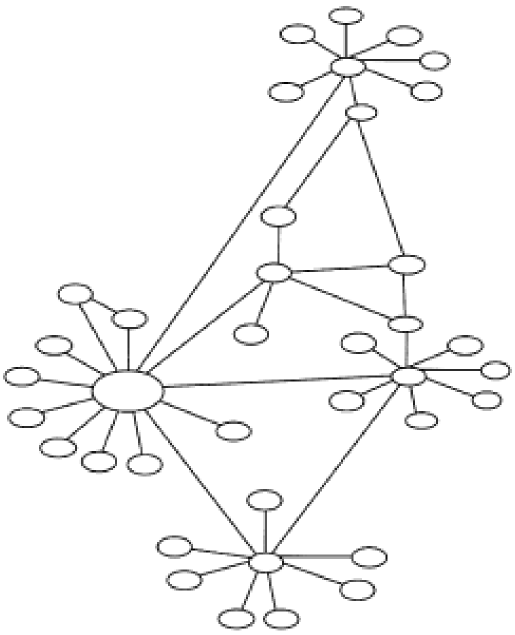

Figure 5: A web of interactions connecting a number of individuals of different species Source: Parker 2001)

The diagram represents only small part of a community based on some spatial extend. All individuals are interconnected directly or indirectly with all other individuals.

Looijen and van Andel (2002) criticize this: "What Parker formulates here is a most important concept that has a long tradition in both ecology and evolutionary biology (Brandon 1990). The extension of this concept is a subset of what is called the environment of an individual, where a distinction is often made between immediate or proximate environment and ultimate environment (MacMahon et al. 1981, Mahner and Bunge 1997). One can make a similar distinction for only the biotic environment of the individual. The question is however, why we should use the word community for this concept. Moreover, if we were to follow Parker, there would be as many communities as there are individuals"

None of the above-mentioned new theories are widely accepted but they open new dimensions to discuss the community concept and provide bases to develop subsequent theories on.

1.2. Implications of Community Concept in Natural Resource Consumption and Biodiversity Conservation

The blurriness of the terms (i.e. ecosystem, community, habitat), which mainly originates from misuse or interchangeable use of them, appears as a problem once more, in the investigation of the use of community concept in natural resource management and biodiversity conservation. Many ecological terms have been used interchangeably or get mixed in spatial expressions (Scott *et al.* 1993, Noss *et al*. 1995, Dinerstein *et al.* 2000, Heywood and Iriondo 2003). On the other hand, in an applied manner, few clearly outline the difference between them. However, it is apparent that mostly all these terms (i.e. habitat, ecosystem, vegetation communities, and ecological communities) used to refer to a broader conservation or resource planning purpose. Thus, the issue will be handled in that manner and further clarification will be supported only when it is necessary. The abstract investigation of differences between these terms will be handled in the Discussion section.

Although there are many problems in describing and mapping the communities, due to the fact that communities are not precise entities of unique composition (Gleason 1926, Curtis 1959), community classification and vegetation mapping is one of the most referred tool for the practical purposes of natural resource use and conservation planning (Jackson 1980, Anderson 1982, Noss 1987, Grossman *et al*. 1998, Maybury edi. 1999).

Communities basically constitute sets of natural interactions, provide numerous valuable ecosystem functions (Constanza *et al*. 1997, Daily *et al*. 1997), and an important basis for the evolutionary context (Grossman et al. 1998).

For all sort of sound planning and management purposes communities provide an important insight for characterization of the ecosystems and landscapes (Grossman et al. 1998) from a biological perspective. Besides, communities are accepted as a link between species and ecosystems and/or landscapes (Noss 1987). Structure, function and composition of the communities can be monitored to draw information for many purposes such as spatial and temporal changes in the biological structure, and impact of the human activities. (Noss 1990, Max *et al.* 1996).

Widespread use of the community concept in the applied fields starts in the 80s with the availability of powerful tools such as GIS and RS. These techniques have helped to express ecological data spatially over large areas (Scott and Jennings 1998, Stoms 1994, Davis *et al* 1990, 1991 Zeydanlı et al. 2005b). This potential was combined with the pragmatic necessity that designing a conservation portfolio only according to species requires tremendous amount of time, resource and expertise due to their high number and difficulty to describe their interactions with other species and the environment. Thus a bigger proxy unit is required to consider the species. Since the early 90s there are many large scale programs (see TNC 1981-1984,Scott *et al*. 1993, Dinerstein *et al.* 2000, Noss 1992, Peterken 1968, UNESCO 1974, Zeydanlı *et al*. 2005b) that consider the communities or relevant entities such as ecosystems or habitats as conservation targets that are believed to play surrogate to species and other features of biodiversity. Among those schemes that use it, the Natural Heritage Program of the TNC is the most comprehensive, long term and influential. In this program, communities have been used as coarse filters (*sensu* Noss and Cooperrider 1994) in identifying priority conservation areas.

Another large scale program or approach that needs to be considered is Gap Analysis. It is an approach developed by Scott *et al*. (1993) that "seeks to identify unrepresented or underrepresented biodiversity elements in the current protected areas". It uses ecosystem or community types (i.e. both terms have been used in the description of the methodology in an interchangeable way) as one of the major surrogate to achieve representativeness of the system. With this approach, species that are not specifically targeted for conservation are protected as well too (Grossman 1998).

This approach has been widely used in conservation studies in Turkey, too. Apart from the regional gap analysis surveys carried out by WWF Turkey-DHKD (Welch *et al.* 2004, Zeydanlı *et al.* 2005a), and TEMA-METU Biology Department, the Ministry of Environment and Forestry - Biodiversity Monitoring Unit established a national gap analysis program for the terrestrial environment, which is using community as the major biodiversity surrogate due to the lack of adequate species distribution data in many taxa (i.e. plants, birds, amphibians, reptiles, butterflies etc.).

Another area that community types can find an application ground is restoration ecology. One of the descriptions of the restoration ecology refers directly to community: 'the recreation of entire communities of organisms, closely modeled on those occurring naturally,' (Jordan *et al*. 1987). Restoration ecology focus on multi species assemblages (Palmer *et al*. 1997) and the natural dynamics of ecological communities may provide models of restoration (Cairns & Heckman 1996). Some other themes and concepts of the community ecology consumed by the restoration ecology are as follows; the individualistic plant association (Cairns & Heckman 1996, Aronson & Le Floc'h 1996, Choi and Pavlovic 1998), facilitation, tolerance, and inhibition models of succession (Choi 2004, Young *et al.* 2005)

One of the rules of thumb in restoration ecology is restoring original community including its patterns and functions (Young *et al.* 2005). Thus, for any restoration activity one of the most pressing problems is determining the frames of reference. This problem is inherent in defining goals of a restoration project (Cairns & Heckman 1996)

Hubbell's neutral theory of biodiversity (Hubbell 1997, 2001) is likely to identify new applications grounds for the community concept. However since the theory has not been widely accepted as yet it only forms a basis for future considerations. If the neutral theory is valid in a way Hubbell describes, i.e. species of a community are randomly thrown on the habitat space and may come and go randomly, this has an important impact on reserve design (Hubbell 2001). If species are adapted to a particular niche and communities are relatively stable, then communities will be hardly invaded by an alien species. In that occasion reserves can be small. On the contrary, if species are more equal and their existence or inexistence over time depends on random events, then communities will be less stable and bigger reserves will be needed to protect rare species from the poundings of changes (Hubbell 2001). However, if the second theory is likely to be valid than it raises another important question (Bell *et al.* 2000): If all the species are equal, what could be the problem in loosing any of them?

Community concept mostly found an application ground in conservation studies. Another important utilization of the concept is related with the species conservation and independence-interdependence debate in community ecology. Many outstanding conservationists advocate the interdependence of the organisms in natural communities and highlight the possibility of negative effects of a loss of seemingly unimportant species on other species (Freedman 1989, Ehrlich 1990, Ehrlich and Wilson 1991, Miller 1993, Noss and Cooperrieder 1994). However, another idea advocating the independency (i.e. interchangeable and individualistic plant association) of the organisms in the natural communities highlights possibility of modifying and synthesizing communities or ecosystems, even in natural environments (Johnson and Mayeux 1992).

1.3. Standardization in the Community Classification Studies

Vegetation and community maps are one of the basic data types for the planning and management studies vary from urban planning to wildlife management. Vegetation types are useful as climate markers, indicators of grazing capacity and wildlife habitat, assessing soil-crop suitability, planning data for timber production, disease, and fire history. Ideally, each application would have its own classification scheme, but this is not practical or efficient in many terms. Hence when wide purposes and geographical extend is considered these classification studies has to be compatible with each other. Also, use of more standardized classification schemes contributes to easier exchange, dialogue and independent interpretation of results (Jennings 1997). This requires a standard classification system that is applicable in wide areas and different scales. There are various global attempts to achieve this goal as described in the section '1.6. Classification of Communities'.

These global or regional initiatives are one of the best proof for the necessity to the standardized classification systems as all of them were created to harmonize classification studies and to create basis for global classification scheme (Daubenmire 1968, Dassman 1973, Udvardy 1975, Adams 1998, Grisebach 1872, Schimper 1898, Braun-Blanquet 1921, 1928, 1932, Rübel 1930, Küchler 1947, Dansereau 1951, 1972, Gaussen 1965, Küchler 1972, UNESCO 1973, Müller-Dombois and Ellenberg 1974).

One of the major attempts in developing a standardized classification system is continuing in the US since late 90's (Grossman *et al.* 1998, Anderson *et al.* 1998, FGDC 1997, Loucks 1996). This study has been going on with a contribution from many institutions such as Ecological Society of America, US Geological Survey, US Federal Geographic Data Committee, NatureServe (FGDC 2004). Currently, it is in use by many organizations for different purposes and some of its applications can be summarized as follows:

1) The USGS Gap Analysis Program (GAP) uses the NVCS in order to assess the conservation status of species and their habitats (Jennings 1997).
2) The Nature Conservancy uses it for the conservation planning, biodiversity management, resource inventory and monitoring.
3) The National Park Service Inventory and Monitoring Program, takes the NVCS as a basis to map the vegetation of the all park units.
4) The U.S. Fish and Wildlife Service use it for the wildlife refuge system.
5) The U.S. Forest Service is used to describe the existing and potential vegetation for the ecoregional subsections in the Eastern and Southern Regions.
6) The Multi-Resolution Land Characterization Consortium of the US has also identified the NVCS as a common basis for vegetation mapping (Grossman *et al*. 1998).

Noss *et al.* (1995) quotation is outstanding to understand the importance of the standard community classification effort: '… to what extend the natural ecosystems in the United States had been reduced in area or degraded in quality due to human activities could be only answered by a relatively crude approach because a systematic approach to understand these systems at a national scale was not yet available' (Grossman *et al*. 1998).

1.4. Basic Features of the Standardized Classification Scheme

In order to fulfill the above-mentioned role, a classification system has to have following features (adapted from the Adams 1999, Grossman 1998, FGDC 1997):

1) It must be hierarchically organized
2) It must have ecologically meaningful hierarchy
3) It has to be applicable over extensive areas
4) Application of it must be repeatable and consistent
5) It has to be based on the actual vegetation
6) It has to be compatible with other vegetation or landcover classification systems.
7) Whenever possible it has to try to use common terminology

8) It has to avoid developing conflicting terminology and methods
9) The classification categories are mutually exclusive and additive 100 % of an area
10) It must be dynamic so that when additional information is available further refinement has to be possible
11) It must be compatible with the remote sensing application.

1.5. Objectives of the Thesis

Although there are various classifications approaches and attempts (see section '1.8 Community-vegetation classification studies in Turkey' and '1.9 EUNIS and its application in Turkey') it is not possible to talk about a standardized, widely accepted, practical classification system in Turkey. Lack of such a system in Turkey is a prominent deficiency in the natural resource management and conservation studies.

In Turkey, since the 1950s geographers, foresters and botanists have all been working on different vegetation types at varying scales. Although, they have carried out several vegetation classification studies depending on their objectives, there is not any particular classification type widely accepted and able to answer the necessities required for different purposes. However, for the appropriate use of natural resources and more effective nature conservation a widely accepted and ecologically meaningful vegetation classification standard is crucial.

The main objective of this thesis is to develop and test a hierarchical standard made up of physiognomic, climatic, floristic categories and suitable for several different uses. USNVC (FGDC 1997, 2004, Grossman 1998) will be used as a basis to develop physiognomic-floristic vegetation classification system for Turkey. This system will be tested in the Mediterranean region for its compatibility with the classes that can be obtained through remote sensing. Further test for the hierarchy of the classes will be carried out with the bird data collected from the field according to plant community types. These tests are expected to improve the hierarchy and the classes of the classification system.

1.6. Classification of Communities

Kimmins (1997) defines vegetation classification as an attempt 'to identify discrete, repeatable classes of relatively homogeneous vegetation communities or associations about which reliable statements can be made'. Although any vegetation classification is a simplification of a complex reality of gradients and mosaics in vegetation (Whittaker 1970), if it does not enable to perform the task easily and without confusion, it will hinder understanding of ecological processes (Adams 1996). Modern attempts of vegetation classification can be traced back to Alexander von Humboldt's studies in South America and his relevant publications (Humboldt 1805, 1806, 1807). These early studies were based on the physiognomic features of the vegetation as it is the most suitable for the broader classification purposes (Daubenmire 1968, Dassman 1973, Udvardy 1975, Adams 1998). Plant geographers like Alexander von Humboldt, Grisebach (1872), Schimper (1898), Dokuchaev (1898), Flauhault (1901) were the major figures who worked on the classification of the vegetation.

Vegetation scientists have been studying plant communities to document their patterns and understand their environmental relations and they have used synthesis tables, intuition, knowledge of autecology, and mathematical analyses to organize and interpret these relationships. However, early classifications were superficial, based on a single manifest character and are a value of where this character is important. Later, as the subject becomes better understood, correlations among characters are discovered and this allows all properties of the units to be considered simultaneously so that a more sophisticated classification is evolved (Daubenmire 1968).

Daubenmire (1968) states that "Although the subject possess great amount of problems because of variants, eco-types, hybrids, botanists succeeded to bind individuals into natural series using the tremendous advantage of the unifying thread of lineal descent".. Ecologists used various features to compile this study such as physiognomy, floristic composition, physical features, geographical ranges etc. (Braun-Blanquet 1921, 1928, 1932, Rübel 1930, Küchler 1947, Dansereau 1951, 1972, Gaussen 1965, Daubenmire 1968, Küchler 1972, UNESCO 1973).

Meanwhile situation got more complicated when the emphasis shifted to more detailed scale where studies focused more on floristic composition and involved analysis of stands formed by a group of plants (Major 1959, Ponyatoskavya 1961, Poore 1962). This approach at a more detailed scale related with species composition and called synecology has occupied the major place with physiognomy in classification research

However still there is not a single universal taxonomy for vegetation science; different natural resource organizations developed their own vegetation taxonomic systems, while synecologists discuss the issue at a detailed floristic level (Kimmins 1997).

When the use and practical properties of the communities are considered, a classification system for the communities can not be considered only for an academic purpose. A sound and standard classification system provides the basis for better communication, reliable planning units, and opportunities to shift between scales which are crucial for more effective planning, management and conservation. In that respect it will be useful to briefly introduce some of the classification approaches and systems.

1.6.1. Hierarchical classification approaches

Küchler (1972) claims that due to nature of the classification studies they are supposed to be hierarchical; however, "one can do without classification *sensu stricto* and use purely descriptive methods". In the descriptive studies there is no hierarchy and no need to relate one vegetation type with other. Küchler and Sawyer (1967), Gaussen (1965), Küchler (1969), Schmid (1948) are examples for the non hierarchical studies that are based on the floristic composition, dominance or physiognomy.

Hierarchical classification is made up of units that are closely related with each other and can be used across various scales due to its interconnectedness. Hierarchical classification approaches gain more and more acceptance due to its practicality, easy use for many purposes, especially its applicability in remote sensing. In a hierarchical classification scheme, classes are nested such that major classes are broken into subclasses and these subclasses can be further broken into more detailed classes. Or in reverse manner, smaller classes can be combined to obtain higher classes for studies at a smaller scale.

In a proper hierarchical system the classes have to be nested spatially or functionally. This will help to maintain meaningful categories in further divisive or agglomerative groupings (FGDC 1997). In terms of hierarchical vegetation classification, one of the critical points is forming ecologically meaningful categories addressing the ecological functionality of each unit. This property of the hierarchy is extremely important since these schemes are widely used in the management of natural resources and in further conservation work.

1.6.2. Physiognomic classification

Physiognomy refers to the structure, growth form (sensu Rübel 1930) and leaf characters (*sensu* Raunkier 1934) of the dominant or codominant plants of the vegetation (Grossman *et al.* 1998, Grabherr and Kojima 1993).

Physiognomic expression of vegetation was first used by von Humboldt (1806). His classification was based entirely on the growth forms of the plants. A few years later he published a physiognomic classification of the earth's vegetation, i.e., there were 16 major units to be arranged in latitudinal and altitudinal belts that are related to climatic types (Daubenmire 1968). However this physiognomic concept of classification has been modified and expanded by botanists such as Grisebach (1838, 1872), Warming (1909), Kerner (1895), Rübel (1930), Raunkier (1934), Schimper and von Faber (1935), and since then a special symbolism was developed for recording physiognomic details by Christian and Perry (1953), Dansereau (1957), Dahlman and Kucera 1965, Küchler 1949, Müller-Dombois and Ellenberg (1974).

Units of the physiognomic classification may encompass large geographical areas since it is the generalization of the climatic conditions (Jennings 2004). The approach can be applied for a quick result over large areas and its practicality makes it an invaluable tool (Daubenmire 1968, Grabher and Kojima 1993, Grossman et al. 1998). Physiognomic classification has units which can be easily equated with remote sensing classification. This can provide a meaningful classification over large geographical areas (Fosberg 1961, Beard 1973, Whittaker 1975).

The basic unit in physiognomic classifications is generally accepted as the formation which is a "community type defined by dominance of a given growth form in the upper most stratum of the community, or by a combination of dominant growth forms" (Whittaker 1962). The term was introduced by Grisebach (1838, 1872). It is usually associated with the climate types in global distribution (Hodlridge 1947, Lieth 1956, Whittaker 1970).

In one of the most complex physiognomic classification Küchler (1947 and Dansereau (1951, 1972) has used six structural parameters, namely growth form, size, function, leaf shape and size, leaf texture, and ground coverage, to describe the vegetation. Similar approaches have been used in later studies such as Descoings (1973), Mueller-Dombois and Ellenberg (1974), Werger and Sprangers (1982).

The most common physiognomic system is a UNESCO (1973) system based on the works of Borckman-Jerosch and Rübel (1912), Rübel 1930, and Fosberg (1960).

A main criticism with the physiognomic classification is about its applicability in expressing the vegetation "without mentioning a name of a single organism and understanding the ecology of it" (Daubenmire 1968). On the other hand, the main advantage of the physiognomic classification is that it starts with the largest units and has a subdivisive approach (Daubenmire 1968, Küchler 1972) that enables it to be used across various scales and various purposes.

1.6.3. Floristic classification

Floristic classification is one of the most widely used classification systems. Vegetation types are determined according to floristic features. It is either based on the features of the dominant species or the full composition of the flora. Succession, history, disturbance are much better understood through floristic classification (Glenn-Lewin and van der Maarel 1992), and vegetation description is carried out in more detail by floristic means.

Three types of floristic classification systems have been commonly used in vegetation studies:

1.6.3.1. Dominance:

Vegetation units are determined according to dominant (i.e. biomass, density, height, coverage) species. Application of this procedure does not require a professional botanist; modest botanical knowledge will be enough to identify the dominant species in large geographical areas. This approach has been traditionally used in describing forest types such as Pine forest, Beech forest, Spruce-Fir forest etc. In floristically diverse areas, selection of a dominant species may be arbitrary (Whittaker 1963); however, on areas with limited variability dominance types can adequately describe major features of the vegetation and some of the smaller vegetation units (Kimmins 1997). Another shortcoming appears with the geographically broad dominant types: They may bear substantial amount of floristic and ecologic variation although they have been named as one type. The dominance criterion has been widely used in the forestry systems of U.S., Canada, U.K and Turkey through photo interpretation, mapping inventories etc, due to its practicality. Especially with the availability of remote sensing for classification purposes dominant types have been identified and mapped over large areas (Scott and Jennings 1998, Lins and Kleckner 1996).

Clements was one of the ecologists who have used the dominance approach widely (Barbour *et al*. 1999). He has classified the North American vegetation on the basis of the dominant species (Clements 1916). Daubenmire (1952) improved this study by using associated species in addition to the dominant species (e.g. *Pinus ponderosa/Agropyron spicatum* woodland-grass community). Under this scheme, two communities of the *Pinus ponderosa* with different associated species may be lumped together as *Pinus ponderosa* in a higher category of the classification scheme.

This approach is in use by the foresters in Turkey too. Forest management plans are based on a stand classification system that is carried out according to dominant species or species with coverage of more than % 10 in the canopy (OGM 1991). It was widely used in the gap analysis studies conducted in the Mediterranean part of Turkey (Zeydanlı *et al*. 2005a), Southeast Anatolia (Welch ed. 2004), Northeast Anatolia (Bilgin et al 2007) and the coastal Aegean (BMU 2004-ongoing)

1.6.3.2. Classification based on the entire flora

Floristic classifications based on the entire flora are the most detailed approach to vegetation classification. Most European and Soviet schools used systems based on this approach and it has also been used in countries like Canada, Japan, Turkey, and Vietnam.

The Braun-Blanquet Relevé technique (also known as Zurich-Montpelier, Relevé, SIGMA technique or Phytosociology) is one of the techniques based on the study of the entire flora for the estimation of the community types. Early studies were made by Schröter (1894, 1926), Flahault (1901), Brockman-Jerosch (1907). But a comprehensive systemization of the method was carried out by the Swiss ecologist Braun-Blanquet (1921, 1928, 1932). Relevés or stands are used for the sampling procedure and afterwards they are grouped and classified according to their floristic similarities (Grabherr and Kojima 1993). In this approach sampling is done within homogenous stands and classification is based on species list through their association within these stands.

Unlike the physiognomic classification systems it is agglomerative, and starts from the smallest unit and by combining them obtains higher ranks of the hierarchy.

Major steps for a phytosociological study can be summarized as follows (Kimmins 1997, Barbour *et al*. 1999, NBS/NPS 1994):

1. Developing concepts about the vegetation features and community types of the study area,
2. Deciding the number of the stands for representation of the area, carried out by investigator subjectively,
3. Investigation of the area by walking through the stands and compiling species list,
4. An area supposed to represent the pre-estimated community type (in step 1) best, is identified to lay stand,
5. Compilation of the species-area curve to identify the size of the quadrat,
6. Estimation and recording of the each species cover value (it is not measured precisely, instead visually estimated as one of 7 cover categories),
7. Preparation of the species and stands table for all of the stands,
8. Estimation of the presence values (presence is the percentage of all stands containing given species)
9. Study of the diagnostic species (character species, differential species, Constance,
10. Study of sociability,
11. Preparation of the differential table,
12. Estimation of the fidelity (differentiated species supposed to occur max. in % 20 of the stands, this is value of fidelity)

Based on this analysis, relevés are grouped into associations. Association, a central theme for the Braun-Blanquet method, is described as "a plant community of definite floristic composition and definite physiognomy which occurs in uniform habitat conditions" (Flahault and Schroter 1910)

Species that are common to several associations can be used to assemble the associations into broader groups. For example, the Braun-Blanquet approach groups plant associations with common diagnostic species into units called "alliances." In this way associations can be arranged into a hierarchy based on floristic composition (Mueller-Dombois and Ellenberg 1974). Hierarchy and the naming of the Braun-Blaunqet system, from smallest unit to largest one, is as follows:

Table 2: Hierarchy and naming of the Braun-Blaunqet floristic system

Supra-class	etales	Astragaletales microcephali
Class	etea	Astragaletea microcephali
Sub-class	enetea	Astragalenetea microcephali
Ordo	etalia	Astragaletalia microcephali
Subordo	enetelia	Astragalenetelia microcephali
Alliance,	ion	Astragalion microcephali
Sub-alliance	enion	Astragalenion microcephali
Association	etum	Astragaletum microcephali
Sub-associaton	etosum	Astragaletosum microcephali

The Braun-Blanquet system has been explained in detail by Poore (1955), Becking (1957), Whittaker (1962), Mueller-Dombois and Ellenberg (1974), and Westhoff and van der Maarel (1973).

Another important classification system based on the entire flora is the Habitat/Association type classification that is mainly used in the United States (Daubenmire 1952, Daubenmire and Daubenmire 1968, Pfister and Arno 1980, Kotar et al. 1988). It is usually called the Daubenmire system (Layser 1974, Kimmins 1997, Barbour *et al.* 1999, Jennings 2004).

Daubenmire (1952) purposely looked for and sampled the least disturbed and oldest plant communities ("near-climax") that he could find across a full range of environments as a basis to define "climax associations" (Jennings 2004). The idea behind this approach was based upon the idea that a classification "based upon climax types of vegetation best expresses the potential biotic productivity of a given combination of environmental factors" (Daubenmire (1953).

In this system first vegetation is classified according to dominant species in the overstory and then out coming units further subdivided according to dominant shrub or herb species and these subunits called “associations” (Kimmins 2000). Although, seral stages were considered in the systems, only climax associations are accepted as main units in the classification system and seral stages were described accordingly.

Daubenmire accepts a polyclimatic approach and uses various parameters like climatic, edaphic, topographic and soil.

The climax associations are used to define habitat types: physical environments or parts of the landscape that will support particular climax plant associations in the absence of disturbance. Habitat types are believed to be a more practical classification tool than associations because once the habitat type is defined, so is the seral sequence of plant communities and the suitability and productivity of different tree species should be identified, too (Daubenmire 1968).

Daubenmire establishes his system on the ecosystem concept, and considers organism, environment and time. Structurally it could include all the terrestrial vegetation to be considered in one system or area. Finally Daubenmire (1968) quotes that "in our classification system emphasis will be laid on units of environment having similar biotic potentialities, using vegetation as an indicator of degrees of similarity". However, Kimmins (1997) considers that this approach is solely vegetation classification rather than ecosystem or habitat classification as in practice it describes the units according to overstory and understory species and do not include features such as soil (Kimmins 1997). Kimmins (1997) also quotes limitations due to available data at the time of Daubenmire, could be an important reason that prevented him to incorporate soil data (Kimmins 1997).

In the Daubenmire system, the smallest unit of the system is habitat type which is identified according to structure of the vegetation, floristic composition, dominance, edaphic factors, microclimate and stage of succession. Application is first based on identification of the series according to grouping of the habitats with the same dominant climax species. Series are grouped into subformations and formations according to physiognomy of the dominant species of the climax (Daubenmire 1968).

Next unit higher in the hierarchy is vegetation zone which is a geographical area "with a uniform climate that supports the same climatic association" (Kimmins 2000). It is based on the assumption that edaphic and microclimatic conditions that are important in the local landscapes become less important in larger geographical areas and not able to explain environmental features due to complexity of the mosaic (Daubenmire 1968).

Next unit in the hierarchy is vegetation province, which is based on the grouping of the vegetation zones according to their floristic resemblance. "The vegetation province includes those zones which have had a somewhat common and distinctive geologic history, which for a distinctive geographic unit at present, and which exhibit strong threads of taxonomic homogeneity, sometimes even at the species level" (Daubenmire 1968).

The last unit in the hierarchy is vegetation region, a geographic area with a characteristic physiognomy associated with a distinctive climatic regime. It is the broadest of all levels and applicable only at the global level.

The habitat type approach is a vegetation-based site (land) classification system (Ferguson, Morgan and Johnson 1989). Once the classification of late-successional associations (existing vegetation) is completed, trends toward climax are interpreted and a key to habitat types (areas of similar potential natural vegetation) is developed for field identification and mapping purposes.

This approach is widely used in the northwestern part of the United States and it is accepted as a practical tool for ecosystem based forest management (Kimmins 2000).

1.6.4. Floristic-Physiognomic Classification

The advantages and the disadvantages of the physiognomic and floristic classification approaches in community classification have been presented above. Many plant scientists and ecologists criticize physiognomic and floristic classifications either for being too coarse or being difficult to apply for large areas (Grabherr and Kojima 1993, Kimmins 1987, Scott and Jennings 1998). On the other hand both systems have some advantages that make them indispensable (Scott and Jennings 1998, NVC 2004).

There are various classification systems that are combinations of various features which are already explained in the previous section (i.e. habitat classification, ecosystem classification). The hybrid systems have been developed over the years (Rubel 1930, Ellenberg 1963, Webb *et al*. 1970, Werger and Spangers 1982, Westhoff 1967, Westhoff and Held 1969, Borhidi 1991). However, it is likely that a classification system combining physiognomic and floristic features is likely to be a more fully developed system than others (FGDC 1999, 2004). While physiognomic features express the geographical differences at the larger scale, floristic units express the local site species characters (FGDC 1997). Consequently a system that combines physiognomic and floristic approaches answers a broader spectrum of needs.

Physiognomy and floristic composition are the most direct ways of describing vegetation. Physiognomy of the vegetation can be easily detected in the field, little floristic knowledge is sufficient to apply that sort of systems, it enables generalizations for the large geographic areas, and is easily detectable with remote sensing. Floristic information can be used for more detailed studies to draw information about succession, ecological processes, environmental gradients, and productivity.

Whittaker (1962) was one of the first who had mentioned the favorableness of a system composed of physiognomy and floristic features. "He fully expected that plant associations, ecological species groups, and habitat types could be used to develop flexible, but consistent community units" (FGDC 1997).

Driscoll *et al*. (1984) has worked on a joint system of physiognomy and floristic units using the physiognomic units of UNESCO (1973) and the floristic units of habitat types, of which an example was recently provided by Dick-Peddie (1993) in New Mexico. Strong *et al*. (1990) has proposed a similar system for Canada while Specht *et al*. (1974) has worked on joint physiognomic and floristic system to map the protected areas of the Australia (FDGC 1994).

1.6.5. Ecological (physiographic, biophysical, biogeoclimatic, ecosystematic, ecoregional) classification systems

The ecological classification approach is mainly based on the potential natural vegetation (Lapin and Barnes 1995, Bailey 1996, Omernick 1987). The site classification approach does not provide direct information on actual vegetation (Bailey 1996), but may consider it for successional trends or productivity (Cleland *et al*. 1997). These units can be very large that can be utilized at the global scale, like taiga, temperate forest or at a very small in the ecosystem level that can be used for site planning purposes (Krajina 1965, Pojar et al. 1987, Mac Nally *et al*. 2001). This approach was mainly produced to incorporate ecological principles into forest management (Krajina 1965, Pojar et al. 1987, Bailey 1995, Omernick, 1987).

Classes are explicitly defined according to climate, soil, landforms, lithology, and vegetation. In some forms vegetation types based on the dominance are used but in other types it has not been utilized directly.

In most of these classifications climate is the most generally used criteria to produce the upper ranks of the hierarchy (Köppen 1931, Troll 1964, Walter et al. 1975, Damman 1979, Bailey 1987). There also exist systems that produce classifications based solely on climate Köppen 1931 and they can contribute to knowledge at the biome level (Whittaker 1975). In later ranks soil, topography, elevation was used respectively (Hills 1952, Hammond 1954, Hack and Goodlet 1960, Krajina 1972).

Krajina's biogeoclimatic system (1965, 1969, 1972), developed for the British Columbia, is one of the comprehensive systems that will be useful to give more information about the ecological classification systems. It is widely used in British Columbia for resource management, conservation, ecological research purposes as it provides a common framework for a fundamental knowledge of landscape ecology (Meidinger and Pojar 1991).

First it divides the British Columbia into four climatic formations and seven biogeoclimatic regions, according to Köppen's climate classification. Then these regions are subdived into biogeoclimatic zones according to climatic climaxes and soil, zones are divided into subzones according to floristic and structural differences. Further subdivision called site classification, is carried out along topographic sequences.

These topographic sequences of site types that are associated with gradients of soil moisture and fertility are presented in the form of edaphic girds that can be used to develop silvicultural decisions at the stand level (Pojar *et al* 1987, Kimmins 2000). This system is explained in detail in Krajina (1965, 1969), Bell (1971), Mueller-Dombois and Ellenberg (1974), Beil *et al*. (1976), Kojima (1981), Meidinger and MacKinnon (1989).

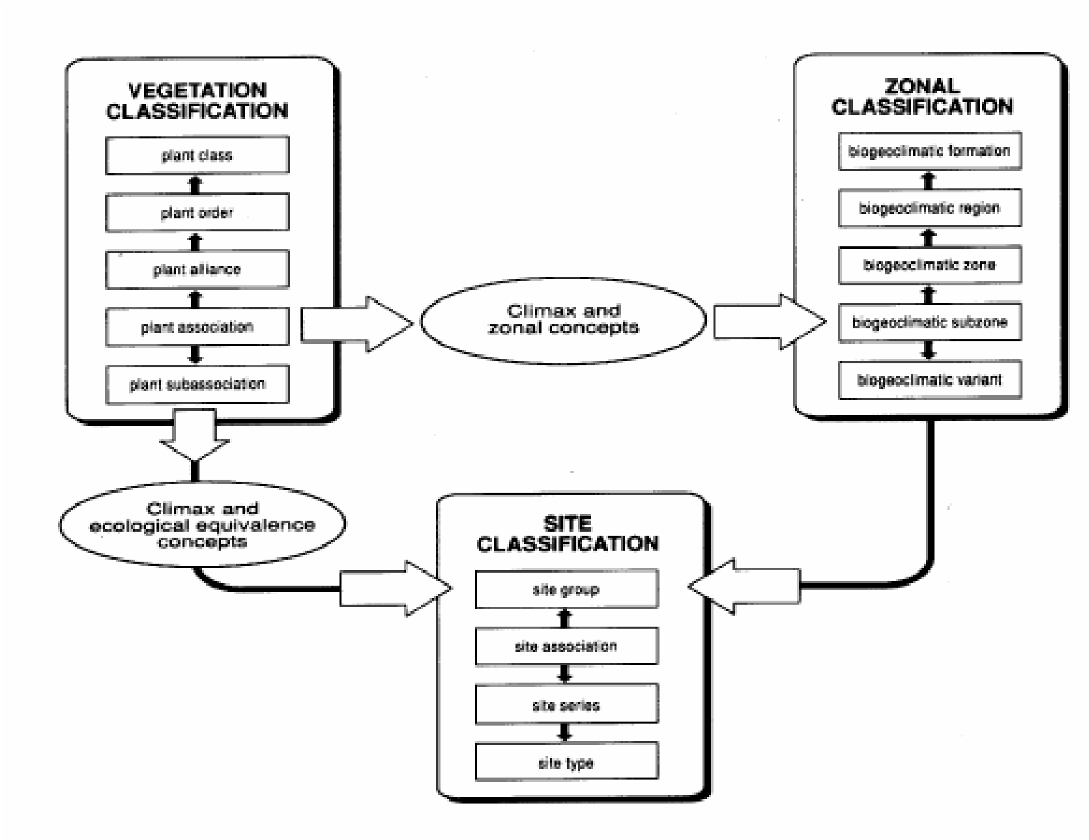

Figure 6: Vegetation; zonal and site classification categories and their relationships (Meidinger and Pojar 1991).

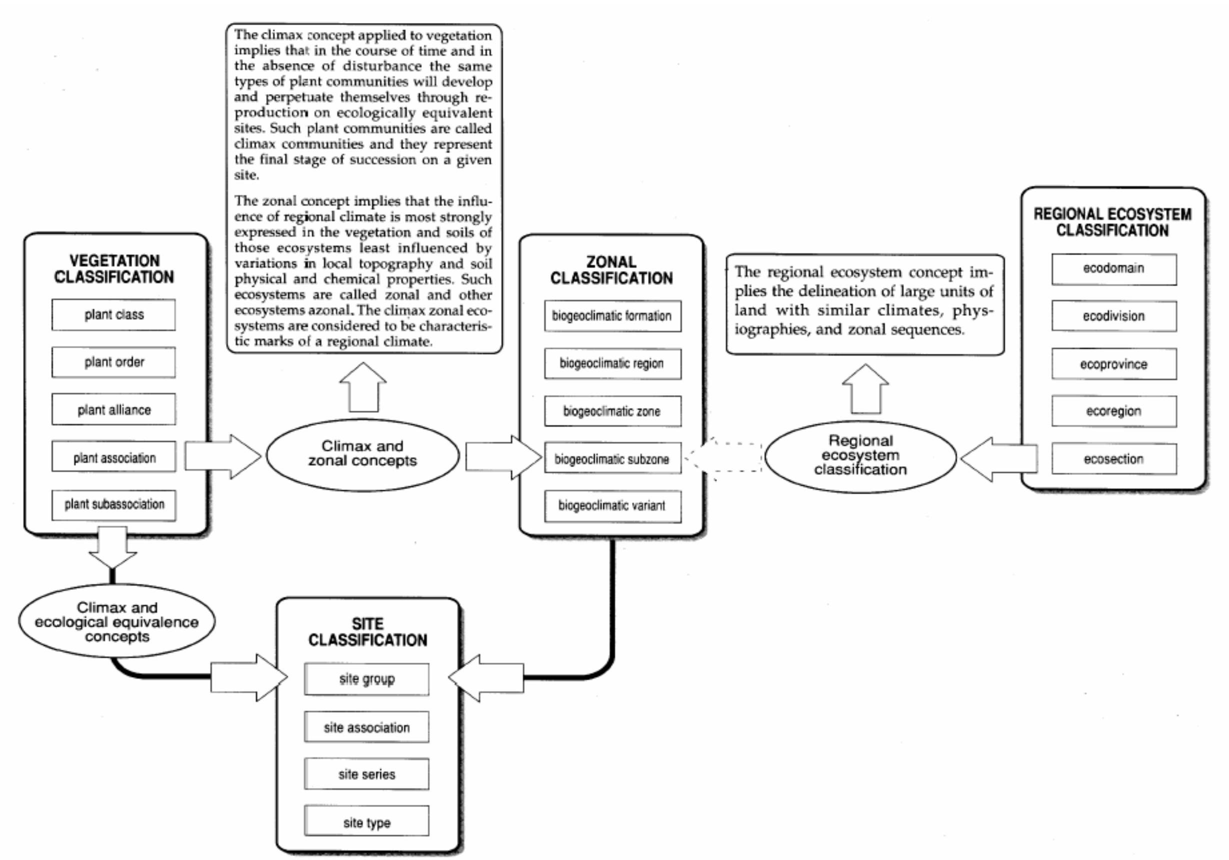

Figure 7: Relationship between ecoregion and biogeoclimatic classification (adapted from Pojar *et al.* 1986) (Meidinger and Pojar 1991)

Table 3: Widely used classification systems, their hierarchy and categories

	USNVCS (FGDC panel) (2000, 2004)	TNC	FAO	UNESCO	Daubenmire	Australia (Hobbs and McIntyre)	Kraijna's System
						Hierarchical representation of two biophysical and two human impact variables. The dendogram has been only partially expanded to illustrate various possible combinations of categories.	
1st Level	**Division:** Vegetated / Non-vegetated	**System:** Terrestrial /non-terrestrial	Vegetated / Non-vegetated	**Class:** Dominant life forms	**Vegetation Region** Geographic areas with characteristic physiognomy associated with a distinctive climatic regime. It is the broadest of all levels and applicable only in the global level.	Climate	**Climatic formations, biogeoclimatic regions**: According to Köppen's climate classification
2nd Level	**Order:** According to dominant life form	**Formation class**: Structure of the vegetation (relative percentage of cover and the height of the dominant uppermost life forms)	Terrestrial / Aquatic or regularly flooded land	**Subclass:** Growth-form characteristics (predominant leaf phenology - i.e., evergreen, deciduous)	**Vegetation Provinces** "Zones which have had a somewhat common and distinctive geologic history, which for a distinctive geographic unit at present, and which exhibit strong threads of taxonomic homogeneity, sometimes even at the species level" (Daubenmire 1968).	Growth form	**Biogeoclimatic zones**: Climatic climaxes and soil.

Table 3 (cont'd)

3rd Level	**Phys. Class:** Structure of the vegetation (relative percent canopy cover of life form in the uppermost strata)	**Formation subclass**: Growth-form characteristics (predominant leaf phenology - i.e., evergreen, deciduous)	Cultivated / Natural-seminatural	**Group:** Forest and woodland; climate (i.e. tropical, temperate), morphology (i.e. broad-leaved, sclerophylous) Dwarf-shrublands; cover, associated forms of vegetation, e.g., mixed with herbaceous plants; climate, morphology Grassland; tree or shrub cover, alpine and subalpine occurrence, Forb; height (1m).	**Vegetation Zone** "Geographical areas with a uniform climate that supports the same climatic association" (Kimmins 2000).	Habitat situation	**Subzones** Floristic and structural differences
4th Level	**Phys. Subcalss:** Leaf phenology of classes defined by tree, shrub, or dwarf shrub stratum (evergreen, deciduous, mixed evergreen-deciduous), and the average vegetation height for the herbaceous stratum (tall, medium, short)	**Formation Group** Leaf characters (i.e. broad-leaved) used in conjunction with broadly defined macroclimatic types (tropical , temperate, cold-deciduous). The presence of woody strata is used with climate to separate groups in the Herbaceous and Nonvascular Classes. Sparse Vegetation groups are separated by major topographic position types or landforms (e.g., cliffs versus flat pavement, talus versus rock flats).	Life form	**Formation:** Vegetation similarities are based on any of the following criteria. (tree size and crown shape, life zone, substrate, kinds of associated vegetation, amount and kind of understory	**Formation** Physiognomy of the dominant species of the climax	Naturalness	Further subdivision called, site classification, is carried out along topographic sequences

Table 3 (cont'd)

5th Level	**Physiognomic Group:** Combination of climate, leaf morphology, and leaf phenology. Different variables are applied to this hierarchical level in the sparsely vegetated class.	**Formation Subgroup:** Natural/Semi-natural or a Cultural Subgroup,			**Subformations**		These topographic sequences of site types that are associated with gradients of soil moisture and fertility are presented in the form of edaphic girds, that can be used to develop silvicultural decisions at the stand level (Pojar *et al* 1987, Kimmins 2000).
6th Level	**Physiognomic Subgroup:** Natural/Semi-natural - Areas dominated by native or established vegetation that has not been cultivated or treated with any annual management or manipulation regime.	**Formation:** vegetation types that share a definite physiognomy or structure within broadly defined environmental factors, relative landscape positions, or hydrologic regimes. Structural factors such as crown shape and lifeform of the dominant stratum are used in addition to the physiognomic characters already specified at the higher levels.			**Union** Dominant climax species.		

Table 3 (cont'd)

7th Level	**Formation:** Ecological groupings of vegetation units with broadly defined environmental and additional physiognomic factors in common. This level is subject to revision as the vegetation Alliances and Associations are organized under the upper levels of the hierarchy. Different variables are applied to this hierarchical level in the sparsely vegetated class.	**Alliance:** Within a formation, the alliance is a physiognomically uniform group of plant associations sharing one or more dominant or diagnostic species, which as a rule are found in the uppermost stratum of the vegetation.					
8th Level	**Alliance:** A physiognomically uniform group of Associations sharing one or more diagnostic (dominant, differential, indicator, or character) species which, as a rule, are found in the uppermost stratum of the vegetation.	**Association:** It is defined as "a plant community type of definite floristic composition, uniform habitat conditions, and uniform physiognomy"					

Table 3 (cont'd)

	Association Physiognomically uniform group of vegetation stands that share one or more diagnostic (dominant, differential, indicator, or character) overstory and understory species. These elements occur as repeatable patterns of assemblages across the landscape, and are generally found under similar habitat conditions.						

1.7. Remote sensing applications in classification studies

"Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation" (Lillesand and Kiefler 1994). Aerial photography, satellite imagery, and radar are different forms of imagery produced through sensors placed on satellites or aircraft (Doğan 2003)

One of the primary applications of remote sensing is to identify patterns of vegetation distribution on the ground and to assess changes in vegetation over time (Bean 1999, Scot et al. 1993, Stoms and Estes 1993, Roughgarden *et al.* 1991, Colwell 1983, Aspinall & Veitch, 1993, Fuller et a. 1994). Vegetation classes that are identifiable by other methods must produce a distinct spectral signature in order to be distinguished by remote sensing. The reflection of incident energy depends on both the properties of plant tissue and the structure of the vegetation cover (Bean 1999)

Degradation of the major limitation about the capability of hardware to processes large volumes of data has enabled to use of remote sensing systems in a more effective way for the analysis of large complex spatial arrays (Constanza and Maxwell 1991). For large areas, satellite remote-sensing techniques have now become the single most effective method for landcover and landuse acquisition (Thompson 1996). Especially its cost effectiveness when working in the large geographical areas makes it one of the major tools for further landcover and vegetation studies (Aspinall & Veitch, 1993; Fuller *et al.*, 1994; Steven & Jaggard, 1995, Morton 1986). Vegetation maps that have been produced through classification exercise with the satellite imageries provide basis for conservation studies and management purposes.

There are two generalized methodology to accomplish image classification (Moik 1982, Richards 1986, Lillesand and Kiefer 1994, Jensen 1996):

1) Unsupervised classification:
2) Supervised classification:

Unsupervised classification involves clustering individual pixels into spectral classes by measured reflectance values in the original channels or in transformations of those channels (Lillesand and Kiefer 1994, Jensen 1996). The spectral classes are than assigned to land-use and land-cover classes based on other information such as field observations, aerial photographs and existing maps.

In unsupervised classification, pixels are assigned to land-use and land-cover classes through a discriminant function based on spectral properties of those classes in a set of pre-selected training sites (Lillesand and Kiefer 1994, Jensen 1996).

In contrast to unsupervised classification, supervised classification is based on *a priori* information about the study area. It incorporates knowledge from field sampling or other maps to relate measured spectral reflectance properties to known properties of the land surface (Bean 1994). In supervised classification, pixel or pixel groups are selected that represent pre-defined classification categories and assigned as a training set for the classification process (Mulder, 1988).

According to Strahler (1981), Franklin *et al* (1986), Trisurta *et al.* (2000), supervised approach, to mapping forest vegetation has been highly successful, especially in the coniferous forest types with the use of digital elevation data. However, methods that have been used for the classification of urban and agricultural areas are not useful for vegetation classification as the spectral heterogeneity of classes makes specification of an adequate set of training sites difficult (Scott *et al* 1993). When the numbers of classes are high, supervised classification is likely to provide more accurate results (Bolstad and Lillesand 1992). However, choosing between supervised and unsupervised classification approaches depends on the availability of ancillary data and knowledge of the study area.

The success of image classification depends on whether land use or land cover classes have distinctive spectral signatures. In the electromagnetic spectrum, different species respond light in a different way (Verbyla 1995). Near Infrared, Middle Infrared and Thermal Infrared are the most suitable bands for vegetation classification, regarding their ability to differentiate chlorophyll, biomass, and leaf-water content (Nixon *et al*. 1985, Salisbury and Milton 1987, Asrar 1989, Taylor 1993, Verbyla 1995).

Geomorphometric variables also play an important role in the formation and spatial distribution of vegetation types (Barrio *et al*. 1997, Hoersch *et al*. 2002, Doğan and Doğan 2006), especially within high relief environments (Florinsky and Kuryakova 1996, Gong et al. 1996, Ekstrand 1996, Vogelman 1998). Thus, high classification accuracies may also depend on incorporating ancillary cartographic information to segment the image into regions that are physically or spectrally more homogeneous (Treitz and Howard 2000). For example, digital elevation data have been used to account for illumination effects and to stratify a scene into ecological zones. Similarly, maps of soils, geology, or general land-use and land-cover patterns can be effective in segmenting imagery to improve relationships between spectral classes and land-use and land-cover classes (Gerçek 2003, Zeydanlı and Domaç 2004, Hoersch 2002).

Forests are among the most challenging types of vegetation to classify with remote sensing as they are found in areas with complex topography, occur at high altitudes, with their understorey creating spectral confusion, and with factors inducing shadows (Peterson and Running 1989, Verbyla 1995, Warring and Running 1998).

Atmospheric corrections and band transformations often improve the ability to separate classes (Lillesand and Kiefer 1994).

Many studies has shown that vegetation classification with multi-spectral data successively classifies vegetation according to structural types and cover but is less able to discriminate different species or vegetation composition within communities (Graetz 1989, Hobbs 1989). Although trees are the objects that can be most effectively recognized through remote sensing, a classification that separates different species is rarely achieved (Nagendra 2001).

Pu *et al.* (2005) mentions that for identification of tree species through their canopies by remote sensing, the pixel size has to be smaller than 0.5 m. This resolution is not considerable when large area classification is attempted, due to the large volume of data that is difficult to handle (Warring and Running 1998). In large area mapping, with imageries having coarser resolution (i.e. Landsat ETM 30 m, Spot HRV 20 m, Aster 15 m) vegetation is mainly described through their cover and structural features, and dominant species are generally identified through other sources such as expert opinion, geographical distribution, or altitudinal distribution (Scott and Jennings 1998).

In order to increase the success of the classification, the relationship between study object and spatial resolution should also be considered (Simmons *et al.* 1992). Besides the objective of the study, classification classes also have to be determined according to size of the patches and the minimum mapping unit.

Gap Analysis Program applied in the US by the USGS-NBII has carried out extensive vegetation classification exercises with satellite imagery for the purposes of biodiversity conservation and resource planning. Supervised classification by pattern delineation was one of the methods used in the Gap Analysis Program (Jennings 1996). Jennings (1996) mentions two different approaches in pattern delineation such as, 1) Rendering the land cover patterns into broad categories, such as dominant vegetation type, non-vegetated areas, water bodies, through visual interpretation of false color digital Landsat TM scenes. 2) Using relevant data sources such as aerial photography, literature etc. to analyze the different texture, color, context of the image on the screen. Moreover, Jennings (1996) suggests that although using single mapping method to obtain highest accuracy is requisite, the use of hybrids of two procedures and efforts to develop other methods present due to the:

- Existence of a single physical reality, yet more than one method for depicting biologically meaningful and comparable abstractions.
- Fact that vegetation characteristics change form region to region requiring the use of a different method,
- Expertise of the scientist resulting in different approaches,
- Requirement of various sources of data to introduce variability into the final product.

Thus a variety of methods are used to delineate land cover patterns by the Gap Analysis Program's state project analysts (Davis et al., 1991; Davis & Stoms, 1996; Davis et al., 1995; Edwards et al., 1995; Lillesand, 1996; Scott et al., 1993; Slaymaker et al. 1996).

Another important criterion for the successful classification exercise is to choose the right image type regarding its spectral, spatial, temporal features (Warring and Running 1998) and scale of the final map.

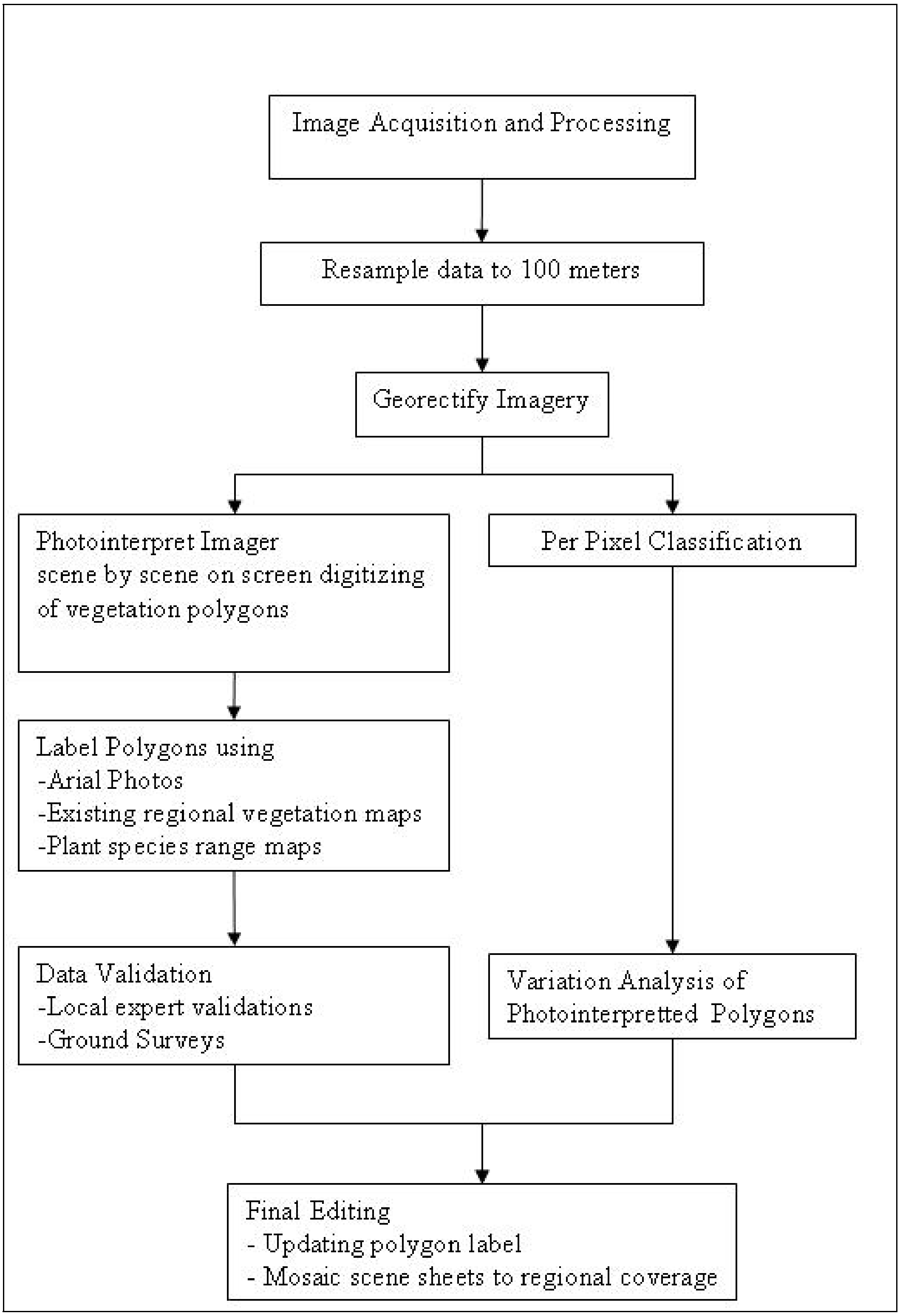

Figure 8: Algorithm for the supervised classification exercise for the vegetation classification study in the Gap Analysis (Jennings 1996).

Table 4: Characteristics of operational sensors currently used to map land use and vegetation cover in different scales are as follows:

Satellite Series	Sensor	First Date Available	No of Bands	Spectral Sampling	Resolution	Sampling Frequency	Swath width (km)
NOAA	AVHRR	1978	5	VIS/NIR/TIR	1-4 km	12 hours	2,850
LANDSAT	MSS	1972	4	VIS/NIR	80 m	16 days	185
	TM4,5	1982	7	VIS/NIR/TIR	30/30/120 m	16 days	185
	TM 6	1992	8	VIS/NIR/TIR	20/30/120 m	16 days	185
	TM 7		8	VIS/NIR/TIR	20/30/120	16 days	185
SPOT	HHV-P	1986	1	VIS	10 m	3 days	60
	HRV-XS	1986	3	VIS/NIR	20 m	3 days	60
IKONOS	MS	1997	5	VIS / NIR	4 m		11
IRS	WIFS	1999	5	VIS / NIR	25 m	25 days	141

** VIS: visible light, NIR: near infrared, TIR: thermal infrared

When the relevant literature and above features are considered, it is likely that NOAA is the most suitable imagery for small-scale mapping purposes (Mehner et al. 2004); LANDSAT TM, SPOT HRV are the most preferred imageries for the intermediate scale mapping purposes (Franklin and Wulder 2002, Hoffer et al. 1982, Dottavio and Williams 1982, Ahern *et al*. 1983, Nelson *et al*. 1984, Ahern and Archibald 1986), and IKONOS, QUICKBIRD, ORBVIEW are the most suitable for the large scale studies (Mehner *et al.* 2004).

Since its launch in 1972 LANDSAT is the most preferred image type for the vegetation classification studies (Taylor *et al.*, 1991, Mehner *et al*. 2004). In comparison of two LANDSAT imager types, LANDSAT TM imageries have some advantages over LANDSAT MSS imageries:

- Higher signal –to- noise ratio

- Higher precision of radiometric data
- Higher cartographic accuracy
- Higher spectral dimensionality (particularly midinfrared bands)

SPOT imageries are another source that is suitable for the intermediate scale vegetation classification applications. Its advantages can be summarized as:

- Contemporary acquisition
- High cartographic quality
- High radiometric resolution
- Late-morning acquisition (reduces shadowing)
- Multiple viewing angles for better temporal coverage

On the other hand LANDSAT TM is much more preferred for studies with natural vegetation since SPOT data has lower spectral dimensionality and lack mid-infrared bands (Taylor *et al.*, 1991, Mehner *et al.* 2004). Also SPOT data is more expensive. The higher spatial resolution of SPOT data is useful for analyzing localized environments such as wetlands and urban areas but produces even more unwanted disaggregation of some vegetation types than TM. SPOT data should be considered as an alternative only when TM data are unavailable.

Advanced Very High Resolution Radiometer (AVHRR) satellite data is very useful for frequent monitoring of vegetation characteristics such as greenness, but large contribution of nonvegetative surface characteristics to the spectral signature of pixels 1 to 4 km on a side make this imagery less useful for mapping the floristic composition and structure of vegetation at the series level. Besides it has the most suitable spectral resolution and data volume for small scale classification studies (Warring and Running 1998).

Although, Mehner *et al.* (2004) mention the inappropriateness of the LANDSAT ETM and SPOT HVR and highlights the spatial appropriateness of the IKONOS due to its low spectral resolution and small pixel sizes, it does not seem to be suitable for meso and large scale vegetation classification purposes due to high cost and large volume of the data that need to be processed.

1.8. Community-vegetation classification studies in Turkey

First information about the vegetation and communities of Turkey can be drawn from the geographical or botanical studies of the European scientists in 19th century and early 20th century such as Boissier (1867-1888), Bornmüller (1909), Andraosvzky (1914), Davidoff (1915), Handel-Mazzetti (1909, 1912-1916). During their research, they have given information about the landscape and plant cover of the regions they were surveying. Although, none of these studies were for the vegetation purpose they have provided a basis for later studies.

P.H. Davis studied the flora of Turkey and published his studies in ten volumes 'Flora of Turkey and East Aegean Island' in 1965-1988. Although he has conducted floral studies and he has not studied the vegetation of Turkey directly, his studies provided fundamental basis for the vegetation studies, especially for the phytosociological ones.

The first local botanist with an international reputation was Georges Vincent Aznavour (1861-1920), a wealthy Armenian of Christian confession. His collection of plants from the Bosporus region comprised about 20.000 samples.

Studies concentrated on the vegetation and phytogeography of Turkey has started in the mid 20th century such as Kasaplıgil (1947), Walter (1956a, 1956b), Regel (1959), Zohary (1973), Davis and Hedge (1975). Also, there is few earlier studies worth to mention Krause (1915, 1932), Czechott (1938), Louis (1939). Among these studies by Handel-Mazetti, Krause, Schwarz are important due to information they have provided about the Turkey's vegetation (Birand 1960). However, these studies give general information about the nature and vegetation of Turkey and are far from demonstrating a systematic approach.

Phytosociological studies have been the most comprehensive vegetation classification studies in Turkey. Many botanists and plant ecologist has applied phytosociological methodology in their surveys such as Birand (1960), Çetik (1971, 1985), Yaltırık (1964), Akman (1973, 1974, 1976), Düzenli (1976, 1979), Quezel (1973, 1985), Ketenoğlu (1982, 1983), Vural (*et al.* 1985, 1996), Adıgüzel (1995), Seçmen and Uslu 1977, Uslu 1977, Tatlı (1985), Duman (1994, 1995). Being the first Turkish botanist and plant ecologist to carry out phytosociological research, Birand (1969) is worth to be highlighted (Çırpıcı 1987).

Main contribution to the phytosociological description of Turkey's vegetation came from the botanists of the Biology Department of Ankara University. Under the leadership of the Akman, Ketenoğlu and Yurdakulol has carried out many studies in different parts of the country in collaboration with Quezel and Barbéro, French phytosociologists from Montpellier University (Akman and Ketenoğlu 1976, 1978, Quezel 1985, Akman *et al*. 1978a, 1978b, 1978c, Quezel and Pamukçuoğlu 1969, 1973, Quezel 1973, Quezel *et al.* 1980, Yurdakulol 1977, Ketenoğlu 1982, 1983). Phytosociological studies and approaches have widely dominated the vegetation description and classification studies in Turkey. Almost all the botanists and plant ecologists follow the school of Zurich-Montpellier due to their German and French supervisors in the early times of the establishment of the biology as a science in Turkey, and after a while, high number of the supporters of this school has played an inhibitory effect in development of other approaches. Although there are many papers on phytosociological analysis in several parts of Turkey there is not any for other sort of classification studies in the last five years of the Turkish Journal of Botany.

Another major branch of vegetation classification studies in Turkey is maintained by geographers. Erinç and Atalay are the best known of them. Atalay has carried out classification studies in many parts of Turkey including Mediterranean (Atalay 1987, 1993), Northeast Anatolia (Atalay *et al.* 1985), North Anatolia (1992) and for the whole Turkey (1994, 2002). His studies were supported by the Ministry of Environment and Forestry and were widely used for seed improvement work as he had described seed transfer regions. His classification scheme is mainly based on climate, physiognomy, geology and soil (Atalay *et al.* 1985, 1987, 1993, 1994). In his studies Atalay mainly divided his study area into regions and classified vegetation according to climate, dominant species and other physical and edaphic factors.

Mayer and Aksoy (1986) have made another important comprehensive study in the classification and description of the forests vegetation of Turkey. Although the purpose of their study was to give information about the Turkish forests rather than classify them, however, they have unavoidably used a certain kind of classification system to present their study. This classification is not designed in a systematic way but is more easily understandable in comparison to another book about the Turkey's forests (Akman 1995) which is based on phytosociological work. The classification system in Mayer and Aksoy (1986) first divided the country into three major groups according to climate and geography: Euxin forests of the northern Turkey, Steppe Forests of inner Anatolia, and Mediterranean Forests of southern and western Turkey. Next ranks are designed according to geography, climate, dominant species and elevation in a changing manner. Forest types are presented either according to dominant species for the widely dominant species or based on phytogeographical alliances (i.e. *Pinus brutia* forests, *Pinus nigra* forests or *Oleo-Ceratonion, Quercion coccifera*). Elevation is the most systematically used criterion for classification in this book (i.e. coastal, colline, submontane and montane). However, the system does not include a systematical hierarchy

Another classification system worth mentioning is the one used by the Department of Forest Planning and Management of the Ministry of Environment and Forestry (OGM 1991). This classification is designed mainly for the forest management purposes with a special emphasis on timber production. Thus, the classification system is based on dominant tree species, associated overstory species with at least 10% abundance, tree height and tree age. The classification is applied at 1/25.000 scale and its major unit is forest stand that is determined according to above mentioned criteria. Although this classification system is not designed for ecological purposes, it gives a high amount of information about the forest and can be interpreted to derive ecological features of the areas (Zeydanlı and Domac 2004, Domaç 2005). However, it does not involve any hierarchy either.

1.9. EUNIS and its application in Turkey

EUNIS (European Nature Information System) is a pan-European classification system, which was developed in 1997 by the European Environment Agency in collaboration with experts from throughout Europe. It covers all types of natural and artificial habitats, both aquatic and terrestrial. A web application has been developed for easy access on data collected . EUNIS is a live system, which will change over time with new data. (EEA 2004).

EUNIS data are collected and maintained by the European Topic Centre for Biodiversity and Nature Protection for the European Environment Agency and the European Environmental Information Observation Network, for use in environmental reporting and assisting the NATURA2000 process (EU Birds and Habitats Directives), and is coordinated with the related EMERALD Network of the Bern Convention.

EUNIS focuses on key biodiversity elements such as species, habitat types and major sites of importance for protecting Europe's biodiversity. The data are collected and arranged to establish a hierarchical format for habitats and displayed as a tree classification of habitat types.

The information includes:

- Data on Species, Habitats and Sites compiled in the framework of the NATURA2000 (EU Habitats and Birds Directives), but also data collected by ETC/NPB(formerly the European Topic Centre for Nature Conservation) from literature and other sources as reference data.
- Information on Species, Habitats and Sites taken into account in relevant international conventions.
- Specific data collected in the framework of the EEA reporting activities, which also constitute a core set of data to be up-dated periodically.

The Species part of EUNIS contains information about more than 275 000 taxa occurring in Europe. By 2005, the EUNIS database provides information for: 276.000 species, 5.397 habitat types, 80.600 sites, and 800.000 species information in DiGIR.

Spatial-temporal information (including species population size and trends) is available for birds. Other groups might only have their geographic distribution (grid distribution for mammals, amphibians and reptiles). Data concerning the conservation status has been collected from all national Red Books made available to the ETC-NPB and from other relevant literature. International conservation status as well as major international legal status is displayed.

The EUNIS Habitat type classification is a comprehensive pan-European system to facilitate the harmonized description and collection of data across Europe through the use of criteria for habitat identification; it covers all types of habitats from natural to artificial, from terrestrial to freshwater and marine.

A) Marine habitats
B) Coastal habitats
C) Inland surface waters
D) Mires, bogs and fens
E) Grasslands and lands dominated by forbs, mosses or lichens
F) Heathland, scrub and tundra
G) Woodland, forest and other wooded land
H) Inland unvegetated or sparsely vegetated habitats
I) Regularly or recently cultivated agricultural, horticultural and domestic habitats
J) Constructed, industrial and other artificial habitats

K) Habitat complexes

Habitat type is defined for the purposes of the EUNIS habitat type classification as follows: 'Plant and animal communities as the characterizing elements of the biotic environment, together with abiotic factors operating together at a particular scale.' All factors included in the definition are addressed in the descriptive framework of the habitat classification. "Most but not all EUNIS habitats are in effect 'biotopes', that is to say 'areas with particular environmental conditions that are sufficiently uniform to support a characteristic assemblage of organisms'. A few EUNIS habitats such as glaciers and highly artificial non-saline standing waters may be devoid of living organisms other than microbes. These features, although not strictly habitats, are included for completeness." (Davies *et al.* 2004)

The scope of the EUNIS classification is limited to level 3 in its hierarchy (level 4 for Marine habitat types). At level 4 (5 for the Marine types) and below, the component units are drawn from other classification systems and combine these in the common framework.

A criteria-based key has been developed for all units to level 3 and in addition for salt marshes at level 4. The key takes the form of a sequential series of questions with additional detailed explanatory notes. Depending on the answer chosen, the user is directed to the next question in the series or to a habitat type identified by the parameters. The user may follow the key question by question, or view the criteria for each habitat level in a series of static diagrams.

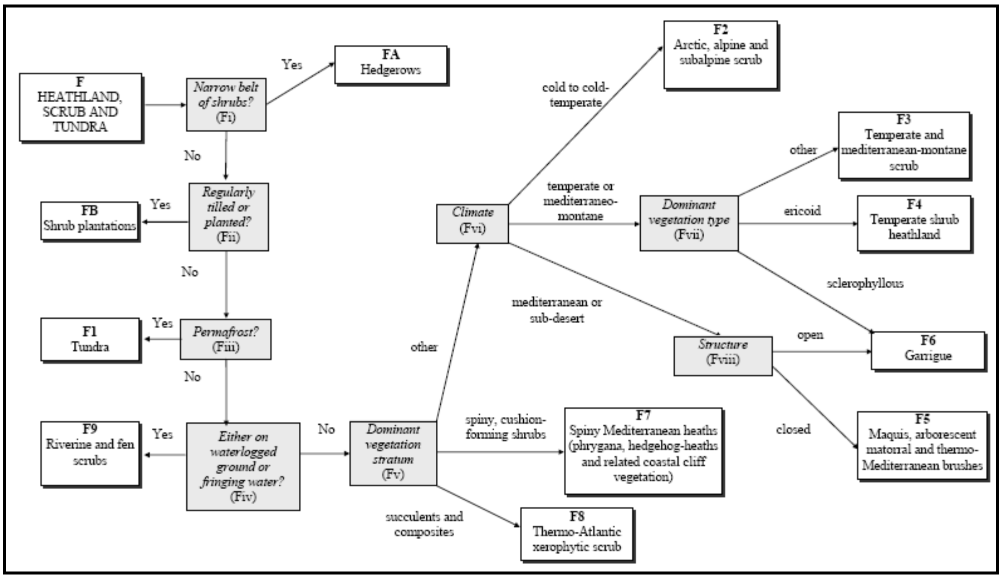

Figure 9: Sample to EUNIS classification key

CHAPTER 2

MATERIALS AND METHODS

2.1. Study Area

Study area is chosen as the Mediterranean region of Turkey. Reasons behind this selection can be summarized as:

1) Diverse vegetation of the region,
2) Relatively well developed road structure enabling access to most corners of the region,
3) High number of literature and availability of forest maps for the whole region,
4) WWF Turkey's Gap Analysis study in the region, which has carried out extensive field surveys and examined the whole region.

Boundaries of the study area determined according to terrestrial ecoregions of the world compiled by the WWF US (Dinerstein *et al.* 2001). This study is reconsidered with the Atalay's regionalization studies (Atalay 1987, 2002). Furthermore, boundaries were refined according to DEM, 1/100,000 scale forest maps and the vegetation classification study.

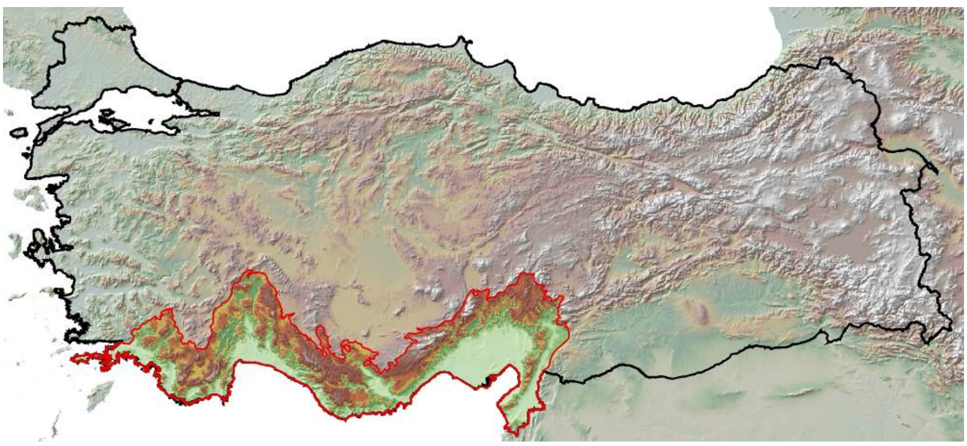

Figure 10: Map showing the study area in relation to its position in Turkey

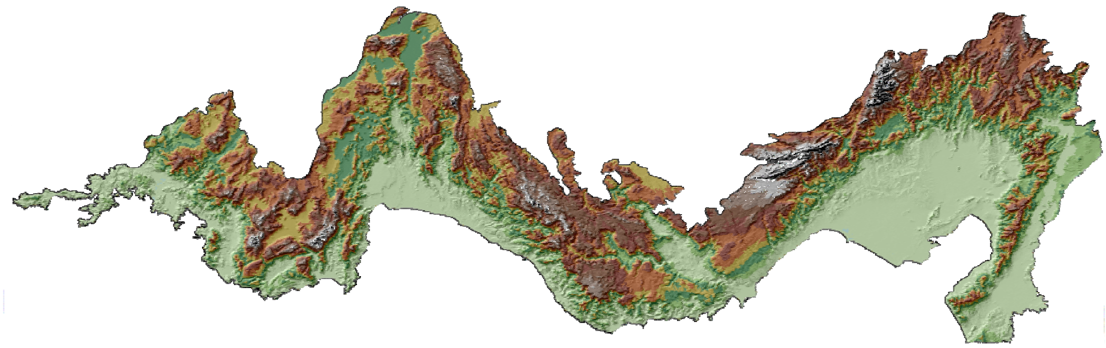

Figure 11: Map showing the Digital Elevation Model of the study area on the shaded relief

The study area is made up of two ecoregions and 9 sub-ecoregions (Zeydanlı *et al.* 2005a):

1) Eastern Mediterranean (Southern Anatolian) Conifer Forest & Maquis:
Lying between the Taurus Mountains and the Mediterranean Sea (Kaya and Raynal 2001), the nature of this ecoregion is greatly influenced by the sea and the mountains lying parallel to sea. The climate is characterized by severe summer drought and an annual precipitation of 600-1250 mm concentrated in the winter. Maquis formations and Turkish Red Pine are the main vegetation components. The northern boundary of this ecoregion follows the distribution of Turkish Red Pine along an altitudinal gradient. It is subdivided into 4 subecoregions as follows:

1.1 South Western Anatolia Conifer Forest and Maquis

1.2 Antalya Plain Conifer Forest and Maquis

1.3 Adana Plain Conifer Forest and Maquis

1.4 Amik Plain Conifer Forest and Maquis

2) Southern Anatolian Montane Conifer and Deciduous Forest: This ecoregion is characterized by the Taurus Mountains which extend parallel to the sea. Although the area has Mediterranean climate, its summer droughts are less obvious than in the coastal ecoregions and have higher precipitation levels, varying between 800-2000 mm. The ecoregion is divided into five sub-ecoregions, mainly following the mountain ranges.

2.1 Akdağ (Western Taurus) Montane Conifer Forest

2.2 Isparta-Burdur Montane Conifer Forest

2.3 Geyik (Middle Taurus) Montane Conifer Forest

2.4 Aladağlar (Eastern Taurus) Montane Conifer Forest

2.5 Amanos Montane Mixed Conifer and Deciduous Forest

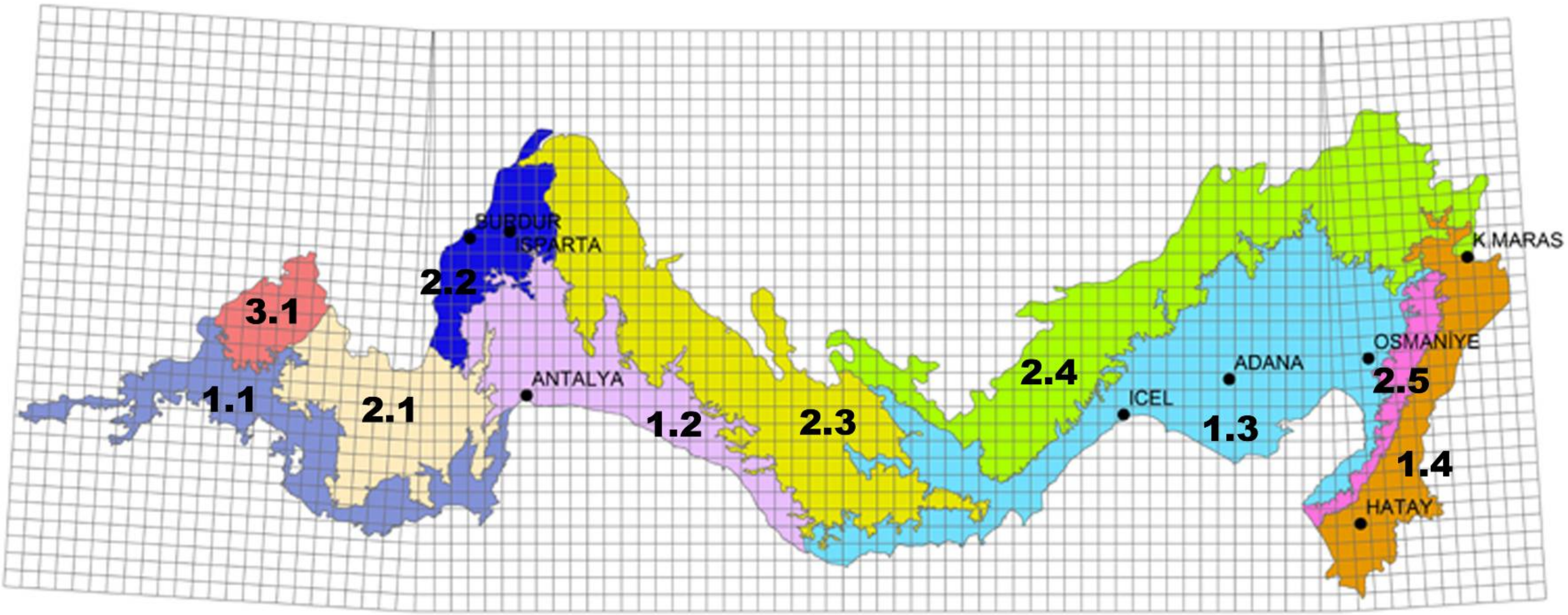

Figure 12: Sub-ecoregions of the study area with the 10x10 km^2 UTM grids.

2.2. Physiognomic-Floristic Community Classification System

The Nature Conservancy, US Federal Geographic Data Committee has developed a physiognomic-floristic classification system called USNVCS (Grossman et al. 1998, FGDC 1997, 2004). It is taken as a basis to adapt to Turkey.

First level of the classification system is "*System*". It is made up of two categories; Terrestrial and aquatic. Further downward levels of the system are suggested only for the "*Terrestrial System*".

Categories from the second level to sixth level are determined according to physiognomic features.

Second level of the classification system is "*Physiognomic Class*". It is made up of 7 categories that are determined according to dominant life forms: Forest, Woodland, Shrubland, Dwarf Shrubland, Herbaceous, Non-vascular, Sparse Vegetation. Descriptions provide below are according to Grossman (1998).

Forest is defined as tree (single stemmed higher than 5m) dominated formations with the crown closure more than 60 % and woodland is defined as tree dominated formations with the crown closure between 25-60 %.

Shrubland is individuals or clumps of shrubs (multi-stemmed between 0.5-5 m) with more than 25 % coverage. Trees have less than 25 % coverage in the shrublands.

Dwarf shrubland is low growing shrubs usually less than 0.5 m tall and have similar coverage features with the 'Class Shrubland'

In 'Class Herbaceous', herbaceous plants have more than 25 % cover and trees, shrubs, dwarf shrubs forms less than 25 % cover.

In 'Class Nonvascular', nonvascular types (e.g. bryophytes, non-crustose lichens, algae) are dominant and forms at least 25 % cover.

Sparse vegetation has less than 25 vegetation cover and abiotic substrate is abundant.

Third level of the classification system is "*Physiognomic Subclass*". It is determined according to growth form characteristic. It is divided as evergreen, deciduous, mixed for the woody vegetation and forb, graminoid, hydromorphic, annual, perennial for the herbaceous vegetation.

Fourth level of the classification system is "*Physiognomic Group"*. It is determined according to leaf characteristics and/or associated macroclimate types. It is divided as needle-leaved, broad-leaved, and mixed for the woody vegetation and as short, tall, and with woody vegetation for the grassland.

Fifth level of the classification system is "*Subgroup*". It is determined according to human impact and the alteration of the natural community type. It is made up of two groups both for the woody and herbaceous formations. It is divided as natural/semi natural and cultivated.

Sixth level of the classification is the "*Physiognomic Formation"*. It is determined according to various physiognomic and physical features which are not expressed in the above categories. Life zone, substrate type, geological formations, tree size, crown shape, amount and kind of understory.

Seventh and eight categories are determined according to floristic features.

Seventh category is called "*Alliance"* and determined according to dominant species.

Eighth category is called "*Association*" and is determined according to characteristic species in addition to dominant species.

Table 5: The USNVC's hierarchy for terrestrial vegetation (Grossman 1998)

Level	Basis for Classification
Class	Growth form and structure of vegetation
Subclass	Growth form characteristics
Group	Leaf type
Subgroup	Relative human impact
Formation	Additional physiognomic or environmental factors
Alliance	Dominant/diagnostic species of uppermost or dominant stratum
Association	Additional dominant/diagnostic species

Table 6: The USNVC's hierarchy and classes for terrestrial vegetation

Physiognomic Class	**Forest**
Physiognomic Subclass	Evergreen Deciduous Mixed Evergreen-Deciduous
Physiognomic Group	Broad-leaved Needle-leaved Mixed
Physiognomic Subgroup	Natural/Semi Natural Planted/Cultivated
Physiognomic Formation	Substrate, soil, altitude and/or other criteria can be used
Alliance	First floristic level determined according to dominant sp.
Association	Second floristic level determined according to associated sp.
Physiognomic Class	**Woodland**
Physiognomic Subclass	Evergreen Deciduous Mixed Evergreen-Deciduous
Physiognomic Group	Broad-leaved Needle-leaved Mixed
Physiognomic Subgroup	Natural/Semi Natural Planted/Cultivated
Physiognomic Formation	Substrate, soil, altitude and/or other criteria can be used
Alliance	First floristic level determined according to dominant sp.
Association	Second floristic level determined according to associated sp.
Physiognomic Class	**Shrubland**
Physiognomic Subclass	Evergreen Deciduous Mixed Evergreen-Deciduous
Physiognomic Group	Broad-leaved Needle-leaved Mixed
Physiognomic Subgroup	Natural/Semi Natural Planted/Cultivated
Physiognomic Formation	Substrate, soil, altitude and/or other criteria can be used
Alliance	First floristic level determined according to dominant sp.
Association	Second floristic level determined according to associated sp.
Physiognomic Class	**Grassland**
Physiognomic Subclass	Perennial Annual Graminoid Forb Hydromorphic
Physiognomic Group	No woody cover Sparse tree cover Sparse shrub cover
Physiognomic Subgroup	Natural/Semi Natural Cultivated

Table 6 (cont'd)

Physiognomic Formation	Substrate, soil, altitude and/or other criteria can be used
Alliance	First floristic level determined according to dominant species
Association	Second floristic level determined according to associated species
Physiognomic Class	**Sparse Vegetation**
Substrate types and other physical features were used. Not developed extensively	
Physiognomic Class	**Non-Vascular**
Substrate types and other physical features were used. Not developed extensively	

2.3. Vegetation Classification with LANDSAT Enhanced Thematic Mappers (ETM)'s

2.3.1. Data Sources and Landsat ETM images used

The images were used this study was acquired from the latest Landsat Earth Observation Satellite, which is Landsat 7 Enhanced Thematic Mapper (ETM). Landsat ETM is made up of nine bands two of them are thermal bands with 60 m resolution, one of them is panchromatic band with 15 m resolution, six of them are visible and infrared with 30 m resolution.

The 14 Landsat ETM images used in this study. They come from three different years – 1999, 2000 and 2001. Although May or June images were preferred, the high percentage of cloud cover on images from these months made them unusable. As a result the images used were also from three different months, June, July and August. It was thus considered that calibration of the images to mosaic them would cause data loss and so it was decided that each image should be studied and classified separately. The images and their acquisition dates are given in Table 7 and Figure 13.

Supervised classification was chosen as the main classification approach. Training sets were prepared using the following data sources:

1. 1/100,000 scale digital forest maps in vector format;
2. 1/25,000 scale forest maps in raster format, their size depending on the *Forest Management Unit* area;
3. 1/25,000 scale topographic maps in raster format;
4. A digital elevation model (DEM) prepared from the 1/250,000 scale contour data.

Table 7: Landsat ETMs used in the classification and their acquisition date

Path	Row	Acquisition Date
180	00	08/03/00
179	35	08/10/99
179	34	08/10/99
178	00	08/21/00
178	35	08/05/00
178	34	08/05/00
177	35	07/13/00
177	34	07/13/00
176	35	07/08/00
176	34	08/10/01
175	35	06/13/00
175	34	07/31/00
175	33	07/18/01
174	35	07/08/00

In preparation of the training sets, the DN values and UTM coordinates of each sample area were recorded separately for the band combinations 5/4/3, 5/TVI/4 and NDVI. Image classification study is made up of three main steps.

TNT Mips 6.4 (Microimages Inc. Co.) was the RS&GIS software used in all stages of the classification study.

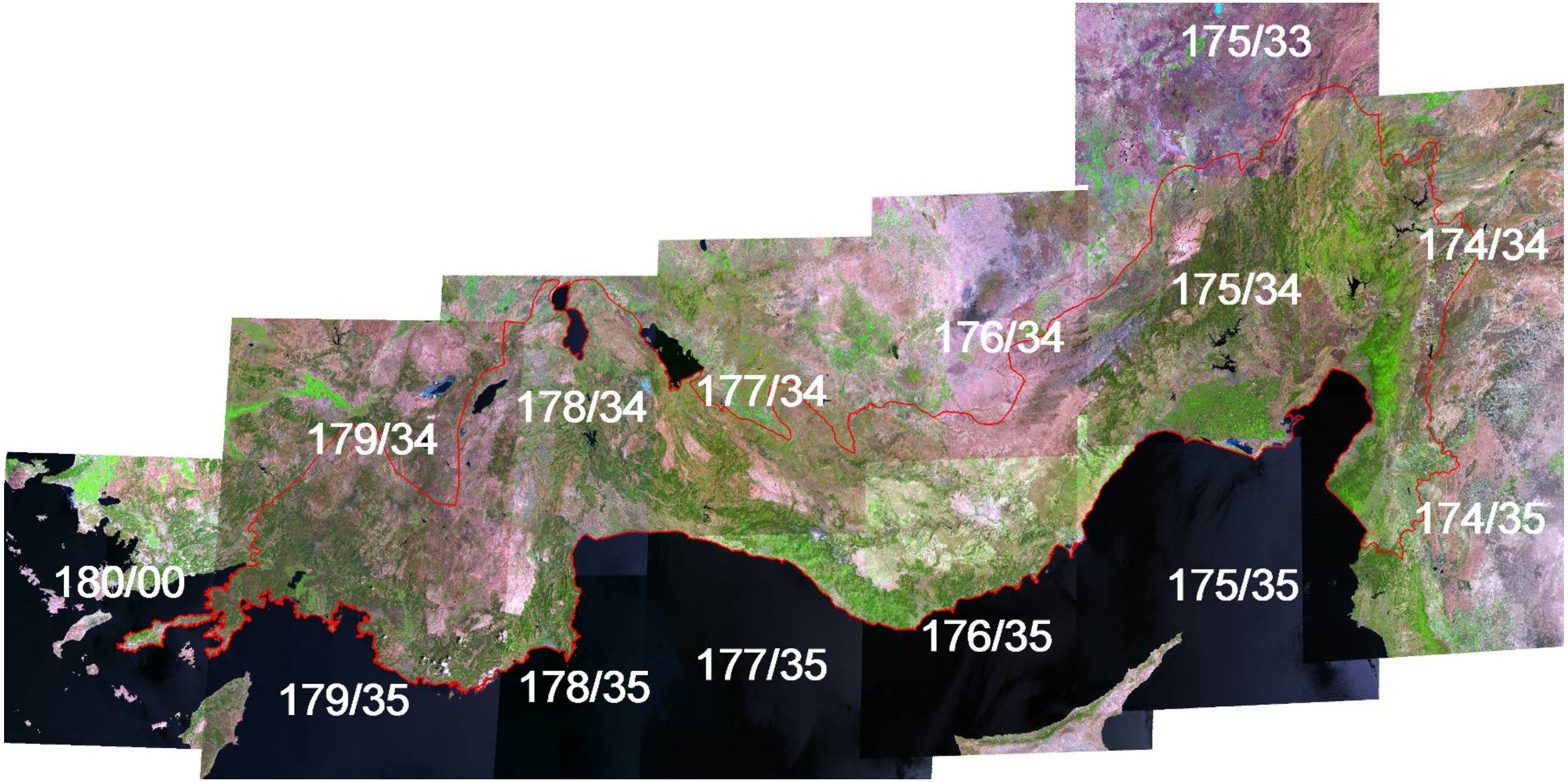

Figure 13: Tiled Landsat ETM images of the study area

2.3.2. Pre-classification studies:

The area of the image which was to be classified was extracted according to the boundaries of the study area.

1/100,000 scale forest maps and 1/25,000 scale stand maps were the main ancillary data sources in the formation of the training set. However, although 1/25,000 forest maps were more accurate, it was not possible to obtain or digitize all 1/25,000 forest maps for an area the size of the Mediterranean region. Another source of data was the 1/25,000 topographic maps. These maps were also scanned and georeferenced to be used in training set formation. They do not inquire directly vegetation data but they were useful to estimate some of the vegetation types through examining landscape features and topography of the area.

Since the quality of the training data is critical for the success of the classification exercise, during the training set formation pixels were chosen from relatively homogenous large patches of vegetation. Visual interpretation of Landsat ETM bands 5, 4 and NDVI color composite and 1/25.000 forest maps were the most useful sort of data to find the best fitting training set. DN values for the Band 5, 4 and NDVI of training pixels were recorded to compare the different classes and to solve the possible problems in separation of the classes.

Settlement and agricultural areas were not subjects of interest in the current classification exercise and could cause a wide variation in the reflectance values which could result in misclassification due to spectral confusion (Corner *et al*. 2003). Thus agricultural and settlement areas were digitized as vector elements and the resulting vector layer was then used to mask out the settlement and agricultural areas during the classification. This helped to reduce the spectral confusion and resulted in better differentiation between the unique 'spectral signatures' of each vegetation type.

One of the key strategies used in order to increase the success of the classification was stratification of the study area. During the classification procedure the images were divided into smaller areas according to sub-ecoregion boundaries and 1/100.000 forest maps. First each Landsat ETM was divided into pieces according to 9 sub-ecoregions. Then these pieces were subdivided according to forest blocks that were detected via 1/100.000 forest maps. If forest type (e.g. Turkish Red Pine, Anatolian Black Pine, Taurus Fir, and Anatolian Black

Pine-Turkish Red Pine) is covering couple of thousands of area it is accepted as forest block and this polygon is used for the stratification. Dividing them resulted in smaller data sets for analysis and this further reduced the variation and confusion between spectrally similar objects.

The next step was to visually select which of the Landsat's seven electro magnetic bands were best for discrimination of vegetation types. Bands TM 4, 5 and NDVI were chosen as they were found to provide the best results. NDVI is the most widely used index for vegetation analyses (Tucker *et al* 1986, Prince 1991, Derrien *et al* 1992). The index is calculated as a ratio between measured reflectivity in the red and near infrared portions of the electromagnetic spectrum. These two spectral bands are sensitive to the absorption of chlorophyll in leafy green vegetation, so when used with false color band combinations the NDVI provides improved detection of chlorophyll.

Supervised classification performs classification by clustering the pixels into information classes by means of training data based on probability distribution models (Favela and Tores 1998). The purpose of defining a training set is to gather statistical information on the spectral features of the vegetation. The training set is formed by using 1/100,000 forest maps, 1/25,000 forest maps, 1/25,000 topographic maps (all three maps produced by General Directorate of Forestry), and the 1:250,000 contour maps (produced by General Command of Map).

2.3.3. Classification:

Classification, in remote sensing, is assignment of particular pixel or group of homogenous pixels into a particular class. Classification was performed on the raw bands of the image by Maximum Likelihood method. Maximum Likelihood classifier is the most commonly used supervised classification method and supposed to provide better results in comparison to other supervised classification methods (Strahler 1980, Bolstad and Lillesand 1992, Foody *et al*. 1992, Deusen 1995, Maselli *et al.* 1995). Its superiority is due to its sensitivity on the shape, size, and orientation of a cluster (Shestra and Zinck 2001). Number of the classes was identified separately for the each scene.

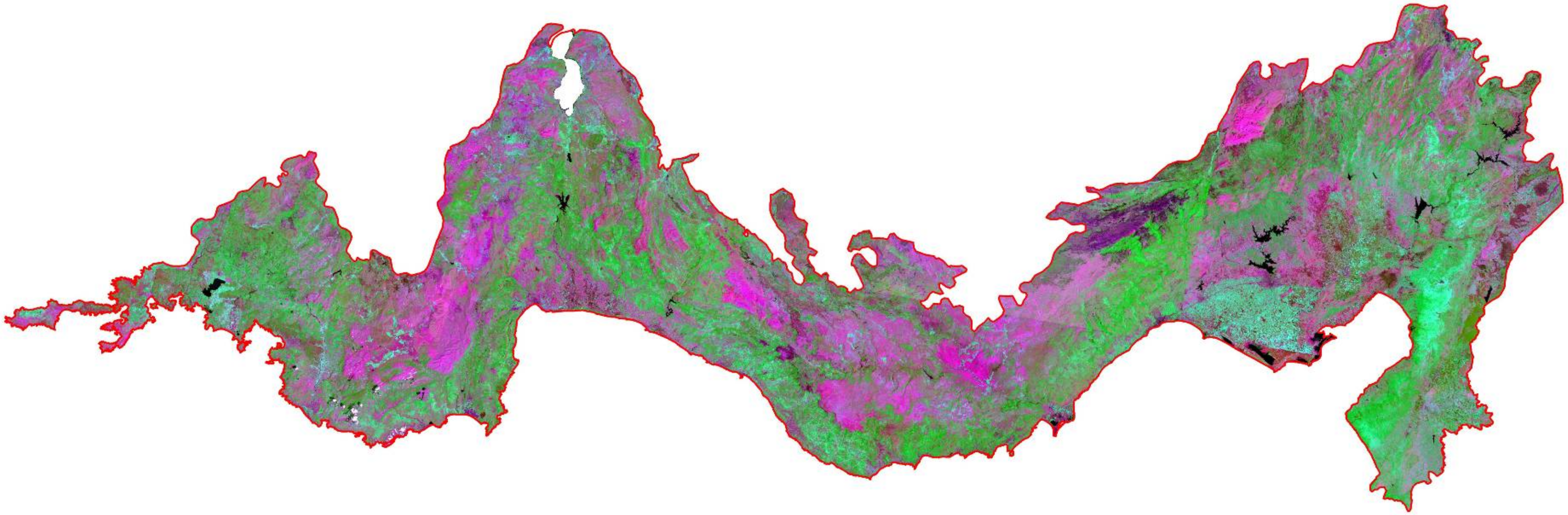

Figure 14: Map showing the composite Band 5, NDVI, Band 4 of the Landsat ETM images of the study area

2.3.4. Post-classification studies:

The geo-referencing process was carried out using 1:25,000 topographic maps. The average error (Root Mean Square Error [RMSE]) between control points and the images was two pixels – equivalent to 60 meters and considered insignificant in a study of the current study scale 1/100.000 – 1/250.000. The images were then resampled using the nearest neighborhood method.

At the end of the classification processes the classified subareas were merged to obtain the vegetation classification map of the whole Mediterranean region. The whole image was then converted to vector format and validated.

An image classification cannot be considered complete until an accuracy assessment has been performed (Tso & Mather, 2001). 'Accuracy' is defined as the level of agreement between the labels assigned by the classifier and the class allocations based on the ground data collected by the user. The most common way to represent the accuracy of a Landsat classification is through an error matrix or contingency table (Congalton *et al*, 1983). Kappa statistics were also calculated which is a discrete multivariate technique used in accuracy assessment for determining if one error matrix is significantly different from another (Congalton & Green, 1999).

Accuracy assessment is compiled through field data which was collected with the Garmin 12 Global Positioning System (GPS) unit and recorded onto standard data sheets whenever possible (see Appendix A: Vegetation Form). Additionally, some of the data were marked on the 1/25,000 topographic maps during the field surveys. After filtering out the unreliable data, the remaining 582 records were transferred to Microsoft Excel 2000.

Minimum Mapping Unit (MMU) is estimated as 100 ha. A 33x33 noise reduction filter was applied to reduce the noise. The most commonly used noise reduction technique is the Median filter, which ranks the input values from the current filter window in numerical order and assigns the median (middle) value to the output cell. Because the median value is not affected by the actual value of the noise cells, the Median filter is particularly good at removing isolated random noise. It is also better at preserving edges than other methods.

2.4. Production of the Community Map According to Developed Classification Scheme:

Vegetation map produced through classification of the Landsat ETM's were re-assessed through developed classification scheme. Resulting map can be called as community map produced through physiognomic and floristic features of the vegetation and some other physical features of the environment. Final community map can be seen through Map 17 to Map 19.

2.5. Bird Data

Birds are usually accepted as one of the best indicator groups for biodiversity and many environmental factors (Stotz 1996, Blair 1999). They are one of the most studied or preferred group due to reliability of identification, easiness of observation and quickness of survey.

Bird data were collected in relation to community types that were detected in the field. Thus they are highly suitable to check the validity of the classification scheme.

In order to collect bird data, field surveys carried out in the breeding season which is between May and June for the study region. The data were collected over surveys in 2000, 2002 and 2003. The timing was planned to coincide with the main period of breeding activity when birds are most easy to detect, and when all of the summer migrant species would have reached their breeding grounds. Additionally, individual surveys were timed to coincide with peak daily periods of activity – usually the first three hours after sunrise and the two hours before sunset. At other times of the day bird activity tends to be reduced and so the efficiency of detecting species and individuals also tends to be lower.

Within each of the study areas selected for investigation, the 'best' areas of habitat to survey were selected by eye, though on occasion the survey sites were restricted by access or the overall size of the site (i.e. more or less homogenous community type with a length long enough to walk for an hour and with a suitable breadth). The survey technique used was Timed Species Counts (TSCs) as described in (Bibby *et al.* 1998). One hour visits are made to areas of representative habitat and all bird species seen or heard are listed in the order in which they are encountered. Each survey is sub-divided into six 10 minute periods and each species is listed only once, in the first 10 minute period in which it is encountered. The concept behind this technique is that commoner species will be encountered earlier and in more surveys than rarer species and will therefore have a higher occurrence score.

As it proved impractical to carry out the recommended minimum of fifteen TSCs at each site, a minor modification was made to the technique whereby all species seen in each 10 minute period were recorded. With information on the number of 10 minute periods in which each species was recorded, it was then possible to score species from 6 to 1 according to the frequency with which it occurred (rather than at the point in the hour it was first seen). Therefore those species which occurred in every 10 minute period scored 6, whilst those that occurred in only one 10 minute period scored 1. Thus the resulting occurrence scores effectively became abundance scores and these appeared to provide a more accurate picture when relatively few surveys were carried out. The only difficulty of this variation on the technique was that there was a need for fieldworkers to be aware whether an individual bird recorded in one 10 minute period was the same as the one recorded in the next; this was particularly important with scarce species.

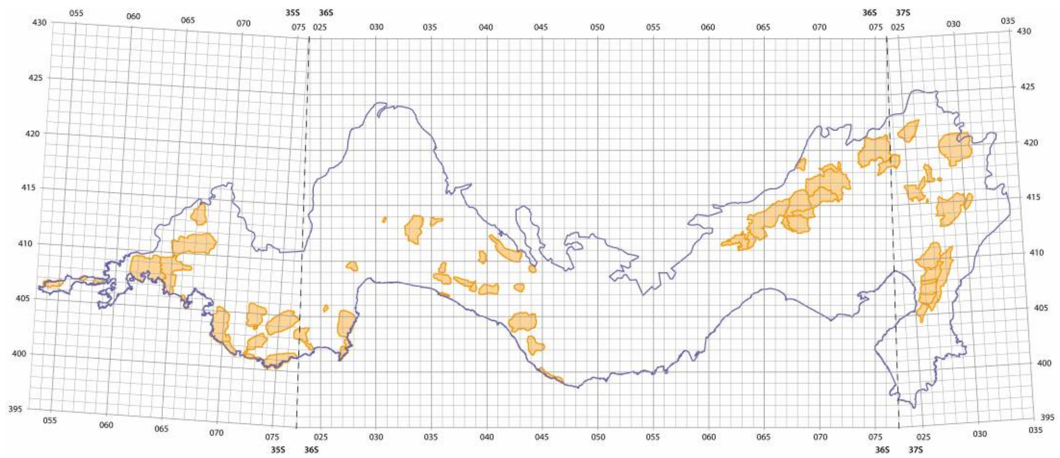

Figure 15: Field survey sites for the bird data collection

2.6. Ordination of Community Data in Relation to Bird Data

Multivariate direct analysis is compiled to examine the sites according to bird species. Detrended Correspondence Analysis is used with the PC-ORD for Windows version 4.39 (McCune et al. 1999). Detrended Correspondence Analysis is one of the eigenanalysis ordination technique based on reciprocal averaging (RA; Hill 1973, Ludwig and Reynolds, 1988). DCA implicitly uses a chi-squared distance measure (Chardy *et al*. 1976). The variables are grouped in the factors according to their eigenvalues. Large amount of variables are reduced into several features to see their overall characteristics. In PC-ORD Detrended Correspondence Analysis is performed with a modified version of DECORANA from the Cornell Ecology Program series (Hill 1979). PC-ORD applies Oksanen and Minchin's "super strict" criteria of tolerance=0.0000001 and maximum number of iterations = 999 (McCune et al. 1999).

CHAPTER 3

. RESULTS

3.1. Vegetation Map produced through LANDSAT ETM's

Final vegetation map has 22 classes with accuracy of 54,55 % (see section 3.2). There are 13 classes for the different forest types, 4 classes for the woodlands and shrublands, 1 class for the grasslands, 1 class for the agricultural areas, 2 classes for the 2 unvegetated natural areas.

Table 8: Vegetation classes and their coverage in the study area

No	Classes	Area (ha)
1	Agriculture	1525332.2
2	Anatolian Black Pine and Turkish Red Pine Forests	79886.2
3	Anatolian Black Pine and Taurus Cedar Forests	30002.5
4	Anatolian Black Pine Forest	230734.9
5	Turkish Red Pine Forest	1243461.4
6	Deciduous Oak Forest	40104.9
7	Grassland	3821890.0
8	Juniper Woodland and Shrubland	1006034.1
9	Kermes Oak and Juniper Woodland	21203.5
10	Kermes Oak Shrubland	287873.3
11	Maquis	520817.7
12	Sparse vegetation and Open Areas	881501.8
13	Oriental Beech Deciduous Oak and Hornbeam Forests	52093.3
14	Oriental Beech Forest	13418.8
15	Oriental Sweet Gum Forest	1092.4
16	Rocky Areas	7649.6
17	Taurus Cedar and Turkish Red Pine Forest	1746.6
18	Taurus Cedar and Juniper Woodland and Forest	4109.42
19	Taurus Cedar Forest	90908.58
20	Taurus Fir and Taurus Cedar Forests	52892.1
21	Taurus Fir Forest	16224.1
22	Water Bodies	15831.7
Total		9944809.1

DN values recorded for the Band 5, 4 and NDVI of the training pixels were organized and their average and standard deviation were recorded. Band 5 has relatively higher standard deviation. Classes with the lower number of sample pixels such as Water, Turkish Red Pine – Anatolian Black Pine have much lower standard deviations.

Table 9: Average and standard deviation of the DN values of the Band 5, NDVI, Band 4 for the training pixel

Type	Function	Band 5	NDVI	Band 4
Bare Area	Average	202,54	-26,03	105,15
	Standard Deviation	52,74	4,52	27,92
Anatolian Black Pine	Average	61,13	5,16	58,85
	Standard Deviation	17,25	9,64	7,48
Anatolian Black Pine Young	Average	118,3	-3,44	73,67
	Standard Deviation	16,80	9,59	8,67
Anatolian Black Pine-Taurus Cedar	Average	84,82	-6,28	62,43
	Standard Deviation	32,37	5,28	9,97
Juniper	Average	133,24	-14,42	74,29
	Standard Deviation	29,076	6,72	12,02
Kermes Oak	Average	118,15	-11,35	75,15
	Standard Deviation	20,56	5,22	8,05
Maquis	Average	89,35	8,61	78,3
	Standard Deviation	19,99	21,98	22,96
Oak	Average	122,78	-13,89	74,89
	Standard Deviation	16,31	4,4	6,13
Sparse Vegetation	Average	179,91	-18,31	89,39
	Standard Deviation	24,82	5,19	11,45
Taurus Cedar	Average	80,21	3,56	68,87
	Standard Deviation	29,32	4,26	13,57
Taurus Fir	Average	56,44	17,21	68,72
	Standard Deviation	11,06	11,14	11,28
Taurus Fir-Taurus Cedar	Average	62,44	12,04	60,32
	Standard Deviation	23,75	10,17	11,68
Turkish Red Pine All	Average	70,41	1,13	58,17
	Standard Deviation	20,89	7,24	8,35
Turkish Red Pine	Average	66,09	2,5	57,78
	Standard Deviation	14,03	5,96	8,25
Turkish Red Pine Young	Average	112,3	-10,3	65,7
	Standard Deviation	17,83	4,11	5,44
Turkish Red Pine2	Average	83,21	-3,69	58,4
	Standard Deviation	32,41	9	8,86
Turkish Red Pine - Anatolian Black Pine	Average	62	12,5	60,5
	Standard Deviation	5,66	2,12	3,54
Water	Average	23,5	-29,5	19
	Standard Deviation	2,12	13,44	0

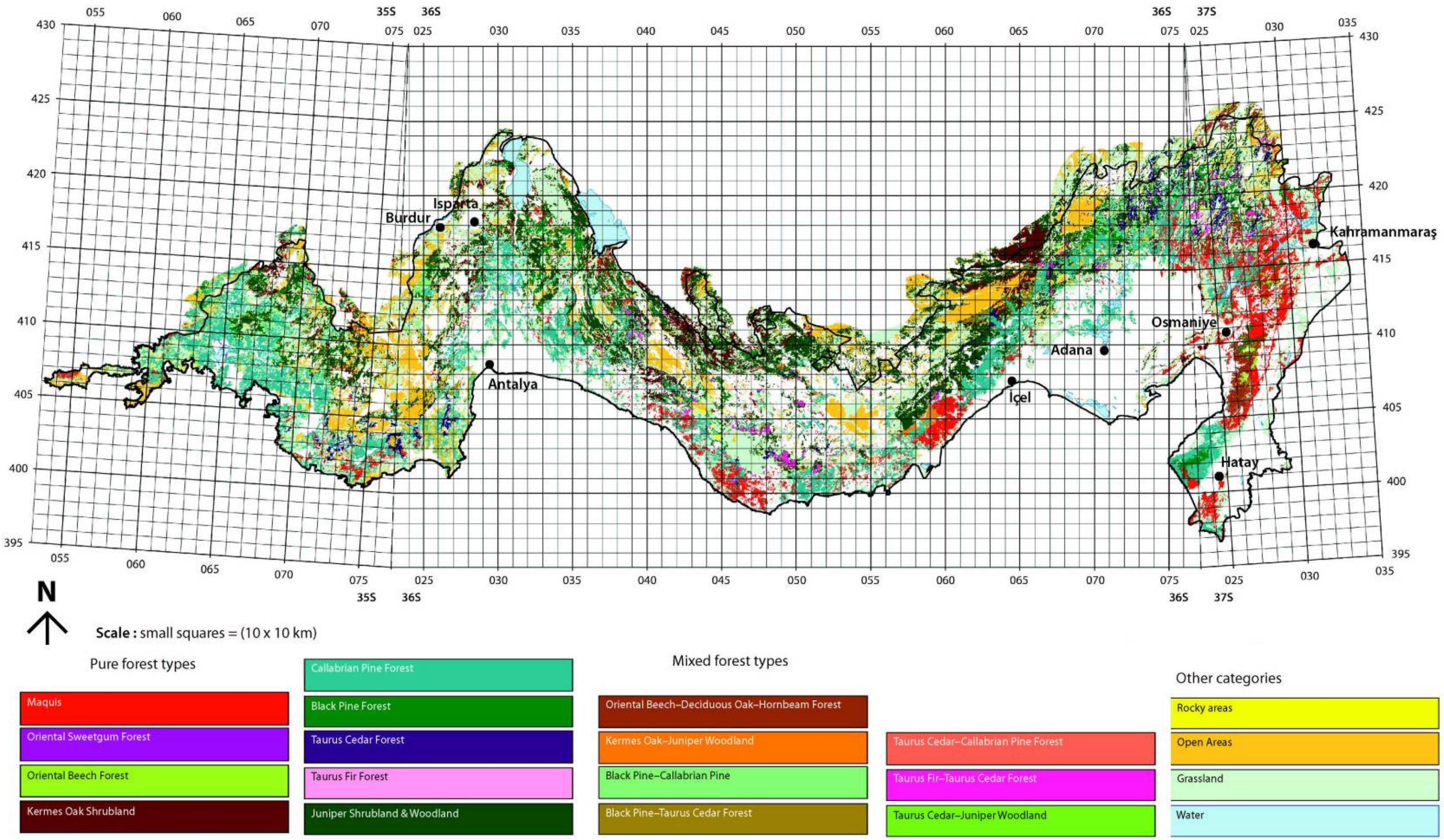

Figure 16: Vegetation Map of the Mediterranean Region of Turkey produced through classification with the Landsat ETM’

3.2. Accuracy Assessment

Resulting vegetation classification with the Landsat ETM's has 54.55 % overall accuracy. Kappa statistics is even lower than the overall accuracy 50.37 %

Table 11 shows the accuracy of the classification for each class obtained from the vegetation classification and the overall accuracy. Although some of the classes are at the physiognomic class level (e.g. Grassland) and some at the physiognomic group level (e.g. maquis), in general classes can be accepted at the alliance and formation levels, especially for the 'Class Forest'.

Kermes Oak Shrubland, Kermes Oak-Juniper Woodland, Deciduous Oak Forest, Taurus Fir-Cedar Forest, Anatolian Black Pine-Cedar Forest, Anatolian Black Pine Forest, Anatolian Black Pine-Turkish Red Pine Forest, Turkish Red Pine Forest, Cedar-Juniper Forest have accuracies lower than overall accuracy.

Further accuracy assessment was carried out by combining the classes according to hierarchy of the proposed classification scheme. The values of the accuracy assessment for the different levels of the classification scheme were given in the Table 10. According to physiognomic class level forest, woodland, shrubland, grassland, non-vascular types has to be studied. Existing groups were classified according to these types (Table 12). In the physiognomic subclass level evergreen, deciduous, mixed evergreen-deciduous types were used to group the classes of the vegetation classification (Table 13). In the physiognomic group level needle-leaved, broad-leaved, mixed needle-broad-leaved types were used to group the classes of the vegetation classification (Table 14).

Table 10: Results of the accuracy assessment according to different levels of the classification system.

Level of the Classification	Overall	Kappa
Physiognomic Class	69,04%	50,45%
Physiognomic Subclass	65,00%	54,17%
Physiognomic Group	56,75%	48,05%
Physiognomic Formation/Alliance	54,55%	50.37%

Table 11: Error matrix assessing the accuracy of the vegetation classification

Classified Data \ Reference Data	Grassland	Juniper	Mixed Dec. Forest	Anatolian Black Pine	Maquis	Cedar	T. Fir- Cedar	Sparse Veg.	B.Pine-C.Pine	Taurus Fir	B.Pine-Cedar	Cedar-C.Pine	Kermes Oak	Turkish Red Pine	Cedar-Juniper	Dec. Oak	Water	Kermes Oak-Junip.	Total	User's Accuracy
Grassland	25	8	0	7	2	1	0	1	1	0	4	0	7	20	0	9	0	1	86	29,70%
Juniper	3	18	0	5	1	2	2	0	0	0	1	0	0	4	0	2	0	3	41	43,90%
Mixed Dec. Forest	1	0	12	2	0	2	0	0	0	1	0	0	0	2	1	9	0	0	30	40,00%
Anatolian Black Pine	0	1	1	24	0	2	1	0	1	1	4	0	1	1	1	0	0	0	38	63,16%
Maquis	0	0	1	5	23	1	3	0	0	1	0	0	7	6	1	10	0	0	58	39,66%
Cedar	0	0	1	1	0	15	1	0	0	0	2	0	0	0	0	0	0	0	20	75,00%
T. Fir- Cedar	0	0	0	0	0	0	7	0	0	2	1	0	0	0	0	1	0	0	11	63,64%
Sparse Veg.	0	0	0	1	1	1	0	3	0	0	0	0	1	0	0	0	0	0	7	42,86%
B.Pine-C.Pine	0	0	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	4	75,00%
Taurus Fir	0	1	0	0	0	1	0	0	0	9	0	0	0	0	0	0	0	0	11	81,82%
B.Pine-Cedar	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	6	100,00%
Cedar-C.Pine	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	100,00%
Kermes Oak	0	0	0	0	2	0	0	0	0	0	0	0	12	0	0	0	0	0	14	85,71%
Turkish Red Pine	1	1	0	0	1	2	0	0	1	0	0	1	2	39	0	1	0	1	50	78,00%
Cedar-Juniper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3	100,00%
Dec. Oak	0	0	3	1	0	0	1	0	0	0	0	0	0	0	0	16	0	0	21	76,19%
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	100,00%
Kermes Oak-Juniper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	100,00%
Total	30	29	18	47	30	27	15	4	6	14	18	2	30	72	6	48	3	8	407	
Producer's Accuracy (%)	83,33	62,07	66,67	51,06	76,67	55,56	46,67	75,00	50,00	64,29	33,33	50,00	40,00	54,17	50,00	33,33	100	37,5		

Overall accuracy: 54,55% Kappa Statistic: 50.37%

Table 12: Error matrix assessing the accuracy of the vegetation classification in the Physiognomic Class level

Reference Data									
Classified Data		Forest	Woodland	Shrubland	Grassland	Sparse Veg.	Water	Total	User's Accuracy (%)
	Forest	185	3	5	2	0	0	195	94,87
	Woodland	16	18	4	3	0	0	41	43,90
	Shrubland	28	0	47	0	0	0	75	62,67
	Grassland	42	8	10	25	1	0	86	29,07
	Sparse	2	0	2	0	3	0	7	42,86
	Water	0	0	0	0	0	3	3	100,00
	Total	273	29	68	30	4	3	407	
	Producer's Accuracy (%)	67,77	62,07	69,12	83,33	75,00	100,00		
		Overall 69,04%			Kappa 50,45%				

Table 13: Error matrix assessing the accuracy of the vegetation classification in the Physiognomic Subclass level

Classified Data	Reference Data									
	Forest Evergreen	Forest Deciduous	Woodland Evergreen	Shrubland Evergreen	Mixed	Grassland	Sparse Veg.	Water	Total	User's Accuracy
Forest Evergreen	131	4	3	4	1	1	0	0	144	0,91
Forest Deciduous	10	40	0	0	0	1	0	0	51	0,78
Woodland Evergreen	14	2	18	1	3	3	0	0	41	0,44
Shrubland Evergreen	17	11	0	44	0	0	0	0	72	0,61
Mixed	0	0	0	0	3	0	0	0	3	1,00
Grassland	33	9	8	9	1	25	1	0	86	0,29
Sparse Veg.	2	0	0	2	0	0	3	0	7	0,43
Water	0	0	0	0	0	0	0	3	3	1,00
Total	207	66	29	60	8	30	4	3	407	
Producer's Accuracy	0,63	0,61	0,62	0,73	0,38	0,83	0,75	1,00		
	Overall Accuracy 65,00%			Kappa Statistics 54,17%						

Table 14: Error matrix assessing the accuracy of the vegetation classification in the Physiognomic Group level

Classified Data \ Reference Data	Forest Evergreen Needle-leaved	Forest Evergreen Mixed Needle-Leaved	Forest Deciduous Broad-leaved	Forest Deciduous Mixed Broad-leaved	Woodland Evergreen Needle-leaved	Shrubland Evergreen Broad-levaed	Shrubland Evergreen Mixed Broad-levaed	Shrubland Evergreen Mixed	Grassland	Sparse Veg.	Water	Total	User's Accuracy
Forest Evergreen Needle-leaved	95	12	1	2	3	3	1	1	1	0	0	119	79,83
Forest Evergreen Mixed Needle-Leaved	3	21	1	0	0	0	0	0	0	0	0	25	84,00
Forest Deciduous Broad-leaved	1	1	16	3	0	0	0	0	0	0	0	21	76,19
Forest Deciduous Mixed Broad-leaved	7	1	9	12	0	0	0	0	1	0	0	30	40,00
Woodland Evergreen Needle-leaved	11	3	2	0	18	0	1	3	3	0	0	41	43,90
Shrubland Evergreen Broad-levaed	0	0	0	0	0	12	2	0	0	0	0	14	85,71
Shrubland Evergreen Mixed Broad-levaed	13	4	10	1	0	7	23	0	0	0	0	58	39,66
Shrubland Evergreen Mixed	0	0	0	0	0	0	0	3	0	0	0	3	100,00
Grassland	28	5	9	0	8	7	2	1	25	1	0	86	29,07
Sparse Veg.	2	0	0	0	0	1	1	0	0	3	0	7	42,86
Water	0	0	0	0	0	0	0	0	0	0	3	3	100,00
Total	160	47	48	18	29	30	30	8	30	4	3	407	
Producer's Accuracy (%)	59,38	44,68	33,33	66,67	62,07	40,00	76,67	37,50	83,33	75,00	100,00		

Overall Accuracy 56,75% Kappa Statistics 48,05%

3.3. Proposed Physiognomic-Floristic Classification Standard

USNVCS (FGDC 1997, 2004, Grossman 1998) physiognomic-floristic classification system is used as a basis to develop a similar classification system for Turkey. Its hierarchy and the classes are revisited according to bird data, vegetation classification with the Landsat ETM's and general features of Turkey. According to proposed changes and modifications resulting system has:

- 5 Supraclasses (nonvascular and bare area were considered only for the supraclass level)
- 6 Classes (without nonvascular and abre area types)
- 3 Subclasses for tree and shrub dominated
- 3 Subclasses for herb dominated
- 3 Groups for tree and shrub
- 3 Groups for herb dominated
- 2 Subgroups for tree, shrub and herb dominated
- 5 Formations for tree, shrub and herb dominated

Table 15 and Table 16 show the resulting hierarchy and the classes of the proposed system.

Table 15: Hierarchy of the proposed physiognomic-floristic classification system

Supraclass	**TD. Tree dominated**
Class	A. Forest, B. Woodland
Subclass	I. Evergreen, II. Deciduous, III. Mixed
Group	1. Needle-leaved, 2. Broad-leaved, 3. Mixed
Subgroup	a. Natural/Semi-natural, b. Cultivated
Formation	i. Coastal, ii. Colline, iii. Montane, iv. Subalpine, v. Alpine
Supraclass	**SD. Shrub dominated**
Class	A. Tall shrubland, B. Dwarf Shrubland
Subclass	I. Evergreen, II. Deciduous, III. Mixed
Group	1. Needle-leaved, 2. Broad-leaved, 3. Mixed
Subgroup	a. Natural/Semi-natural, b. Cultivated
Formation	i. Coastal, ii. Colline, iii. Montane, iv. Subalpine, v. Alpine

Table 15 cont'd

Supraclass	**HD. Herb dominated**
Class	A. Forb, B. Graminoid
Subclass	I. Tall Dense, II. Short Dense, III. Short Sparse
Group	1. No woody cover, 2. Sparse tree cover, 3. Sparse shrub cover
Subgroup	a. Natural/Semi-natural, b. Cultivated
Formation	i. Coastal, ii. Colline, iii. Montane, iv. Subalpine, v. Alpine
Supraclass	**NV. Non Vascular**
Supraclass	**BA Bare Area (Non-vegetated)**

Table 16: Classes of the proposed physiognomic-floristic classification system

Physiognomic Supraclass	**Tree Dominated**
Physiognomic Class	**A. Forest**
Physiognomic Subclass	I. Evergreen II. Deciduous III. Mixed Evergreen-Deciduous
Physiognomic Group	1. Broad-leaved 2. Needle-leaved 3. Mixed
Physiognomic Subgroup	a. Natural/Semi Natural b. Planted/Cultivated
Physiognomic Formation	i. Coastal ii Colline iii. Montane iv. Subalpine v Alpine
Alliance	First floristic level determined according to dominant species
Association	Second floristic level determined according to associated species

Table 16 cont'd

Physiognomic Class	Woodland
Physiognomic Subclass	I. Evergreen II. Deciduous III. Mixed Evergreen-Deciduous
Physiognomic Group	1. Broad-leaved 2. Needle-leaved 3. Mixed
Physiognomic Subgroup	a. Natural/Semi Natural b. Planted/Cultivated
Physiognomic Formation	i. Coastal ii Colline iii. Montane iv. Subalpine v Alpine
Alliance	First floristic level determined according to dominant species
Association	Second floristic level determined according to associated species
Physiognomic Supraclass	**Shrub Dominated**
Physiognomic Class	**Shrubland**
Physiognomic Subclass	I. Evergreen II. Deciduous III. Mixed Evergreen-Deciduous
Physiognomic Group	1. Broad-leaved 2. Needle-leaved 3. Mixed
Physiognomic Subgroup	a. Natural/Semi Natural b. Planted/Cultivated
Physiognomic Formation	i. Coastal ii Colline iii. Montane iv. Subalpine v Alpine
Alliance	First floristic level determined according to dominant species
Association	Second floristic level determined according to associated species

Table 16 cont'd

Physiognomic Class	Dwarf Shrubland
Physiognomic Subclass	I. Evergreen II. Deciduous III. Mixed Evergreen-Deciduous
Physiognomic Group	1. Broad-leaved 2. Needle-leaved 3. Mixed
Physiognomic Subgroup	a. Natural/Semi Natural b. Planted/Cultivated
Physiognomic Formation	i. Coastal ii Colline iii. Montane iv. Subalpine v Alpine
Alliance	First floristic level determined according to dominant species
Association	Second floristic level determined according to associated species
Physiognomic Supraclass	**Herb Dominated**
Physiognomic Class	**Forb**
Physiognomic Subclass	I. Tall Dense II. Short Dense III. Short Sparse
Physiognomic Group	1. No woody cover 2. Sparse tree cover 3. Sparse shrub cover
Physiognomic Subgroup	a. Natural/Semi Natural b. Cultivated
Physiognomic Formation	i. Coastal ii Colline iii. Montane iv. Subalpine v Alpine
Alliance	First floristic level determined according to dominant species
Association	Second floristic level determined according to associated species

Table 16 cont'd

Physiognomic Class	Graminoid
Physiognomic Subclass	I. Tall Dense II. Short Dense III. Short Sparse
Physiognomic Group	1. No woody cover 2. Sparse tree cover 3. Sparse shrub cover
Physiognomic Subgroup	a. Natural/Semi Natural b. Cultivated
Physiognomic Formation	i. Coastal ii Colline iii. Montane iv. Subalpine v Alpine
Alliance	First floristic level determined according to dominant species
Association	Second floristic level determined according to associated species
Physiognomic Supraclass	**Non-Vascular Dominated**
Physiognomic Supraclass	**Bare Area (Non-Vegetated)**

3.4. Community Map produced According to Classification Standard

After the vegetation map is processed according to classification scheme resulting community maps were created based on the seven hierarchical categories of the classification scheme.

Detected classes and maps according to each hierarchical level are shown in the following maps.

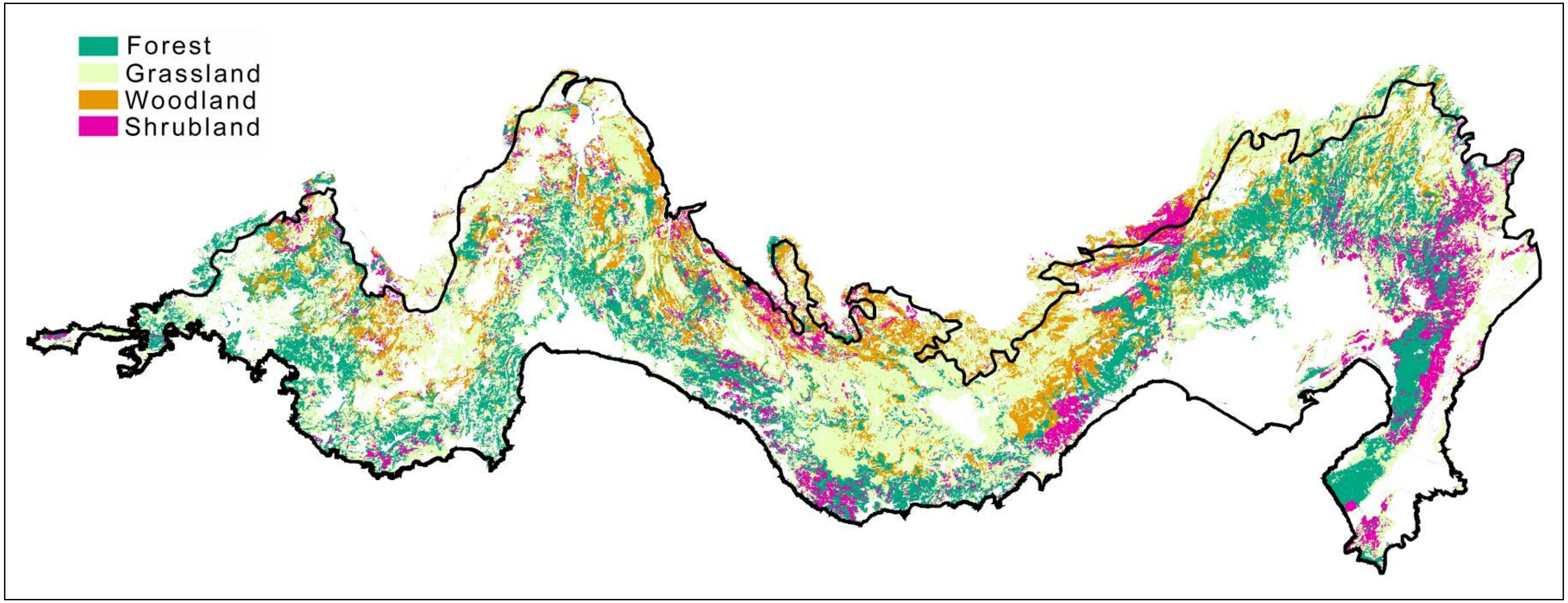

Figure 17: Community map according to second level (i.e. physiognomic class) of the classification scheme

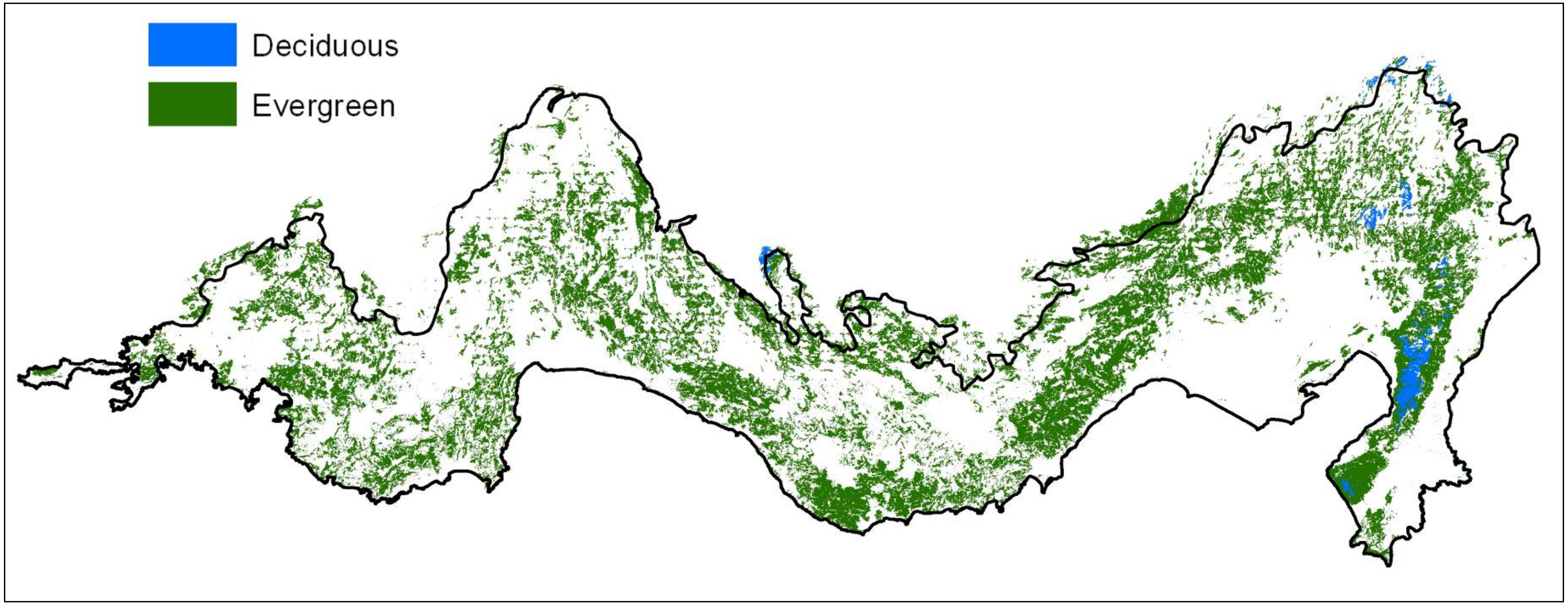

Figure 18: Community map according to third level (i.e. physiognomic subclass) of the classification scheme

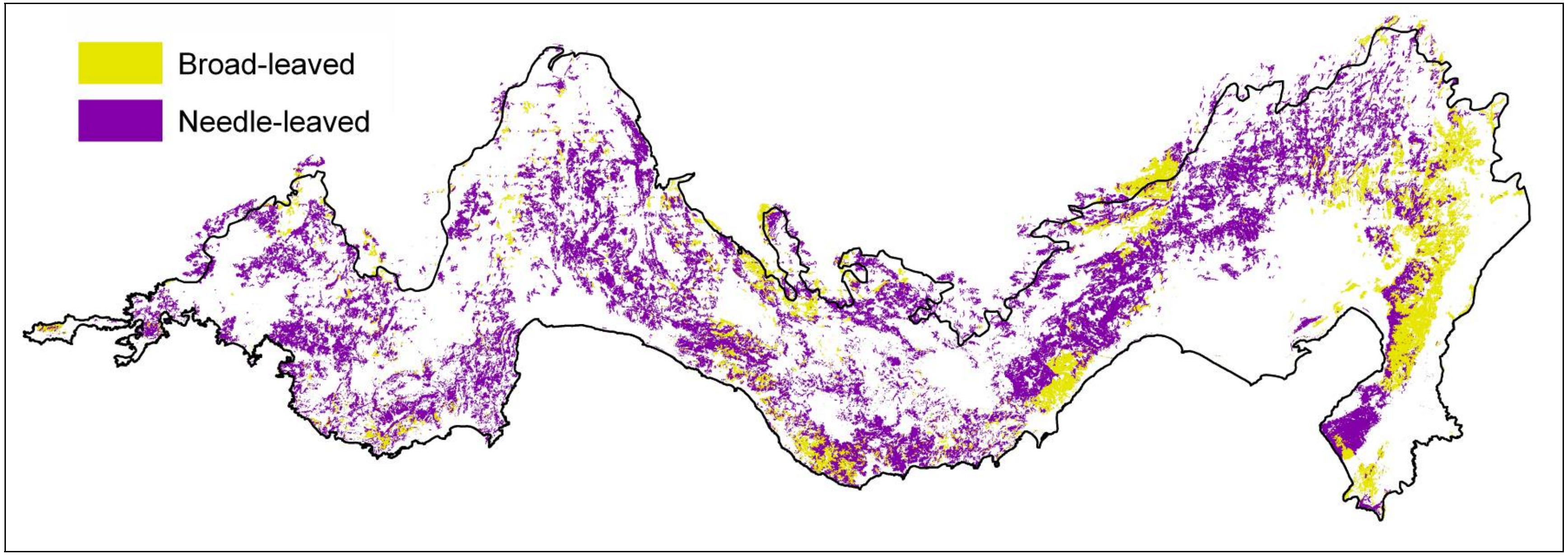

Figure 19: Community map according to fourth level (i.e. physiognomic group) of the classification scheme

3.5. Bird Data

Bird data are collected according to community types identified in the field. 193 ecological communities were sampled at 83 sites. 121 bird species were recorded during the bird surveys. The list of bird species recorded is given in Appendix F.

Table 17-20 gives scores of the bird species richness, evenness, and diversity for the top ten sites. Scores for all sites are given in Appendix G. The Giden Gelmez Mountains alpine community with sparse juniper trees was the richest site in terms of breeding birds. The second richest site was an oak shrubland community at Bozkır, close to Seydişehir. Three herb dominated, four woodland, and three forest communities comprise the top ten sites. There is some indication that a positive relationship exists between open spaces and breeding bird richness.

In terms of evenness the Çığlıkara herb dominated montane community appeared as the most even site. Next three most even sites are maquis communities.

Table 17: Top 10 species richness sites according to breeding bird data

Site No.	Site Code	Site Name	Species Richness	Evenness	Shannon-Weaver Index	Simpson's Diversity Index
164	Gi3GhMi	Giden Gelmez Mountains	27	0.973	3.206	0.9555
169	Bo4WDbMo	Bozkır-Seydişehir	26	0.971	3.162	0.9536
145	Ol1FEnMe	Olimpos National Park	23	0.966	3.027	0.9458
89	Cg6GhMi	Sandıras Mountains Çiçekbaba	23	0.965	3.025	0.9455
167	Bo2WEnMf	Bozkır-Seydişehir	22	0.966	2.984	0.9439
92	Ib1WEnOj	İbradı	20	0.983	2.943	0.9448
106	Ki4FDbCq	Köyceğiz, Kavakarası	20	0.978	2.930	0.9430
150	Ey1FEnOn	Eynif-Kavanozdağı	20	0.967	2.897	0.9395
90	Al5WEnMj	Alacadağ-Sarıalan	20	0.948	2.839	0.9317
4	Al1GwMi	Alacadağ	19	0.982	2.891	0.9418

Table 18: Top 10 sites according to Evenness of the breeding bird species data

Site No.	Site Code	Site Name	Species Richness	Evenness	Shannon-Weaver Index	Simpson's Diversity Index
3	Cg7GspMi	Çığlıkara Nature Reserve	17	0.991	2.807	0.9381
129	Ks4SEsCm	Kaş	6	0.991	1.775	0.8276
144	Cv1SEsCa	Çavuşköy Markiz Dağı	8	0.989	2.057	0.8693
117	Gz1SEsCk	Gazipaşa, Gıcıt-Anıtlı	3	0.987	1.084	0.6569
158	Ce4GhAi	Cevizli-Kuyucak	9	0.986	2.166	0.8813
51	Ek1FEnMc	Eski Söğüt Yolu	14	0.984	2.597	0.9224
118	Dm1SEsMm	Gülnar, Damalanı	14	0.984	2.596	0.9224
92	Ib1WEnOj	İbradı	20	0.983	2.943	0.9448
4	Al1GwMi	Alacadağ	19	0.982	2.891	0.9418
152	Ar4SEmOu	Akseki, Ürünlü	6	0.982	1.760	0.8229

According to the Shannon-Weaver index, the Köprülü Kanyon National Park evergreen colline Turkish Red Pine community is the most diverse site. The second most diverse site is again a Turkish Red Pine community but a coastal one. Five forest, three woodland, and three herb dominated communities make up the top ten sites

Table 19: Top 10 sites according to Shannon-Weaver Diversity Index of the breeding bird species data

Site No.	Site Code	Site Name	Species Richness	Evenness	Shannon-Weaver Index	Simpson's Diversity Index
41	Ko1FEnOc	Köprülü Kanyon National Park	3	0.873	0.960	0.5823
39	Ol4FEnCc	Olimpos National Park	2	0.979	0.678	0.4853
164	Gi3GhMi	Giden Gelmez Mountains	27	0.973	3.206	0.9555
169	Bo4WDbMo	Bozkır-Seydişehir	26	0.971	3.162	0.9536
145	Ol1FEnMe	Olimpos National Park	23	0.966	3.027	0.9458
89	Cg6GhMi	Çığlıkara Nature Reserve	23	0.965	3.025	0.9455
167	Bo2WEnMf	Bozkır-Seydişehir	22	0.966	2.984	0.9439
92	Ib1WEnOj	İbradı	20	0.983	2.943	0.9448
106	Ki4FDbCq	Köyceğiz, Kavakarası	20	0.978	2.930	0.9430
150	Ey1FEnOn	Eynif-Kavanozdağı	20	0.967	2.897	0.9395

According to Simpson's Diversity index, the Giden Gelmez Mountains montane grassland with sparse shrub community site is the most diverse one. Three forest, four woodland and three herb dominated communities comprise the top ten sites.

Table 20: Top 10 sites according to Simpson's Diversity Index of the breeding bird species data

Site No.	Site Name	Site Code	Species Richness	Evenness	Shannon-Weaver Index	Simpson's Diversity Index
164	Gi3GhMi	Giden Gelmez Mountains	27	0.973	3.206	0.9555
169	Bo4WDbMo	Bozkır-Seydişehir	26	0.971	3.162	0.9536
145	Ol1FEnMe	Olimpos National Park	23	0.966	3.027	0.9458
89	Cg6GhMi	Çığlıkara Nature Reserve	23	0.965	3.025	0.9455
92	Ib1WEnOj	İbradı	20	0.983	2.943	0.9448
167	Bo2WEnMf	Bozkır-Seydişehir	22	0.966	2.984	0.9439
106	Ki4FDbCq	Köyceğiz, Kavakaras	20	0.978	2.930	0.9430
4	Al1GwMi	Alacadağ	19	0.982	2.891	0.9418
20	Ak2WEnMb	Akdağ, Çamköy	19	0.981	2.888	0.9409
78	Ko5FEmOn	Köprülü Kanyon National Park	19	0.978	2.879	0.9403

3.6. Test of Classification System's Categories and Hierarchy with the Bird Data

Multivariate direct analysis is carried out to examine the sites according to bird species. In Detrended Correspondence Analysis (DCA) the variables are grouped in the factors according to their eigenvalues. The total eigenvalue for the analysis is 3.661, and the first three axes have eigenvalues of 0.478, 0.321 and 0.237, respectively. Coefficients of determination for the correlations between ordination distances and distances in the original n-dimensional space (R^2) range between 0.197-0.409 for the first, 0.120-0.199 for the second, and 0.036-0.032 for the third axis, using chi-squared and correlation distances, respectively. This means especially the first two axes have higher descriptive power. Ordination results are given for class, subclass and formation levels of the classification hierarchy (Figures 17-19):

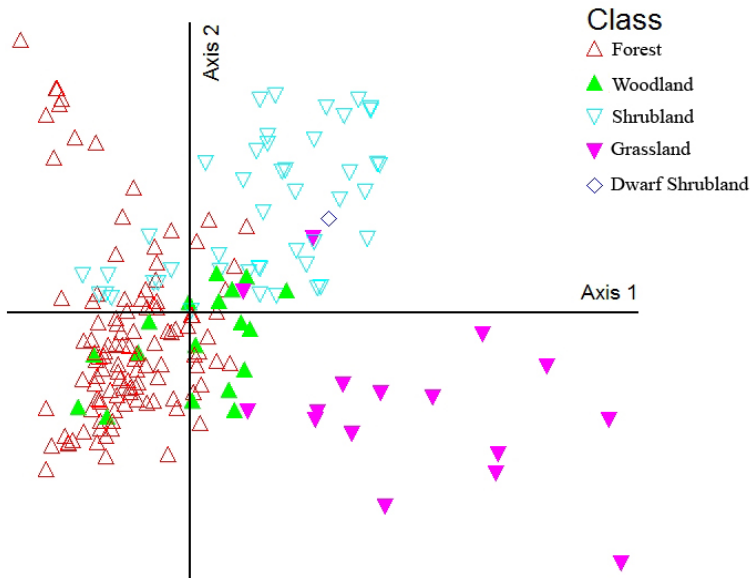

Figure 20: Detrended Correspondence analysis of the bird species-vegetation type data in the class level according to axis 1-2

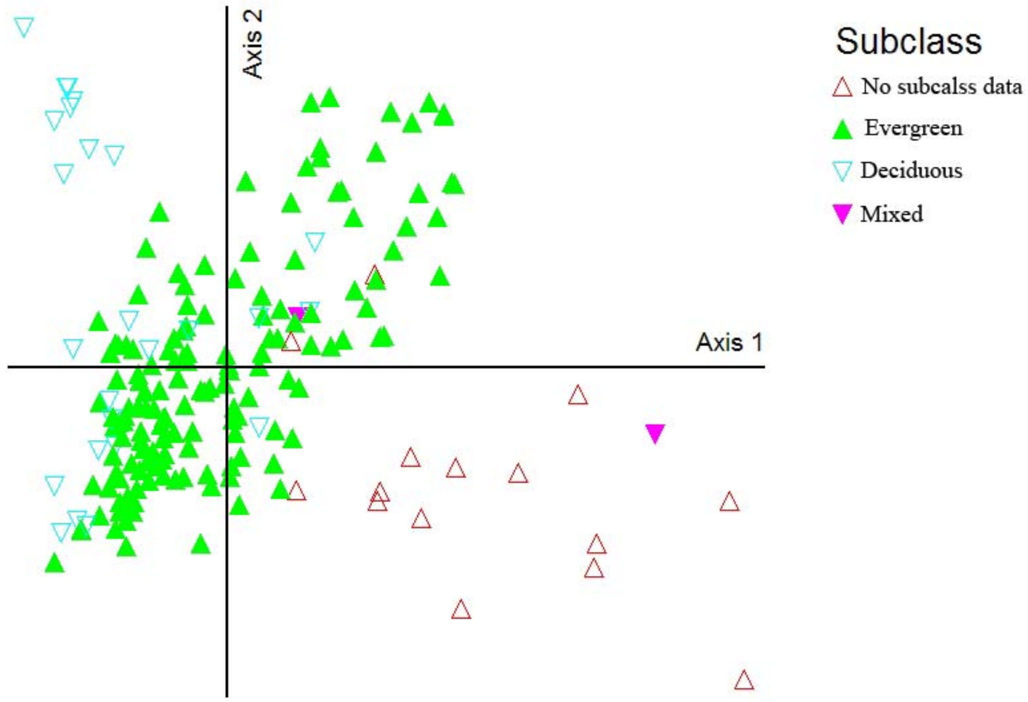

Figure 21: Detrended Correspondence analysis of the bird species-vegetation type data in the subclass level according to axis 1-2

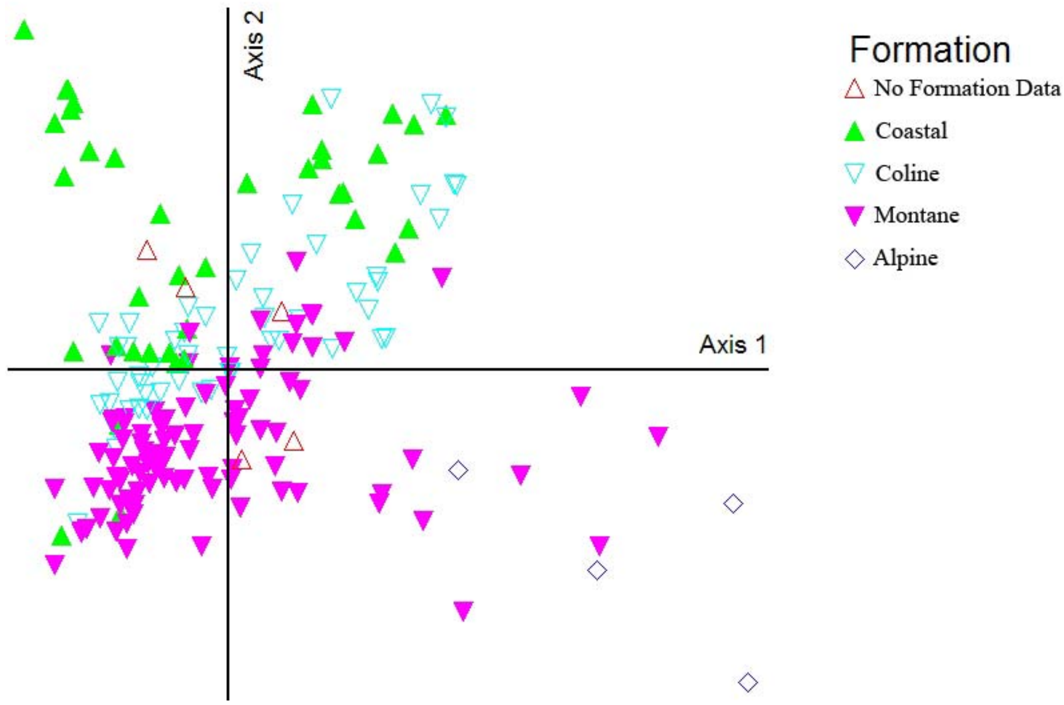

Figure 22: Detrended Correspondence analysis of the bird species-vegetation type data in the formation level according to axis 1-2

CHAPTER 4

DISCUSSION

4.1. Comparison of the terms: habitat, ecosystem, vegetation, community

Many ecologists have expressed concern that progress in ecology has been insufficient (Wilkinson 1998, Austin 1999, O'Connor 2000, Swihart *et al*. 2002). Among the most compelling, Austin (1999) suggests that progress is limited by fundamental inconsistencies between paradigms within ecology. There are still considerable overlaps in definition and use of the major terms such as habitat, ecosystem, community and vegetation (Udvardy 1959, Davis 1960, Mitchell 2005). Hence, this issue is a key to classification purposes as the ecological units were named and classified differently regarding to usage of any of the above terms.

Although the ecosystem concept becomes more critical for natural resource managers (Bailey 1976, Society of American Foresters 1993, Wood 1994, Jennings 1995, Alverson 2004), due to its easily detectable spatial features, the community concept becomes a central issue for conservation planners (Scott *et al.* 1993, Parker 2004, ESA 1932) as it associates with the purpose of the conservation biology, protecting the living things.

However both terms has been used interchangeably for the same meaning. On the other hand, there are other terms, that when the issue comes to classification, creates confusion and has been used interchangeably by many researchers such as vegetation and habitat. In this section these terms and misuse of them will be addressed briefly for the classification purpose. In that respect two of the suggested features of the classification systems has to be considered: Inclusiveness and functionality in different scales.

Ecosystem classification is one of the most used terms (see Ellenberg 1973, Walter 1976, USDA Forest Service 1992, Driscol *et al*. 1984) and it can be traced back to Dokuchaev

(1898). This famous term of ecology that was coined by Tansley 1935, is defined as all of the interacting parts of the physical and biological world (Tansley 1935, Lindeman 1942, Odum 1971, Whittaker 1975). According to Kimmins (1997) the concept has five attributes; 1) Structure, 2) Functionality, 3) Complexity, 4) Interaction and interdependence, 5) Temporality. Ecosystem classification is adopted and widely used by the natural resource managers due to its size that fits well with the practical and applicable planning units and its functionality that fits with the planning purposes (Krajina 1965, Bailey 1976, 1995, Driscoll *et al*. 1984, Miller 1978, Keys *et al*. 1996).

Kimmins (1997) underlines that ecosystem classification in which classes are explicitly defined according to climatic, soil, geological, landforms and vegetation is much more suitable for the natural resource management purposes when compared to the classification system solely based on the vegetation.

However, for ecological and conservation purposes, an ecosystem classification may stay coarse if vegetation is not used widely, especially in the lower ranks of the system. In such a situation, the classification system may not help differentiate the dominance types within a continuum of vegetation, which is usually accepted as an important feature for the conservation and natural resource management purposes.

Community is defined as an association of interacting populations (plant, animal and microbial). Whitaker (1975) defines community as an 'assemblage of plants, animals, bacteria and fungi that lives in an environment and interacts with one another, forming a distinctive living system with its own composition, structure, environmental relations, development and function.

One clear distinction between ecosystem and community concept is the exclusion of the physical environment in the community concept. Lack of floristic information in the ecosystem classification is another difference in the usage of the terms in the classification. However, this does not prevent the misuse of two terms interchangeably. One of the reasons is both terms use more or less similar features such as vegetation, climate, soil etc. in the classification system. Main difference appears to be weight in use of these criteria.

Community classification appears to be the more inclusive for the conservation purposes and when a more detailed classification is required. There are conservation institutions like The Nature Conservancy or World Wide Fund for Nature, that use community as main theme of their studies (see Maybury edi. 1999, Grossman *et al*. 1998). It could help to identify smaller units such as alliance and association that are the main units of the floristic classification systems. However, in most of the community classification schemes physical parameters were used in the lower ranks (e.g. formation) of the classification system and this is another reason of the misuse of the terms ecosystem and community.

The term habitat by itself bears so many discussions. Mitchell (2005) states that 'there does nor exist any authoritative definition'. The term habitat is misused in place of niche (Udvardy, 1959), ecosystem (Mitchell 2005, Davis 1960), community (Mitchell 2005). However, when the current definitions and approaches about the habitat concept are investigated, it is likely that one of the terms that is most ambiguous is ecosystem. One aspect of the habitat is described as 'environment in its physical and chemical aspects' (Whittaker 2005). Mitchell (2005) found this definition too narrow and introduced the biotic component, which increases the amount of overlap with the ecosystem term. Another definition of the term described as 'standing place' or 'living space' by Looijen (1995) is more useful to make a clear distinction between the ecosystem and habitat terms.

However it is widely used in identification of the distribution of the species. It is mostly expressed through either physical environment (i.e. north faced cliffs, sand dune etc.) or vegetation/ecosystem type (i.e. broad-leaved forest ecosystem, oriental beech forest etc.). Especially zoologists working at the species level use the habitat terms so generally that this may potentially create confusion with the ecosystem and vegetation terms. Habitat classification is much more used for the specific purpose of explaining species distributions. It will not be inclusive for the large areas and more general purposes.

Vegetation is simply described as the plant cover of any region. Vegetation is widely used to describe the area of interest as generally vegetation cover is the most prominent feature of the earth. Vegetation classification system will be failing to inclusively cover the areas that are non-vegetated, which could be an important feature for management purposes. However confusion between terms, vegetation, community and the ecosystem are high, as in community and ecosystem classification vegetation is used as one of the main descriptive feature.

When the inclusiveness is considered ecosystem and community appears as the most suitable terms. Both of them were widely used to express ecological classification systems. On the other hand in regard to above explanations, community appears to be the more appropriate term to express the classification type especially for the conservation purposes. Thus, it is proffered to use community term in this study.

4.2. Vegetation Classification with LANDSAT ETM's

Overall accuracy of the classification is 54,55% and Kappa Statistic is 50,37%. These moderate values can be explained by errors occurred during preparation of training pixels, the age of the data, the quality of the ancillary data and detailed classes of the final map.

However, when these results are examined it can be concluded that in large area mapping (scale *circa* greater than 1/100.000) alliance level mapping with the Landsat ETM does not provide satisfactory results regarding the number and types of classes and accuracy. On the other hand, formation level classification is too coarse as with good ancillary data and DEM some of the alliances can be easily detected.

It is worth discussing some of the problems faced during the classification study and some suggestions for further improvement of the mapping large areas with the Landsat ETM's. These discussions are valid for the other similar satellite imagery such as SPOT, ASTER, too.

One of the main difficulties was experienced in separating Turkish Red Pine (*Pinus brutia*) and Anatolian Black Pine (*Pinus nigra*). Without stratification and using the DEM as a band (e.g. Domaç *et al* 2004), it was very difficult to separate these two classes through their reflectance values alone. Therefore, use of expert knowledge, ancillary data and DEM are necessary to differentiate the Turkish Red Pine and Anatolian Black Pine at the current study scale. However in transition zones between 800-1200 m for the study region, it was not possible to separate these two classes if their distribution was in a mosaic of patches.

Besides, a similar problem has occurred in some other vegetation type pairs such as Taurus Cedar and Taurus Fir, Deciduous oak and Mixed Deciduous Forest, and Juniper shrubland and Kermes Oak-Juniper Shrubland, respectively. In these cases using DEM was not solution since they occupy similar life zone in terms of elevation. To overcome this problem stratification was the main strategy. Areas with a scrambled mixture of classes were clipped and, according to the species composition these areas were clumped and named accordingly. However, small areas which may be of conservation importance were neglected in this approach. Although detection of such vegetation types requires quite detailed study which is not possible to implement at this scale, post classification sorting can be the way for the previously known specific vegetation types.

The 'sparsely vegetated and bare areas' class was another problematic class. In consideration of the size of the study area and the main object of the classification (forests) it is worth mentioning that sparsely vegetated areas and bare areas could not be accurately detected or separated. Due to this problem it seems more appropriate to combine these classes.

Grassland covers a much larger area, 3,821,890 hectares, than would be expected for the Mediterranean region. This high figure is probably due to problems in differentiation at both ends of the spectrum. One is in the less vegetated areas, between grassland and sparse vegetation, and the other is between grassland and woodland or shrubland. These difficulties are due to the continuum of vegetation. Within the framework of this study the problem of detecting the transition between grassland and sparse areas was not very important, but the transition between grassland and woody vegetation types was important and even more difficult to detect and classify.

A further important problem with the grassland classification at this scale is the difficulty of producing any information at the floristic level. Even at the dominant species level it is not possible to make any differentiation.

Tall maquis and short maquis cannot be discriminated by their reflectance values although ecologically they are distinctive communities. For example in terms of birds short maquis bear considerably higher number of species. On the other hand maquis in their tall status is a more mature community and valuable in terms of ecological processes.

An important problem that we have encountered with this class is that although maquis formations are rarely found above 1000 m, in the first classification trial they appeared extensively above this altitude. When the DEM was used as a band to separate Anatolian Black Pine and Turkish Red Pine it also helped to correct this misclassification of maquis formations.

Classifying maquis according to its species composition was not possible. As the composition changed in small patches, even in a few hectares there could be several dominant species and this made it very difficult to classify them within such a large study area. Separation of these units would be a challenge even for more detailed classification studies in smaller areas. Thus, it can be said that alliance level classification of the maquis formations is not possible in large area mapping.

Woodland and forest were another two classes that need to be separated but could not be achieved fully in this study. Woody formations comprised of trees and having a canopy cover of 40-60% is defined as woodland, and if it is more than 60% it is called forest. However, it is not possible to detect these physiognomic features through Landsat ETMs. Thus they were probably all merged into the forest class. Only some Juniper and Oak formations that are found in the transition between steppe and Mediterranean forest types, or high on the tree line were classified under the woodland group.

4.3. Further improvement of the accuracy of the classification with Landsat ETM's

Although some of the problems are inherent due to the scale of the study, accuracy and quality of the classification can be improved by the following means:

1) According to proposed classification scheme in the large area mapping or in a scale smaller than the 1/100.000, formation has to be accepted as a classification level rather than the alliance. However, alliance level classification has to be forced whenever possible.
2) Alliance level can be achieved by either segmentation during the classification or through post classification sorting. Hence, all these procedures require good quality ancillary data, expert opinion, and a high amount of time.
3) Stratification is crucial for successful classification. Use of ecological units such as ecoregions, sub-ecoregions, etc. – as appropriate to the study scale – is the first step to successful stratification. Further stratification could be carried out according to altitude or dominant vegetation types.
4) Feature mapping should be tried as means of improving the spectral quality of the training set (Domac *et al* 2004).
5) Although they are situated at higher ranks of the proposed classification scheme, at scales lower than the 1/100,000 the amount and resolution of the data do not enable to differentiate canopy cover to separate forest and woodland if they do not cover large areas,
6) Ideally a set of images taken on the same month, even though the year is different, is needed, and May to June is the preferred period as this coincides with the main

growing season.

7) Usually it is suggested to carry out classification with two sets of images of different seasons,.

4.4. General features of the proposed classification system

4.4.1. Why is Physiognomic-Floristic System Preferred?

Various classification systems according to different approaches were reviewed in the first chapter. There is not a single globally accepted system of vegetation classification in the world (Adams 1996). However some of the globally recognized systems can be listed as:

- Braun-Blanquet phytosociological system
- EUNIS system
- FAO Classification system
- UNESCO physiognomic classification system
- US-NVCS physiognomic and floristic classification system

Although the Braun-Blanquet system is a comprehensive system with detailed floristic description, it requires a high degree of floristic expertise. Additionally, a proper application of the system requires detailed field sampling procedures and analyses.

However, one of the main criteria of the current study is to establish a system that is suitable for more general purposes as well as able to give information about the floristic composition of the community in the lower ranks of the hierarchy. Although the Braun-Blanquet method gives far more detail in terms of floristic composition of the vegetation, it does not satisfy the former criteria.

The UNESCO system, with its physiognomic classification criteria, is highly suitable for the broad use at the global level. However, in more detailed regional studies inclusion of the floristic categories is crucial to classify the vegetation into detail that will serve to natural resource management, planning and conservation purposes. Besides it has to be mentioned that even in the global studies when the floristic features at least in the dominant species level has not been considered some misleading results can appear. For example one can not differentiate Mediterranean maquis formations from the California chaparral without usage of the floristic information or introducing regionalization to the classification system.

An idea of combined physiognomic and floristic system is an old endeavor in developing ecologically comprehensive global wide classification system (Rubel 1930, Whittaker 1962, Ellenberg 1963, Webb *et al.* 1970, Westhoff 1967, Beard 1973, Werger and Spangers 1982). One of the first attempts that found large scale implication ground was suggested by Driscoll *et al.* (1984) in the US. They have suggested developing a joint system using the physiognomic units of UNESCO (1973) and the floristic units of habitat types (Grossman *et al.* 1998).

Vankat (1990) in North America, Strong *et al.* (1990) in Canada, and Specht *et al.* (1974) in Australia used a combined physiognomic and floristic approach.

USVCS system including, both physiognomic categories and floristic categories, is much more suitable to satisfy both practical classification for the general purposes and more detailed classification including some floristic information. In the higher ranks which are derived according to physiognomic features it is possible to classify the vegetation into subunits very easily even without detailed floristic information about the area. On the other hand lower classes enable use of more detailed floristic information. Thus USVCS was selected as a main source for the current study. This system was chosen for the following reasons:

1. It keeps both physiognomic and floristic levels in its hierarchy,
2. It is adopted from the previous internationally accepted study of UNESCO (1973).
3. It is global in scope and can be used by different agencies throughout the world,
4. It has an ecologically meaningful hierarchy,
5. It is applicable at various scales (circa 1/25.000 to 1/1.000.000),
6. It is easy to implement in the field and can provide detailed floristic information when needed.

Hierarchy and classes of the some of the globally accepted systems are provided in Table 3.

Due to broad use of Braun-Blanquet and EUNIS systems in European context, they have been discussed in more detail in the following chapters in this section.

4.4.2. Categories and the hierarchy of the classification scheme

Proposed physiognomic-floristic system is studied and adapted for the terrestrial communities. For the marine and freshwater communities separate classification system has to be prepared starting from the supraclass level.

Bird community data has enabled us to test the ability of the classes to separate different communities from each other and to test the hierarchy of the system. Thus, the analysis was conducted to test the robustness of the widely used physiognomic-floristic system and to improve it according to breeding bird species composition.

The physical structure of the vegetation has been considered as one of the key factors in the niche dimension of the birds for a very long time (Lack 1933, Wiens 1969). It provides shelter from predators and the physiological stress, nesting substrate, prey etc. This is one of the long ago accepted themes of ecology (Wiens and Rottenbery 1981). However, some recent studies suggest opposing results; although they do not underestimate the importance of the physiognomic structure they also highlight the importance of the floristic composition (Cushman and Garigal 2002, MacNally 1990, Lee and Rotenberry 2005).

On the contrary, recent studies appears with opposing results; although they do not underestimates the importance of the physiognomic structure they also highlights the importance of the floristic composition (Cushman and Garigal 2002, MacNally 1990, Lee and Rotenberry 2005). Scale dependency is another feature need to be considered. Different features of the habitat (e.g. cover type, vegetation structure, floristic composition) seem to be important at different scales (Mac Nally 1990, Cushman and Garigal 2002). One of the first things to be analyzed is the hierarchy of the system, especially the upper ranks.

4.4.2.1. Physiognomic Supraclass and Physiognomic Class levels

Although USNVC is used as a basis to adapt it to Turkey, some changes are proposed for the upper levels of the system based on the breeding bird data and the classification exercise with satellite remote sensing.

It is apparent that three classes (i.e. forest, shrubland, grassland) are separated distinctively and woodland class is much more inline with the forest and shrubland according to axis 1 and 2 of the DECORONA (Figure 23). These two axes explain the great amount (see section 1.6) of the distribution of the breeding birds according to communities. Class Forest, Class Shrublands and Class Grassland were clearly separated from each other regarding to the breeding bird data. However, Class Woodland is distributed between the Class Forest and Class Shrubland according to DECORONA analysis ordination graph.

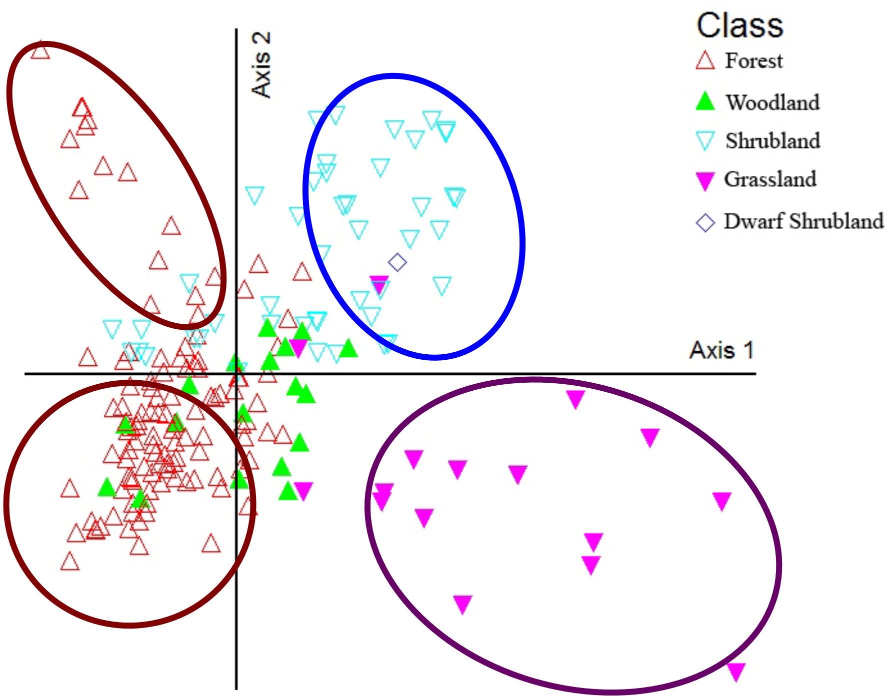

Figure 23: Detrended Correspondence analysis of the bird species-vegetation type data in the class level according to axis 1-2 and their separation

This separation is not that distinctive in the other categories such as Subclass, Group, Formation and Alliance (Figure 22, 22, 30). Thus placing the widest physiognomic feature forest, woodland, shrubland and grassland in the higher level of the classification scheme is appropriate according to breeding bird data too.

In the higher level of the system, one of the first discussion points is about the Class Woodland. The class category is proposed as seven categories made up of 1) Forest, 2) Woodland, 3) Shrubland, 4) Dwarf Shrubland 5) Grassland 6) Non-vascular 7) Sparse Vegetation in the NVCS of the US (FGDC 2004, Grossman 1998). In the classification of the communities according to breeding birds Class Woodland (green rectangles) was too much inline with the Class Forest (Figure 24).

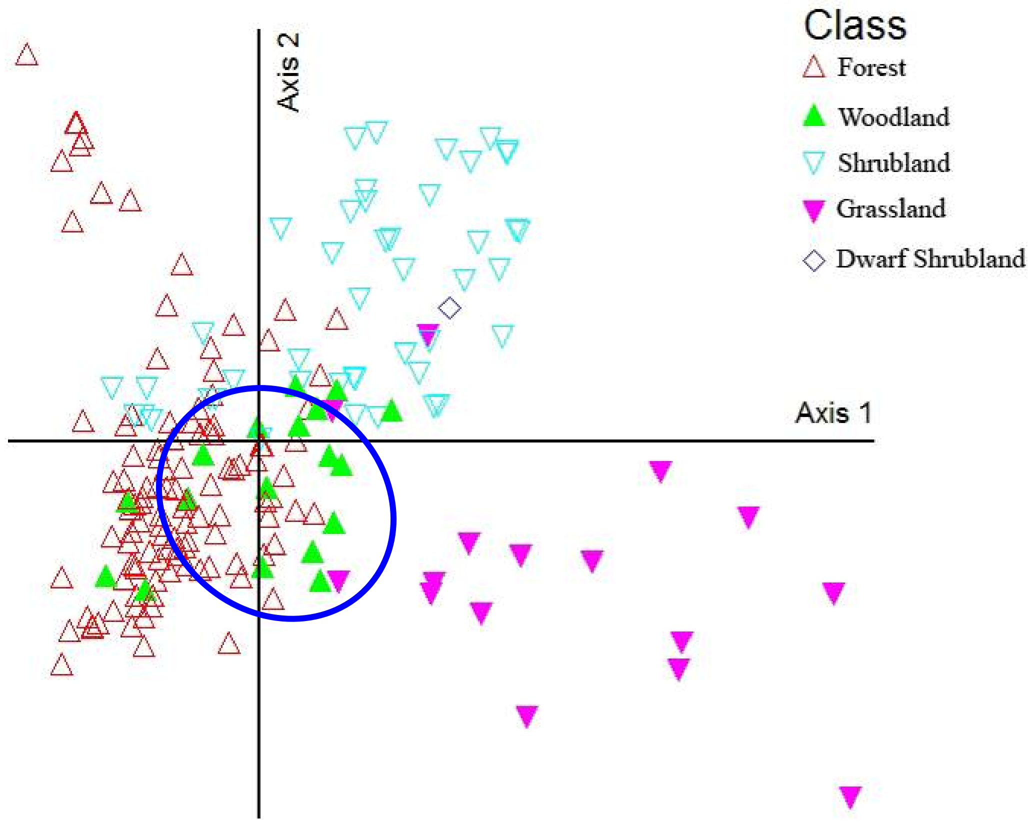

Figure 24: Detrended Correspondence analysis of the bird species-vegetation type data in the class level according to axis 1-2 and the separation of the class woodland

Although it was in between Class Forest and Class Shrubland further test was carried out to decide about joining Class Forest and Class Woodland.

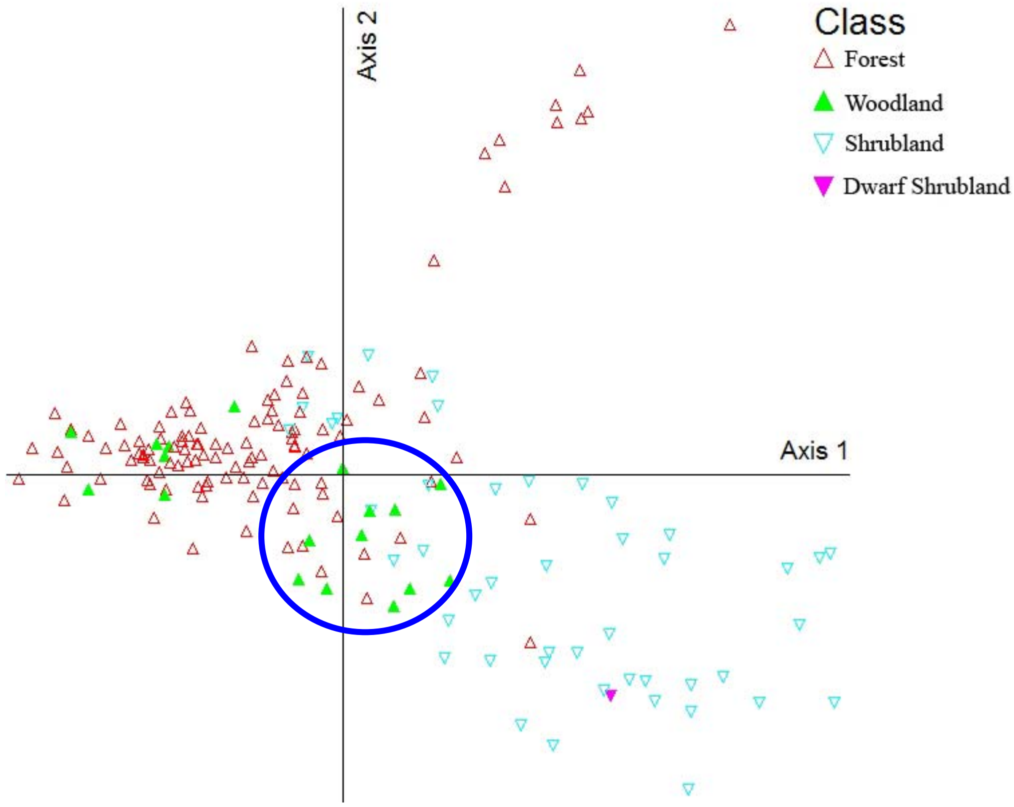

Figure 25: Detrended Correspondence analysis of the bird species- woody vegetation type data in the class level according to axis 1-2 and the separation of the class woodland

In this analysis Class Woodland was situated more between the Forest and Shrubland Classes. Thus it was decided to keep original classification for the Class level as it was. Besides, in Turkey Woodland formations can be seen in two different places and form. The first one is between the forest steppe transition areas in the Northern slopes of the Taurus Mountains or in the Southern slopes of the Black Sea Mountains. Juniper and Oak are the two most commonly dominant species of these transition areas. The second one is in the upper limits of the forest belt where forest cover gradually gives rise to subalpine shrublands or alpine grasslands. In these areas woodland is much closer to the forest due to its ecological relatedness.

However, separation of the forest-steppe transition communities is an important issue thus as Figure 24 and Figure 25 supports, keeping Class Forest and Class Woodland separate is much more appropriate from an ecological point of view.

In order to solve the Class Forest and Class Woodland discrimination problem, another level is introduced into the hierarchy above the class level. It is called Supraclass and it is made up of four units: 1) Tree Dominated, 2) Shrub dominated, 3) Herb dominated 4) Nonvascular dominated 5) Bare area.

This upper level helps to use them combined if there is a difficulty of separating those two classes. Besides, breeding bird data supports this treatment too. While forests and woodlands can not be easily separated, shrublands and grasslands were easily clumped as two separate groups in the DECORANA (Figure 23). Another important reason behind this new level of hierarchy is having forest, woodland, shrubland, dwarf shrubland in the class level gives too much emphasis to the woody formations but underestimates the herbaceous vegetation by including only one type 'Class Grassland'. Thus, an upper level mainly separating these three forms (e.g. tree dominated, shrub dominated, herb dominated) will be improving the ecological features of the classification system

USNVC have followed a similar approach (see FGDC 1997) but in the most recent version of the USNVCS, they did not include the tree dominated, shrub dominated, herb dominated, nonvascular dominated criteria. While the FGDC Vegetation Panel Report (1994) classification system had started at the Class level, in the 1997 report a new category called 'Division' was introduced anticipating the tree, shrub, and herb dominated separation. However in the 2004 report 'Division' was made up of only the units called 'Vegetated' or 'Non Vegetated'.

There are no nonvascular community types that are detected in the study area. This is mainly due to nonvascular communities being rarely large enough to be detected through satellite imageries. Additionally it was not possible to associate any bird species with the nonvascular communities. Thus, at this level, only tree dominated, shrub dominated, herb dominated, forest, woodland, dwarf shrubland types will be discussed.

4.4.2.2. Classification of the 'Supraclass Herb Dominated'

Although the main objective of the study is to develop a practical and ecologically meaningful classification system for woody formations, due to availability of more comprehensive field data a basic system was proposed for herbaceous formations as well. These results have to be accepted as a guideline for further studies rather than completely tested statements for Supraclassclass Herb Domianted.

It has to be mentioned that since separation of the Class Forb and Class Graminoid was not possible in the current study conducted with Landsat ETMs, a generic category called Class Grassland were used to represent both classes. One of the discussion points in the upper ranks of the classification system for herbaceous communities is about the sparsely vegetated areas. It is possible to keep Sparse Vegetation as a separate class or instead evaluate it within the lower ranks to use the cover value as one of the criteria within Class Grassland. Although Sparse Vegetation can not be accepted as a separate community type from an ecological viewpoint, due to compatibility with classes obtained from remote sensing, it is necessary to include this unit in the classification system.

Since sparsely vegetated areas are going to be herbaceous formations rather than woody formations, it is appropriate to consider them under Class Grassland. When the DECORONA analysis is repeated by including the Sparse Vegetation under Class Grassland, sparse vegetation is not separated from other grassland types distinctively. Thus, this result tells us to use Sparse Vegetation in the lower ranks of the hierarchy in relation to the cover value of the vegetation.

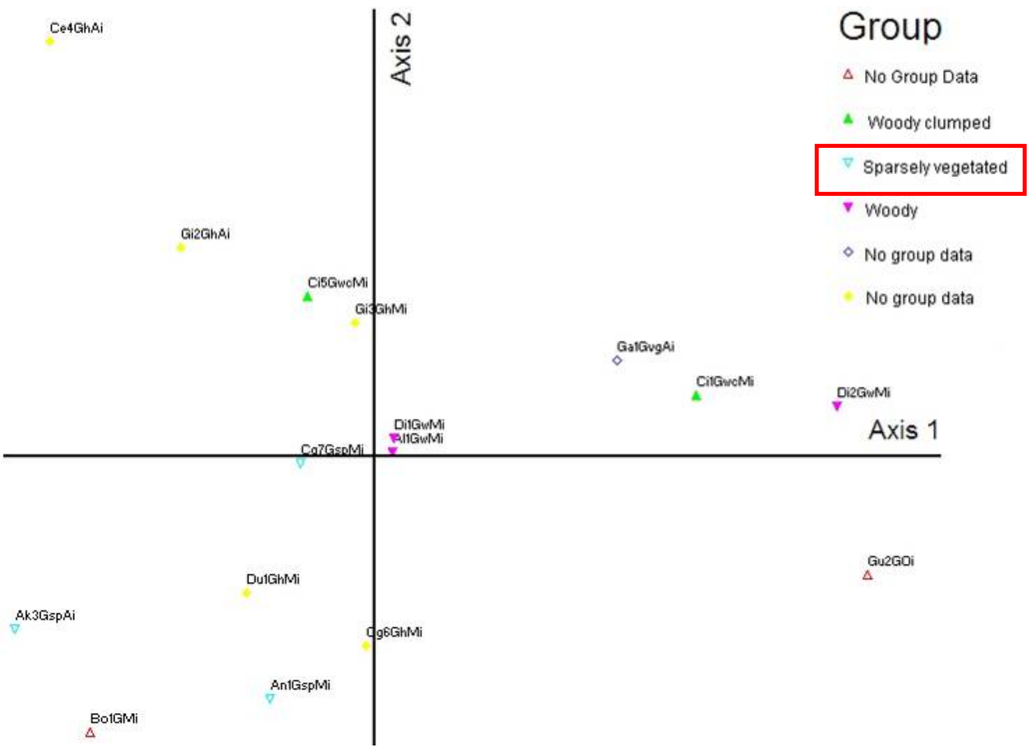

Figure 26: Detrended Correspondence analysis of the bird species-grassland vegetation type data in the group level according to axis 1-2

Sparseness is considered in the 'Subclass' level together with the height of vegetation: I. Tall Dense, II. Short Dense, III. Short Sparse.

In the class level grassland was easily separated from the other class types as can be seen in the Figure 23. In the next rank where some criteria (e.g. existence of the woody species, sparseness) were identified for the class grassland it is not possible to separate communities effectively from each other in relation to the bird composition (Figure 26).

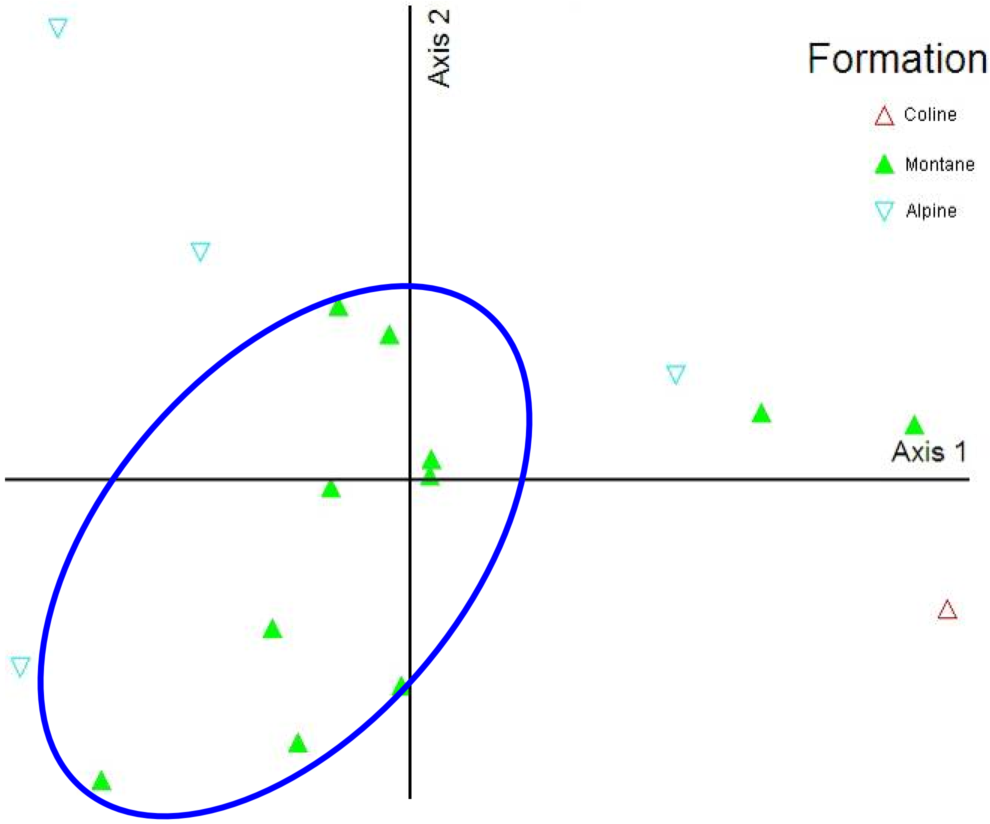

Figure 27: Detrended Correspondence analysis of the bird species-grassland vegetation type data in the formation level according to axis 1-2

In the formation level where altitude was used as classification parameter communities were separated very easily. It can be concluded that using the altitudinal parameter in a higher rank than the existence of the woody species could be much explanatory regarding the ecologically meaningful hierarchy in the classification of the communities. Hence, in order to suggest this as a rule much more study is required.

4.4.2.3. Physiognomic Subclass level for the woody formations

In the subclass level evergreen and deciduous groups were easily separated from each other according to breeding-bird data (Figure 28). This proves that leaf phenology has to be considered in the upper ranks of the hierarchy.

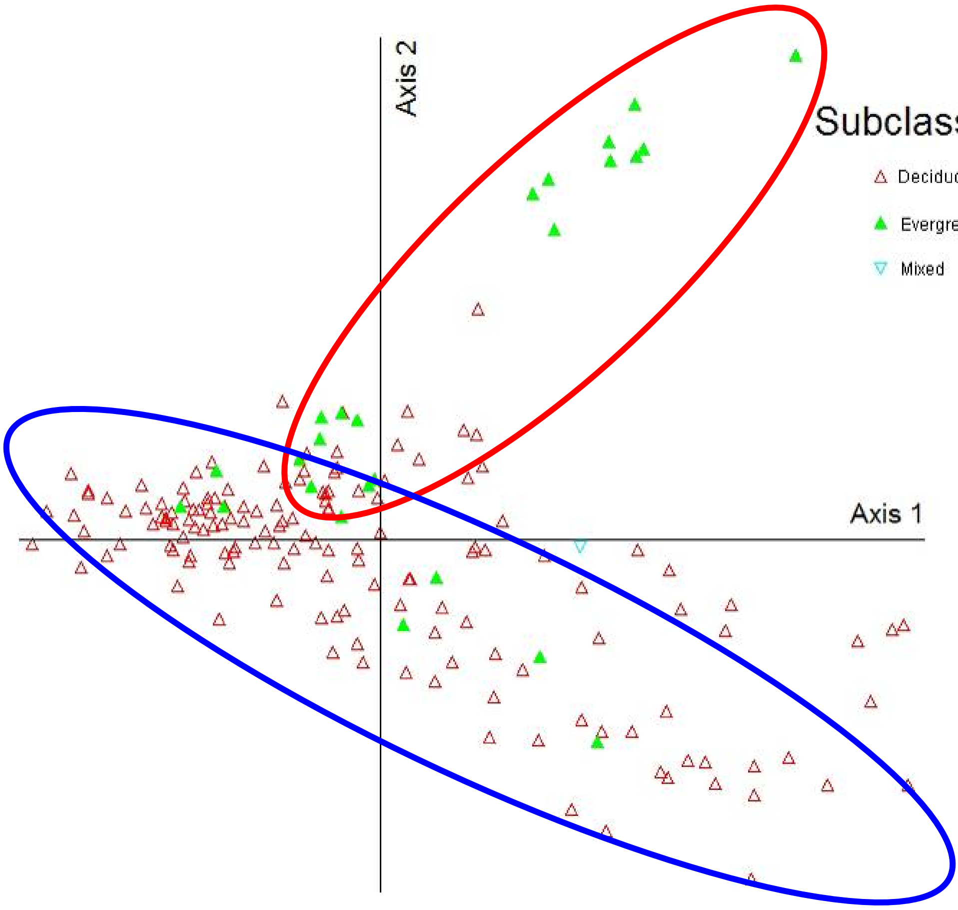

Figure 28: Detrended Correspondence analysis of the bird species- woody class data in the subclass level according to axis 1-2

4.4.2.4. Physiognomic Formation level for the woody formations

Formation level is one of the most critical levels in the classification system. It is one of the most easily detectable and one of the most useful level for the natural resource management and conservation studies due to information it possess. Although, there is not much clear separation between the sites as it was observed in the higher ranks of the hierarchy, three different groups for the different formation types were detectable within the red ellipse (Figure 29). Colline, montane and alpine formations are more or less forms distinct groups within the red ellipse. The group in the upper part surrounded with the blue ellipse are the Coastal Oriental Sweet Gum Formations. Although they appear as a separate group in the classification it has to be mentioned that they appear as a distinctive group at all levels due to their relation with aquatic systems.

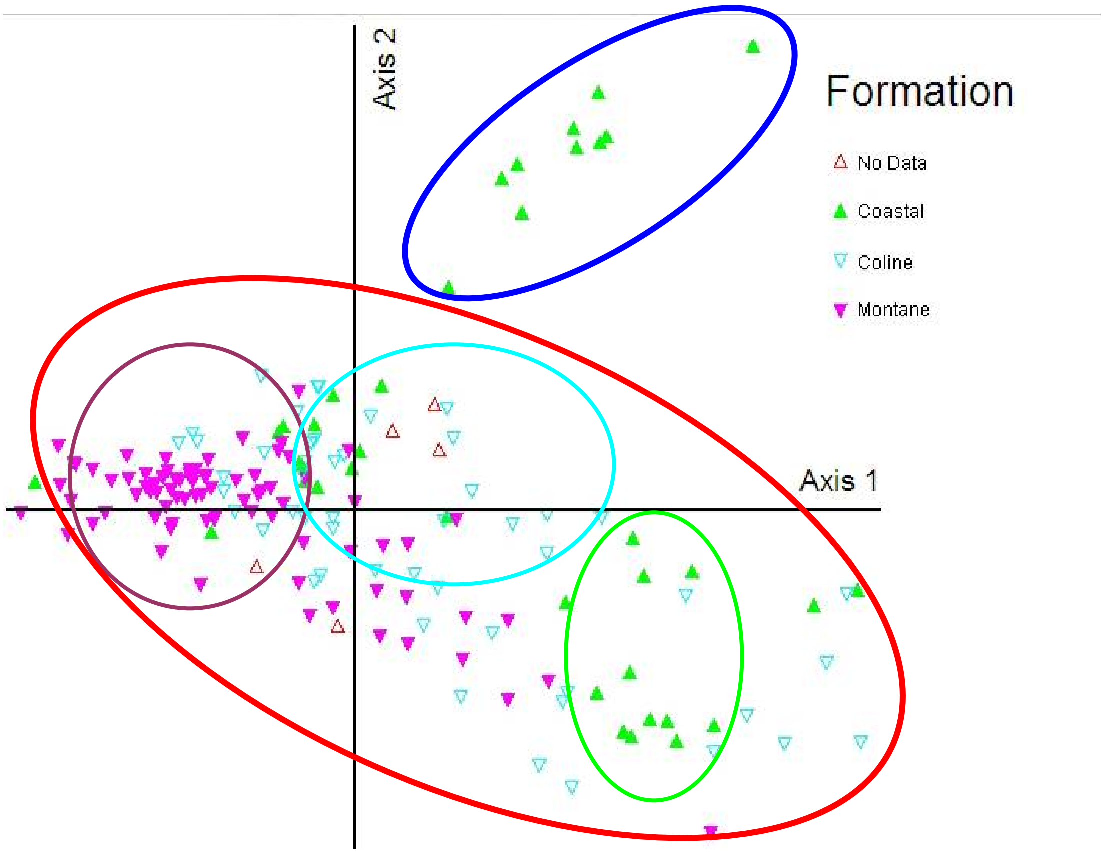

Figure 29: Detrended Correspondence analysis of the bird species- woody units in the formation level according to axis 1-2

4.4.2.5. Alliance level for the woody formations

Alliance level is the first floristic level in the classification scheme. As number of the community types increases separation of the communities in this level gets much more complicated. Eventough all units are associated with each other alliances were aggregated together as it can be recognized in the Figure 30.

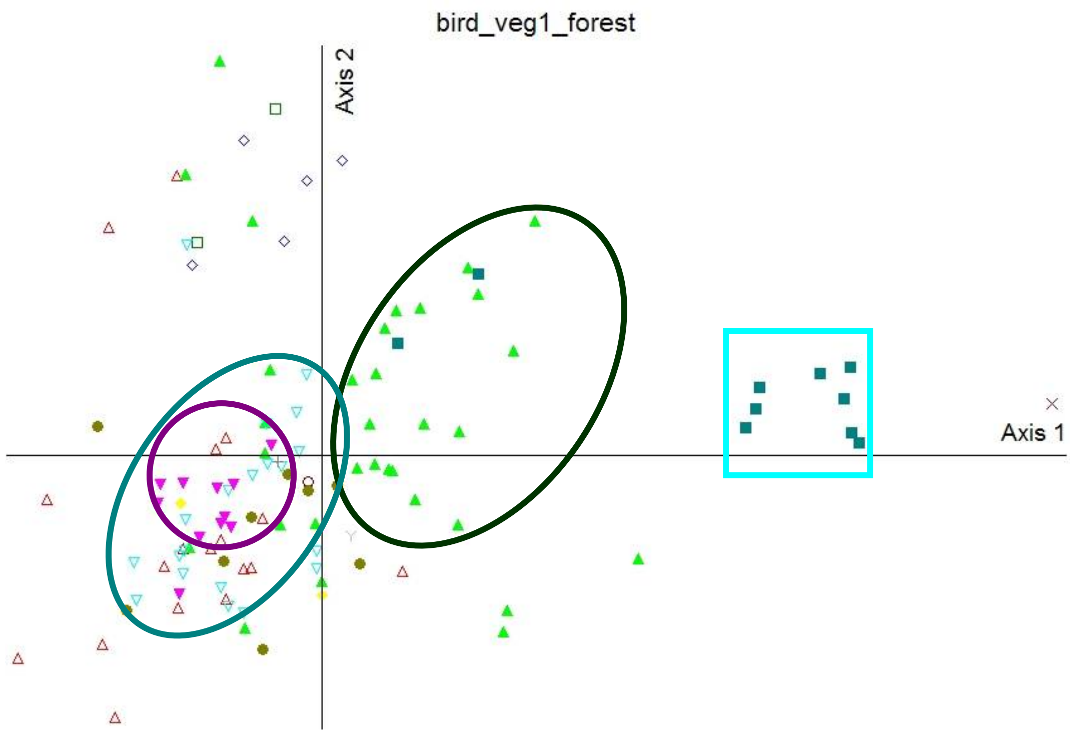

Figure 30: Detrended Correspondence analysis of the bird species-woody units data in the alliance level according to axis 1-2

4.5. Comparing classification system with Phytosociological classification

As the Braun-Blanquet approach does not put emphasis to successional stages, ecological amplitude of the associated species, or quantitative coverage value of the species it has important limitations to express the features of the vegetation at broader scales (Becking 1957, Poore 1955, Poore 1956). One of the most important features of this approach is, starting from its launch in 1921, that the species is accepted as an ecologic unit –that even in contiguous habitats a species is commonly represented by ecotypes that have mutually exclusive ecological amplitudes (Daubenmire 1960, Habeck 1958, McMillan 1959, Sanydon and Bradshow 1961). Hence, in the proposed system physiognomic features of the vegetation is placed at the higher rank of the hierarchy and species appears in the lower ranks. Besides they do not appear as ecological unit. Rather, in the alliance and association level dominant and the most abundant species are expressed at the alliance and association levels.

Thus one of the main differences with the proposed system and the Braun-Blanquet classification system is the former's ability to map the large areas.

Although many vegetation scientists finds the synecological studies in the classification of the vegetation unreliable, complex and subjective due to several features of the vegetation (i.e. individualistic vegetation concept, continuum) (Gleason 1933, Whittaker 1962, Çetik 1973), it is significant that classifications at the association level as made by synecologists with diverse philosophies and using different methods of study show close correlation (Major 1959). Besides, for the detailed floristic classification studies the Braun-Blanquet approach is still one of the most widely used systems, especially in the continental Europe.

However, this approach requires a tremendous amount of expertise to implement the detailed sampling procedure and analysis. Thus, in order to implement the Braun-Blanquet approach in the field, an experienced botanist with a comprehensive knowledge of the study area is crucial (Çetik 1973).

The proposed system does not require detailed field surveys. Especially if the study is at the physiognomic levels of the system, it can be easily conducted through satellite imagery, ancillary data (e.g. 1 /25.000 forest stand maps) and a limited amount of ground truthing. So one can use the proposed system at least, physiognomic levels and even sometimes alliance level without much floristic expertise. However, in the Braun-Blanquet system one needs to have broad knowledge about the vegetation of the area to make initial estimation about the vegetation type of the study area. This will enable one to identify homogenous sites representing the estimated vegetation type for the sampling procedure.

Another superiority of the proposed system is its practicality for the actual vegetation mapping studies due to its labor and cost effectiveness, especially if one is working in large areas.

The Braun-Blanquet system's superiority is its holistic approach in determination of the vegetation type. It considers whole species composition and classifies communities according to this composition (Kimmins 1997). Although it is a long debate between Clementsians and Gleasonians (holistic versus individualistic), considering the whole composition in classification of the communities gives more detailed information about the ecology of the study area. However, proposed system does not inquire to consider whole species composition, mainly due to practical reasons. It is based on the some of the general features of the vegetation such as leaf phenology or dominant species.

Another major difference between the two systems is one of the inherited differences between the floristic and physiognomic approaches: Floristic classification approaches are agglomerative as they start from the smaller units and achieve higher classes by agglomerating many of these smaller units. On the contrary, physiognomic approaches are generally divisive; they start from the higher ranks of the classification hierarchy and end with smaller units by dividing them.

However, one of the main similarities between the proposed system and the Braun-Blanquet is the hierarchical structure of the both systems.

4.6. Comparing classification system with Atalay's regioning and classification study

Atalay is one of the Turkish geographers who have been extensively working on ecosystem classification and regionalization in Turkey (Atalay 1984, 2985, 1987, 1992). He has worked in almost all of the regions of Turkey. His work is mostly based on the identification of the ecosystems or regions of Turkey based on the physical features such as climate, substrate, geography and sometimes dominant vegetation type. Atalay is one of the scientists who has provided a classification to the ecosystems and regions of Turkey with a broader perspective and a systematic manner.

His later studies mainly concentrated on the regionalization of different parts of Turkey especially for the forest tree seed transfer studies, although he had not started his classification studies with that purpose.

One of the important critiques of his study is that he has not considered much biological criteria and features in his classification studies. They are mainly based on the physical aspects of the ecosystem.

Atalay (1987)'s study in the Mediterranean region for the seed transfer regionalization for the Taurus Cedar (*Cedrus libani* A. Rich) is the most appropriate one to compare to the proposed classification system. Atalay (1987) used vegetation series as one of the first classification category. It more or less reflects the physiognomic features of the vegetation. In the second level he used some of the forest types as a classification criterion (e.g. Anatolian Black Pine, Taurus Fir, Taurus Cedar, Beech Forest, Oak Forest, Hornbeam Forest)

Although this classification gives information about the region, it will not be explanatory enough for more detailed biological studies. Additionally, the lack of explicit hierarchical system and other categories prevent this system to enjoy a widespread application.

Atalay *et al.* (1985) used a more comprehensive system in his ecosystem classification study in North East Anatolia. In this study Atalay *et al.* used climatic features, substrate, and dominant species in a more systematic way. Humidity (e.g. dry, humid) and temperature (e.g. Cold), altitude (e.g. high mountain), substrate type (e.g. chernozem), dominant species or vegetation formation (e.g. Oriental Beech, Caucasian Fir) were the main criteria used.

Although Atalay use physical and physiognomic features to identify the ecosystem types, his system is not a systematic hierarchical system.

4.7. Comparing classification system with EUNIS classification categories

EUNIS is the European Nature Information System, a special habitat classification system.

The EUNIS system is made up of eight main categories and it goes down to three to eight levels in hierarchical manner. Main categories are;

1. Marine habitats
2. Coastal habitats
3. Inland surface waters
4. Mires, bogs and fens
5. Grasslands and lands dominated by forbs, mosses or lichens
6. Heathland, scrub and tundra
7. Woodland, forest and other wooded land
8. Inland unvegetated or sparsely vegetated habitats
9. Regularly or recently cultivated agricultural, horticultural and domestic habitats
10. Constructed, industrial and other artificial habitats

11. Habitat complexes

First level categories are identified according to three main criteria 1) Terrestrial-Marine-Lacustrine (Marine, Coastal, Inland surface waters, mires-bogs-fens, inland unvegetated or sparsely vegetated habitats), 2) Physigonomy of the vegetation (i.e. forest-woodland, hetahland-scrubland-tundra, grassland-forbs-mosses-lichens) 3) Degree of naturalness (cultivated, agricultural, horticultural, domestic habitats).

All of the above mentioned tree criteria were used in the proposed system. However, they have been used in separate hierarchical ranks due to their ecological weight as explained in the previous sections and presented in the analysis of the hierarchy in relation to the bird data. Since the classification system is developed for the terrestrial systems it is more appropriate to consider marine and lacustrine systems as separate scheme. Although, the EUNIS system was created for terrestrial environments initially marine and freshwater environments were added later. Thus, they appear at the same level with woodland, forest, shrubland, herbaceous etc., although they are supposed to be at a higher rank (Davies *et al.* 2004).

Unvegetated and sparsely vegetated sites were considered in the same group in the first rank of the hierarchy. In the proposed system sparse vegetation is not considered as a separate class. Instead it is considered with the 'Class Grassland'. It is considered that even the vegetation cover is sparse due to external effects such as grazing or erosion, species composition will be likely in the more densely vegetated areas. Thus the system has to classify the sparsely vegetated areas with their more densely vegetated equivalents instead of grouping then with the completely unvegetated sites such as ice, rocky cliffs etc.

The proposed classification system is mainly for natural and semi-natural areas unlike EUNIS. Artificial systems were not considered in detail since the system is created for ecological purposes. With EUNIS system, it is likely that one aim is to provide classification of the artificial systems too. Another important difference, between those two systems regarding naturalness is about cultivated areas. In the proposed system, cultivated areas are likely to appear in the lower ranks of the scheme (i.e. physiognomic subgroup) as natural/semi-natural or cultivated; however they appear within the first category of the classification scheme in EUNIS.

Naturalness is an important criteria but it is necessary to discuss its place in terms of setting the hierarchy of criteria. For example citrus orchards in the Mediterranean coastal zone are more similar to the maquis formation than the Turkish Red Pine plantation in terms of structure and species composition. In such a case, it is more relevant to consider naturalness at lower ranks instead of considering it within the first rank as the EUNIS system suggests.

Some of the criteria of EUNIS fits with the proposed classification system such as forest, woodland, herbaceous vegetation are separation criteria in the highest rank of the classification (see Figure 31).

Another criterion is habitat complexity, which is likely to be unit that is depend on the study scale rather than being an actual habitat type. A class called habitat complex can appear among several numbers of habitat types in the finer resolution study.

Second and third categories of the EUNIS system for the forest classification are as follows;

- 9000 - Forests of Boreal Europe
- 9100 - Forests of Temperate Europe
- 9200 - Mediterranean deciduous forests
- 9300 - Mediterranean sclerophyllous forests
- 9400 - Temperate mountainous coniferous forests
- 9500 - Mediterranean and Macaronesian mountainous coniferous forests

Few important discussion points can be raised as;

A few important discussion points can be raised here. Major climate types and growth forms were used as some of the criteria. In that respect the proposed system has similarities as both systems use similar criteria within the higher ranks of the hierarchy. On the other hand, EUNIS includes some geographical locations (i.e. Europe, Mediterranean, Macaronesian) as a criteria which has not been used in the proposed system.

In the rest of classification scheme of EUNIS, dominant species, associated species and geographical locations were used to name or differentiate habitat types.

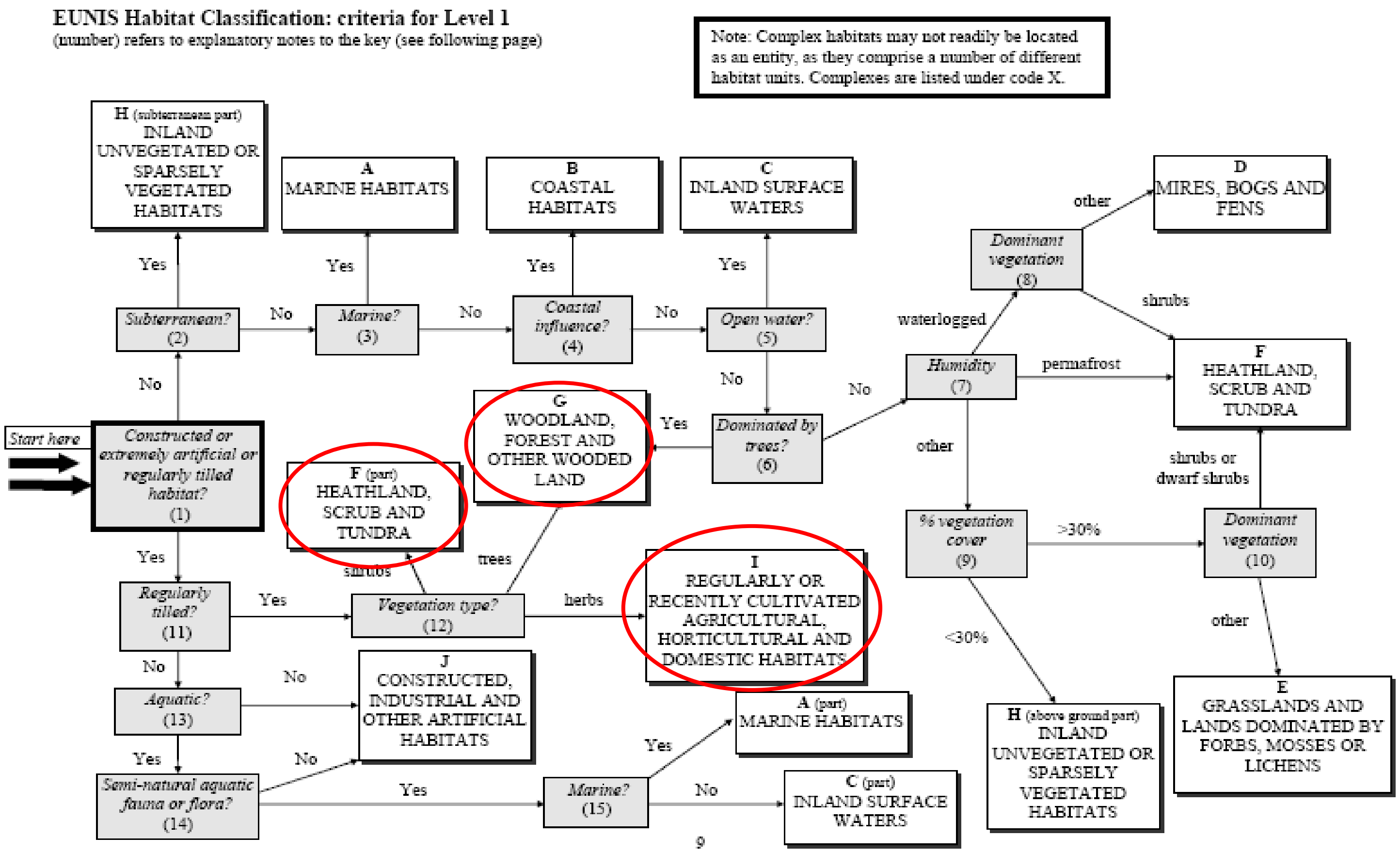

Figure 31: Algortihm for the identification of the EUNIS 1st Level classes

When EUNIS was investigated for other major categories such as "E: Grasslands and Lands dominated by forbs, mosses or lichens, F: Heathland, scrub and tundra" same differences were observed.

However, the main difference between those two systems is that EUNIS uses a different set of the criteria in the same rank of the hierarchy and same criteria in the different ranks of the classification. Unsystematic use of criteria to separate different classes does not fit with the systematic classification approach (Fig. 32).

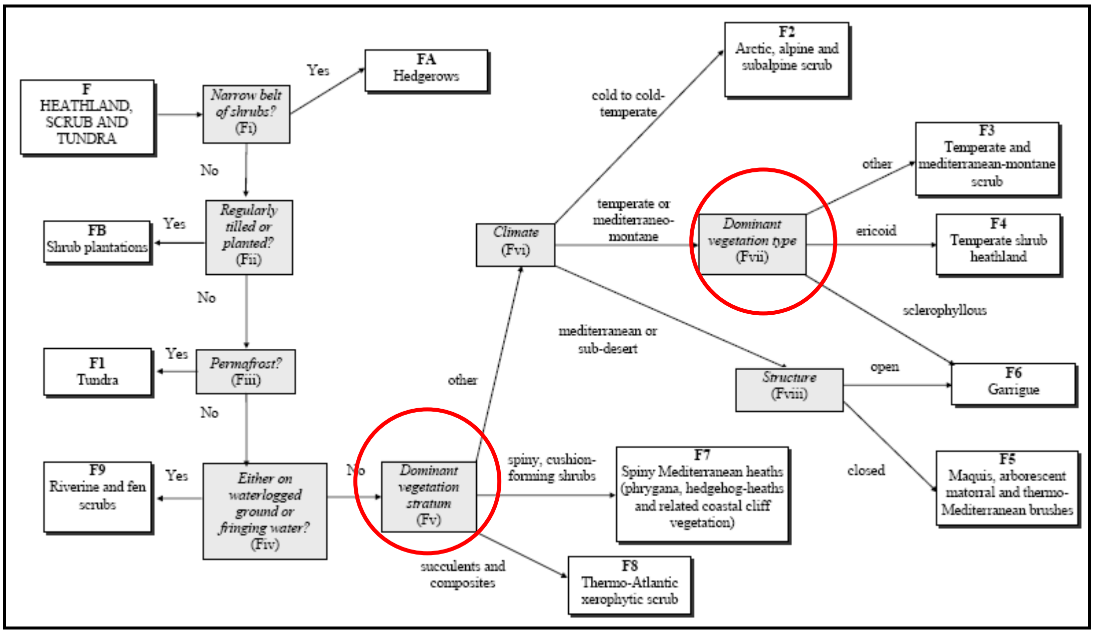

Figure 32: Algorithm for the Class F in the EUNIS classification system

Based on the above explanation, the development of the EUNIS classification is likely to be started through evaluation of the end classes (i.e. finer vegetation types in the lowest rank of the EUNIS system). Existing habitat types were evaluated, grouped and then logical set of hierarchy and upper classes were created as required. Consequently different criteria were used in the different level of the classification system. Finally, the resulting classification scheme of EUNIS is helpful to classify most of the habitat types of Europe but does not have a systematic and ecologically meaningful hierarchy.

4.8. Using the system in other regions

One of the key features of the proposed system is its usability in the other regions without requiring any major modifications in the system. For example, the system can be used in the Black Sea or Central Anatolia regions, which have distinctively different climatic features and consequently different vegetation formation. Climatic differences will help to differentiate these regions' community types in the Physiognomic Subclass and Physiognomic Group. Even if they have similar vegetation type with the same dominant species they will appear as different community types.

For example, if the system could place the Oriental Beech Forests in the Mediterranean and the Black Sea into different classes, it means that the set of criteria to separate different communities are working properly, even in separating classes of the different ecological realms (e.g. ecoregion, bioregion, phytoregion etc.). In the proposed system beech forests of the Mediterranean and the Black Sea will be separated in the formation level.

4.9. Fields of application

A standardized, practical classification system that is compatible with remote sensing will provide an important leverage to increase the efficiency of the resource management and conservation studies. Its contribution can be better understood by the analogy of everybody speaking the same language rather than facing the difficulty of communication between the human communities who speak different languages.

The applications of the standardized classification system can be grouped as follows:

1) Communities are important elements of conservation. Thus, identification of the different community types is crucial to asses their status and to develop conservation means (TNC 1996),
2) Communities provide numerous ecosystem functions through sets of natural interactions between the species (Constanza *et al.* 1997, Daily *et al.* 1997),
3) In many conservation planning studies communities were accepted as one of the best surrogate of the species and widely used, especially in areas with the limited species distribution data are available (Scott 1993, Noss and Cooperrider *sensu* 1994),

4) Communities are essential components of the monitoring schemes as it is cheaper to monitor change in the community structure and extend rather then the monitor many individual species (Noss 1990, Max *et al.* 1996),
5) A standardized classification is also essential to place the basic ecological and biodiversity studies in context (FGDC 2004),
6) Ecologically meaningful classification system can be used to model the distribution of animals,

At the moment there is an important gap between foresters, biologists and conservationists in terms of communication and common working ground in Turkey. All of them use different classification approaches to classify and map the natural systems. Many times, the maps and the classification system of one group are not comprehensible to the others. Consequently, this prevents effective collaboration of these groups. With the existence of a common system they will be communicating more efficiently, sharing the resources, avoiding duplication of efforts, and minimizing the cost for the vegetation mapping and community inventory.

In recent years, the forestry sector attempted to introduce biodiversity features into forest management practices. The proposed system can be helpful to forestry work by introducing the classification realm for non-forest formations such as shrubland and grassland. Besides the woodland concept used in the class level of the proposed system can be introduced to the forest management plans. Non-timber forest trees, which do not appear in the current mapping practices, can be evaluated at the association level.

Mapping of the grassland types could be one of the main benefits of the proposed system to the forest stand mapping practices. At the moment herbaceous formations and agricultural areas appear within the same class. However their differentiation is critical for management and conservation purposes. One of the reasons behind this practice is the lack of floristic knowledge in the teams producing the forest management plans. The phytosociological classification system, which is the system most commonly used in Turkey requires vast floristic knowledge, and is therefore not a convenient system for the forest teams to use. The proposed system, however, can help forest planners to classify the herbaceous vegetation to a certain degree without requiring any floristic knowledge. When this system is applied at a national scale, the amount of available information, even if it is coarse, will be enormous. The proposed system can also be used in the classification of herbaceous vegetation for other than forestry purposes, such as range management or erosion control.

Ecological communities are becoming more and more important units in conservation studies (Scott 1993, Noss and Cooperrider *sensu* 1994, Grossman *et al.* 1998), especially after the availability of the RS&GIS technologies. Community maps produced through satellite imageries provide some of the main data layers used in conservation planning. They were used as biodiversity surrogates (e.g. coarse filter *sensu* Noss and Cooperrider 1994), to improve the distribution maps of vertebrate species, and to evaluate the representation analysis. Community maps with hierarchical features can be useful in the studies for conservation of specific taxa as well. For example in studying butterflies, which have specific habitat requirements, lower units of the classification system could provide the necessary information. At the same time, the same data can be used for the groups such as large mammals, which are habitat generalists and travel along the large areas, when upper classes of the hierarchy considered.

CHAPTER 5

CONCLUSION

Ecological communities are among the most important data layers used for site management and conservation work. By describing, tracking, and mapping ecological communities, resource managers and conservationists can integrate a complex suite of interactions, which are not easy to identify otherwise, into their plans. This approach has broad use and applicability from local all the way to the global scale. However, the community concept is perceived differently by many scientists and this debate is likely to continue in the near future. In this study "species assemblage" was accepted as a main feature of the community concept.

In Turkey, since the 1950's, geographers, foresters and biologists has been working on different vegetation types in varying scales. Although, they have carried out several classification studies depending on their objectives, there is not any particular classification type widely accepted and can answer the necessities of the different purposes, for Turkey. However, for the appropriate use of natural resources and more effective nature conservation studies widely accepted community classification standard based on the vegetation is crucial.

In this study, the USNVC physiognomic-floristic classification system is adapted to Turkey to create a basis for the standardization of classification exercises. A mixed physiognomic-floristic system is the recommended classification system due to its practicality, ability to map extensive areas, and usefulness at different scales. Therefore, the proposed system includes physiognomic, climatic, and floristic categories, which make it useful for several purposes.

Its hierarchic structure enables it to be used at different scales. Compatibility of categories with the units that can be obtained from satellite imageries will promote its extensive use, even to map millions of hectares. Physiognomic classes can be easily detected without much floristic knowledge and limited expertise about the vegetation. Based on the above features, it can be concluded that the proposed system can be extensively used for different purposes and could fulfil the requirement for a common standardized classification and mapping system.

Application of the proposed system to the Mediterranean region and its test with the bird communities was shown that the system has meaningful categories. It works well especially in the forest and woodland classes. However due to the difficulty in mapping the grasslands and shrublands in the floristic levels, the current system could not be tested in detail in these classes. However, higher ranks showed high correlation with the bird species.

One of the major adaptations is addition of Supraclass to the higher level of the system to improve its ecological utility and compatibility with the remote sensing systems.

One of the important features of the system that has to be kept in mind is that different image types work well for different levels of the system. In order to use the proposed system effectively, identification of the image type according to the purpose and scale of the study is important. Landsat ETM's were worked very well upto formation level and some good results were obtained in the alliance level.

It can be concluded that images with low spatial resolution (e.g. NOAA) work well in the higher classes of the system such as physiognomic supraclass, physiognomic class, subclass and group. On the other hand, images with medium spatial resolution (e.g. Landsat, Spot) work best at the formation level. At the alliance level, medium spatial resolution works best on woody alliance types. High resolution images work well at the formation and alliance levels if they are supported with detailed ground data. Post classification sorting helps to add many biologically important rare features.

The proposed system can provide an important leverage to increase the efficiency of resource management and nature conservation. Since different groups will be communicating more efficiently, they will be sharing the resources, avoiding duplication of efforts and minimizing the cost for vegetation mapping and community inventory.

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Appendix A

Landcover form and guidelines to collect vegetation data

I. General Information and Location			
Cloud Cover		**Data Collector** **Date**	
Province **District** **Other Location**		**UTM Coordinates**	E N
		ALTITUDE	m

II. Landscape Data			
Position	Floodplain__________ Terrace_________ Hillslope__________ Hillcrest______________		
Aspect	N___ NE___ E___ SE___ S____ SW___ W____ NW___	SLOPE	0-10^0____ 10-20^0____20-45^0_____>45^0

III. LANDCOVER TYPE: (if there is no explanation please just put into related box)							
Forest		**Shrubland**		**Plantation**		**Cropland**	
Woodland		**Grassland**		**Orchard**		**Riparian**	

IV. Floristic Data **(DOMINANT SPECIES AND ASSOCIATED SPECIES)**
Are you highly confident with your DOMINANT species assessment? YES NO If no list other possibilities: 1)____________________________________ 2______________________________________

V. VEGETATION	
If forest or woodland estimate canopy cover 25-40%_______ 40-75______ >75________	If NOT forest or woodland, estimate %vegetaion cover 25-40%______ 40-75%_________ >75%____________

General Information and Location:

This part is designed to find out geographical position of the site and locate it into relevant zone according to UTM co-ordinates.

Landscape Data:

This part is designed to have general information about the site in relation to landscape.

Landcover Type:

This part is designed to get information about the landcover type in the broadest aspect. If there are some more information about the vegetation type please write into related box. You can use Appendix 1 for the further realisation of second or third categories of this classification. It would be useful to go over this classification scheme (Appendix 1) carefully to fill the forms more effectively.

Floristic Data:

It is usually difficult to handle species data in these kind of small forms. Also waiting this information from the amateur botanists is another constraint. On the other hand, filling this part, at least with dominant species information, by adding the confidential level and list of other potentials, will be very helpful in the determination of alliance during the classification exercise with remote sensing.

Vegetation:

This part is dedicated to estimation of amount of plant cover. It is designed in broad categories to prevent misanalysis.

Appendix B

Bird Data Collection Form I

Site Name:	Map
Team:	
Date: Time spent for the fieldwork (hours) From: To:	
Weather Summary:	
Other technical notes:	
Forest Ecoregion:	

Threats/ Activities	Type	Intensity (1-3)	Comments
	Logging		
	Afforestation		
	Hunting		
	Grazing		
	Agriculture		
	Tourism		
	Recreation		
	Motorways and major roads		
	Settlement		
	Others…		

Habitat	Code	Percentage (%)	*Comments*

Forest Type			
Physiognomic Class	***Physiognomic Subclass***	**Dominant Species**	**Associated Species**
Forest	Needleleaved		
Woodland	Broadleaved		
Shrubland	Sclerophyllous		
Dwarf shrubland	Mixed Needle & Broad		
Herbaceous	Mixed Needle & Sclerop.		
	Mixed Broad & Sclerop.		
Other Explanations:			

Other Observations and Notes:

Appendix C

Bird Data Collection Form II

Date:

Site Name:	Observes:
UTM square ref:	Time:

Habitat:	Comments:
Weather:	

SPECIES	Time period and number recorded					
	0-10 min	10-20 min	20-30 min	30-40 min	40-50 min	50-60 min

Appendix D

Survey Sites and Codes

Codes	Sites
Ad1	Andırın to Çokak road: maquis (Q cerris, 50%), rocky valleys (40%), juniper (10%)
Ad2	Andırın to Çokak road: maquis with tall & semi-mature oaks (Q. cerris). Surveyed from edge as habitat impenetrable.
Ad3	Near Andırın: Turkish Red Pine (plantation at start, mature at end), maquis
Ak1	Akdag, Çamköy Yaylacık: Anatolian Black Pine (patches 60-70%) very few old trees, cushion formation (coverage up to 30%)
Ak2	Akdag, Çamköy Yaylacık: Anatolian Black Pine, open (20-30%), patchy, mature
Ak3	Akdag, alpine plateau at 2150 m, tightly grazed plain, rocky slopes around (40% vegetated)
Ak4	Akdag: Anatolian Black Pine (90%), open areas (10%). Noisy stream.
Ak6	Akdag: cedar (90%), open areas (10%).
Al1	Alacadag: alpine (1600 m), cedar (20% mature, 10% young natural regenertion), much bare ground, steep and rocky.
Al2	Alacadag: cedar (80%) varied age structure but very few old trees
Al3	Alacadag: cedar with elm and Kermes oak (Q coccifera)
Al4	Alacadag: mixed deciduous (Acer and Prunus) plus Kermes oak, juniper and elm
Al5	Alcadag west, Sarıalan road, above Camlıbel: juniper (60%), Kermes oak (Q coccifera) heavily grazed, herb layer c.30 cm. Many timber stockades & other structures though no people or livestock present.
Am1	Asmacık: cedar (80%), open areas (20%)
Am2	Asmacık: fir (90%), Anatolian Black Pine & cedar (10%). Heavy rain, survey incomplete.

Appendix D (cont'd)

An1	Alanya: Turkish Red Pine (mixed)
An10	Alanya: Fir and cedar, Anatolian Black Pine lower down
An2	Alanya: Camalani-Koprubasi, Anatolian Black Pine with fir and cedar
An4	Alanya: Dim Valley and uplands, alpine meadows
An5	Alanya: Dim Valley and uplands, Anatolian Black Pine
An7	Alanya: Dim Valley and uplands, oak forest
An8	Alanya: Dim Valley lowlands, Turkish Red Pine
An9	Alanya: Dim Valley lowlands, degraded Turkish Red Pine
Ar1	Arsus-Antakya forest road: Anatolian Black Pine
Ar2	Akseki - maquis dominated by kermes oak
Ar3	Arsus-Antakya forest road: Turkish Red Pine, maquis understorey
Ar4	Akseki - Urunlu National Park, maquis with juniper and Kermes oak
Ar5	Akseki area - fir/cedar forest with a few Anatolian Black Pine and juniper
Ar6	Akseki: fir (60%), cedar (20%), juniper (J oxycedrus, 20%)
As1	Akseki - juniper, maquis and deciduous shrubland
Ay1	Aydınlıbahçe, Yesiltepe: short maquis (Q. coccifera)
Ba1	Babadag: Turkish Red Pine with dense understorey dominated by Q coccifera and Pistacia terebinthus in forest openings
Ba2	Babadag: Turkish Red Pine, mid storey storax, good herb layer
Ba3	Babadag: cedar forest, patchy open growth, herb understorey
Ba4	Babadag: just below mountain crest, juniper, plus maple and cotoneaster
Ba5	Babadag: mixed cedar and Turkish Red Pine, pine with understorey, cedar with mosses and lichens on trunks
Be1	Beyagaç: mature alders, some Anatolian Black Pine, stream
Bg1	Bögsak, nr Tasucu: Turkish Red Pine (90%), maquis (10%)
Bo1	Bozkir: Seydisehir, alpine
Bo2	Bozkir: Seydisehir, fir
Bo3	Bozkir: Seydisehir, fir and cedar
Bo4	Bozkir: Seydisehir, oak shrubland
Bs1	Bastepe Yangın Kolesi: alpine cedar (70%), open ground (30%)
Bs2	Bastepe Yangın Kolesi: Anatolian Black Pine and fir. Rain but birds singing well.

Appendix D (cont'd)

Bs3	Bastepe Yangın Kolesi: fir, Anatolian Black Pine forest. A well-managed forest.
Bs4	Bastepe Yangın Kolesi: juniper (80%), maquis (20%, Q. coccifera)
Ca1	Çamliyayla-Pozantı road: Turkish Red Pine (90%), low maquis understorey. Not good for birds.
Ce1	Cevizli - fir, with some cedar and juniper
Ce2	Cevizli - juniper, oak and Turkish Red Pine
Ce3	Cevizli - Kuyucak, coppiced oak with Turkish Red Pine and some juniper
Ce4	Cevizli - Kuyucak, rocky slopes with juniper
Ce5	Cevizli - Salihler, mixed Turkish Red Pine and Anatolian Black Pine with oak
Cg1	Çığlıkara, Elmalı: cedar (80%), juniper (20%)
Cg2	Çığlıkara, Elmalı: cedar (80-100%)
Cg3	Çığlıkara, Elmalı: cedar forest with little understorey though some lying dead wood, steeply sloping
Cg4	Çığlıkara, Elmalı: cedar, many old, a few with dead tops; mid strata maple, some very old, large open grassy bowl halfway along survey route.
Cg5	Çığlıkara, Elmalı: cedar, many old, tall (18-22 m) and v. straight trees, a few with dead tops; mid strata maple, some very old, open grassy bowls.
Cg6	Çığlıkara, Elmalı: grassy plain at 1500 m with junipers and rocky outcrops
Cg7	Çığlıkara, Elmalı: sparsely vegetated alpine slope 1700-2000 m
Ch1	Cehennem Deresi: Turkish Red Pine (85%), maquis understorey (15%). Best survey so far!
Ci1	Ciçekbaba south: alpine, open rocky ground, Anatolian Black Pine clumps.
Ci2	Ciçekbaba south: mature Anatolian Black Pine, no understorey. Two grassy plateaus with stream.
Ci3	Çiçekbaba south: Anatolian Black Pine / Turkish Red Pine transitory zone; plus some mature planes and alders bordering stream.
Ci4	Çiçekbaba south: Turkish Red Pine, mixed understorey
Ci5	Çiçekbaba, Kartal Gölü: alpine, snow patches, mostly open but with scattered Anatolian Black Pine patches; lake surrounded by short grass plain.
Ci6	Çiçekbaba, Kartal Gölü: Anatolian Black Pine, very old growth, no understorey but lying dead wood.

Appendix D (cont'd)

Ci7	Çiçekbaba, Kartal Gölü: mature Anatolian Black Pine, large areas of young trees, several streams. V. little understorey.
Cr1	Çardak Yayla: beech and oak (Q. cerris) mature woodland, much open ground
Cv1	Çavusköy - Markiz Dagi, Arbutus-dominated maquis and scrub
Da1	Datça, Hurmabalık Phoenix theophrasti site: garrigue (Genista and Euphobia)
Da3	Datça: maquis, mature Arbutus andrachne, closed canopy, no understorey
Da4	Datça: maquis, short, dominated by Arbutus andrachne and A unedo
Da5	Datça: maquis, short, part of area largely cleared of Arbutus
Da6	Datça: maquis, mature Arbutus andrachne, closed canopy, no understorey
Di1	Dibek: alpine zone immediately above tree-line (cedar) at 1950 m+.
Di2	Dibek: edge of mixed Turkish Red Pine & cedar forest opening out in 2nd half of survey to new area of cedar & pine growth with bushy shrubs and herbs.
Di3	Dibek: upper edge of cedar zone, bordering alpine at 1800 m. Little understorey, steeply sloping.
Di4	Dibek: young cedar forest and forest openings with loosely spaced deciduous shrubs and young cedars; good growth of tall herbs.
Dm1	Damalanı (near Gülnar): maquis. Looks potentially good for plants & butterflies.
Dm2	Damalanı: Turkish Red Pine (young c.20 years), maquis, cedar
Do1	Dogruca: oriental beech forest (100%). Incomplete survey due to heavy rain.
Du1	Dumanli Dag: Kirkkavak-Derebucak, alpine
Du2	Dumanli Dag: Kirkkavat-Derebucak, Anatolian Black Pine, cedar and fir
Du3	Dumanli Dag: Kirkkavat-Derebucak, juniper
Ek1	Eskisögüt Yolu: Calabrian pine (80%), open rock (20%)
Em1	Emecik: Turkish Red Pine, young trees, cistus dominated understorey
Er1	Ertas - Markiz Dagi, Arbutus, Turkish Red Pine and cultivation
Ey1	Eynif - Kavanozdagi, mixed cedar, fir and juniper
Ga1	Gavur Dagı: alpine (2000 m+) steep slope

Appendix D (cont'd)

Ga2	Gavur Dagı: Anatolian Black Pine (90%), open areas (10%). Walked in circle.
Gb1	Nr Gülek on Adana-Pozantı road: open juniper woodland. Walked a circuit.
Ge1	Gembos - Ibradi daglari, juniper
Ge2	Gembos - Ibradi daglari, maquis and juniper
Kk1	Kayrak: maquis with mature oaks (70%), open rocky areas (30%)
Kl1	Karaisalı, near Adana: Turkish Red Pine
Kn1	Katrandag - cedar and juniper
Kn2	Yeni Katrandag
Ko1	Köprülü Canyon National Park: Turkish Red Pine
Ko2	Köprülü Canyon National Park: Turkish Red Pine with Anatolian Black Pine, cedar and oak
Ko3	Köprülü Canyon National Park: cypress
Ko4	Köprülü Canyon National Park: maquis
Ko5	Köprülü Canyon National Park: Pinus nigra, Cedruslibani, Abies cilicica, Pinus brutia
Kp1	Kapıkargın, Dalaman: maquis (Arbutus) and Turkish Red Pine with little understorey
Kr1	Karacaören: liquidambar (60-70%), Turkish Red Pine (20-30%), high proportion of standing dead trees. Open 'leggy' understorey.
Ks1	Kas - Kekova: maquis
Ks2	Kas - maquis
Ks3	Kas: maquis with olives
Ks4	Kas: maquis, olive dominant (80%)
Kt1	Karatas Yani: cedar & Anatolian Black Pine forest , open grassy areas
Ku1	Kırksu Vadisi:Anatolian Black Pine (fairly mature, 90%), open areas (10%)
Ky1	Karayilan
Ky2	Karayilan - alpine
Kz1	Karpuz Cayi - Turkish Red Pine with some oak, alder and plane
Ma1	Manavgat: Turkish Red Pine (60-70%), stone pine (30-40%) shorter trees (tallest c10 m). Dense patches of scrubby understorey dominated by myrtle and pistachio (P lentiscus)

Appendix D (cont'd)

Ma2	Manavgat: Turkish Red Pine (60-90%), stone pine (10-30%) 95% canopy; patchy understorey, some very dense.
Ol4	Olympos National Park: Turkish Red Pine
Sa1	Samadan Bölgesi: Anatolian Black Pine (100%) with open areas
Sa2	Samandag, Ceylandere: maquis, 'good quality'
Sa3	Samandag, Musa Dagı: box and oak (Q. cerris)
Ge3	Gembos - Ibradi daglari, old Turkish Red Pine and young cedar, old juniper and fir lower down
Ge4	Gembos - Ibradi daglari, sparse maquis with juniper scrub
Gi1	Giden Gelmez - alpine meadows with juniper and Anatolian Black Pine
Gi2	Giden Gelmez - alpine with sparse juniper
Gk1	Gökgözini: cedar and fir (80%) with open areas (20%)
Gl1	Göler Yaylası: cedar (70%), open rocky ground (30%)
Gl2	Göler Yaylası: fir (60%), cedar (20%), open ground (20%)
Gm1	Gülmez Dagı, above Asarönü: cedar with maquis understorey, maquis generally dominant
Gn1	Gündogmus - Karadag, Turkish Red Pine, with plane and alder
Go1	Göbüt: cedar (95%), maquis understory (5%)
Gu1	Gulen Dagi - Turkish Red Pine with some oak
Gu3	Gulen Dagi - mixed Turkish Red Pine and fir
Gy1	Geyik Daglari - alpine
Gy2	Geyik Daglari - fir, juniper and oak
Gy3	Geyik Daglari - oak, coppiced shrubland and some juniper
Gz1	Gazipasa: Gicit-Anitli, maquis
Gz2	Gazipasa: Gicit-Anitli, maquis (Q coccifera)
Ha1	Hasa Çardak: Maquis (Q. cerris, coppiced)
Hc1	Hacer Ormanı: bac pine (80%), rocky scrub (20%)
Hi1	Hinzirli: Anatolian Black Pine
Hi2	Hinzirli: maquis (deciduous), coppiced, quite heavily grazed
Hi3	Hinzirli: mature Anatolian Black Pine (dominant) with cedar and fir
Hl1	Halbur Yaylası: fir (mature & regeneration, 90%), open rocks (10%)
Ib1	Ibradı: juniper woodland (60-70%), many rocky open areas, rich grass and herb layer

Appendix D (cont'd)

Ib2	Ibradı: tall (8-10 m) juniper shrubland (60-70%), hay meadows and cultivation
Ib3	Ibradi - Gümüsdamla, fir with some Turkish Red Pine, cedar and juniper
Ic1	Incircikdagı, Dalaman: Turkish Red Pine, some understorey, overlooking Iztuzu beach
In1	Ininbasi Tepe - Karaöz, Markiz Dagi, Turkish Red Pine and maquis
Is1	Iskenderun, Acarca: tall maquis
Is2	Iskenderun: maquis, tall Quercus
Is3	Iskenderun: oriental beech, mature trees and very large coppice stools
Iv1	Ivaçık: juniper (60%), open ground (40%)
Ka1	Kalkan: grazed maquis, dominated by Q coccifera
Ka2	Kalkan: maquis dominated by Q coccifera, grazed
Kc1	Kurtkulagı, near Tufanbeyli: maquis (Q cerris, 85%), with Anatolian Black Pine above (15%)
Kd1	Kırandag: maquis, average 2 m height, Arbutus andrachne dominant (50%+)
Kd2	Kırandag: maquis, tallest trees Arbutus andrachne (>50%) and Turkish Red Pine, vegetation generally 'leggy'; cultivation
Kg1	Köröglubeli: Anatolian Black Pine (100%). Young of Krüper's nuthatch, long-tailed tit and chaffinch seen>
Kg2	Köröglubeli: Turkish Red Pine woodland (70%). open areas (30%)
Kg3	Köröglubeli: cedar (semi-mature, 100%)
Kh1	Kırıkhan: Turkish Red Pine
Ki1	Köycegiz, Gökdere: liquidambar and Turkish Red Pine, some understorey
Ki2	Köycegiz, Hamitköy: liquidambar, isolated stand surrounded by cultivation, cattle grazed. Some wet areas, understorey, mature even-aged trees, closed canopy.
Ki4	Köycegiz, Kavakarası: liquidambar, patchwork of habitats, many dead standing trees, not generally high water table, well-developed understorey.
Ki5	Köycegiz, Kızılyaka: Liquidambar, fragments bordered by cultivation and grazing meadows; forest grazed so no understorey. Generally dry.

Appendix D (cont'd)

Ki6	Köycegiz, Lambataklıgı: liquidambar. Drier site, wide variety of tree & plant species.
Ki7	Köycegiz, Lambataklıgı: liquidambar. Wet site, wide variety of tree & plant species.
Ki8	Köycegiz, Toparlar: liquidambar patches with cultivation and citrus groves. Wet, good understorey, standing dead trees.
Sa4	Samandag: Turkish Red Pine, good maquis understorey
Sa5	Samandag: Musa Dagı: beech, oak, hornbeam
Ta1	Tarsus to Çamlıayla road: maquis (85%, Q coccifera), open ground 15%. Disturbed by road traffic.
Ta2	Tarsus to Çamlıayla road: maquis (85%, Q coccifera), open ground 15%. Heavily disturbed by busy road and quarry
Te1	Termessos National Park: Turkish Red Pine with maquis understorey. More open areas used by black francolin
Uc1	Üçgöz: beech, good understorey, holiday disturbance
Uc2	Üçgöz: Turkish Red Pine, young trees, traffic disturbance
Uc3	Üçgöz: mature oak (Q. cerris) + understorey
Ul1	Ulupınar: Turkish Red Pine (90%), maquis understorey (Q cerris, 10%)
Um1	Umutalanı, near Adana: juniper with open areas (1-00%). Walked a circular route.
XX1	Alanya: Dim Valley and uplands, fir and Anatolian Black Pine
Ya1	Yaragzı: juniper (50%, mature), open rocky ground (50%). Summer grazing settlements 3+
Ya2	Yaragzı: maquis (grazed)
Ye1	Yeldegirmeni Tepe, Dalaman: maquis, equally dominated by olive and arbutus
Yr1	Yarpuz: Anatolian Black Pine
Yr2	Yarpuz: Turkish Red Pine
Yv1	Yavsan Yaylası: cedar (more mature, 95%), open areas (5%)
Yv2	Yavsan Yaylası: maquis (grazed, 60%), open rocky grassy (40%). (28 black-headed buntings recorded during hour indicate open-ness of habitat.)
Yv3	Yavsan Yaylası: yound cedar (80%): maquis understorey (20%)

Appendix D (cont'd)

Ze1	Zeynepdibi stream 2: juniper woodland (all three juniper spp plus Q coccifera)
Ze2	Zeynepdibi stream: juniper woodland (all three juniper spp plus Q coccifera)
Zi1	Ziyaret mountain: arbutus maquis, moderately heavily grazed
Zi3	Ziyaret mountain: maquis

Appendix E

Codes of the Classification System for the PC-Ord

Physiognomic Class	Physiognomic Class Codes
Grassland	G
Shrubland	S
Forest	F
Woodland	W
Dwarf Shrubland	A

Physiognomic Subclass	Physiognomic Subclass Codes
Evergreen	E
Deciduous	D
Mixed	M

Physiognomic Group (for Supraclass Herb Dominated	Physiognomic Group Codes
wc	Wood clumped
sp	Sparse
w	wood
vg	vegetated
s	sclerophyllus
b	Broad-leaved
n	needle-leaved
m	mixed
h	shrub

Physiognomic Formation	Physiognomic Formation Codes
Coastal	C
Coline	O
Montane	M
Alpine	A

Alliance	Alliance Codes
Anatolian Black Pine	b
Turkish Red Pine	c
Turkish Red Pine - Maquis	c
Maple	d
Taurus Cedar	e
Taurus Fir	f
Oriental Beech	h
Alpine grassland	i
Juniper	j
Kermes Oak	k
Alder	l
Arbutus maquis	a
maquis	m
Olive Maquis	m
Anatolian Black Pine - Fir	n
Anatolian Black Pine, Taurus Cedar, Taurus Fir	n
Turkish Red Pine – Taurus Fir	n
Turkish Red Pine and Anatolian Black Pine	n
Taurus Cedar and Anatolian Black Pine	n
Taurus Cedar-Turkish Red Pine	n
Taurus Cedar- Taurus Fir	n
Taurus Cedar- Taurus Fir-Juniper	n
Taurus Fir and Anatolian Black Pine	n
Taurus Fir and Taurus Cedar	n

Appendix E (cont'd)

Anatolian Black Pine-Taurus Cedar-Taurus Fir-Turkish Red Pine	n
Deciduous Oak Shrubland	o
Downy oak	o
Oak maquis	o
Turkey Oak	o
Liquidambar	q
Box	s
Juniper and Kermes Oak	u
Cypress	y
Juniper-Oak-Turkish Red Pine	z

Appendix F

List of bird species recorded during the field surveys (in alphabetical order)

No	Scientific name	English name
1.	Acanthis cannabina	Linnet
2.	Acanthis cannabina	Mistle thrush
3.	Accipiter brevipes	Levant sparrowhawk
4.	Accipiter nisus	Sparrow hawk
5.	Aegithalos caudatus	Long-tailed tit
6.	Alectoris chukar	Chukar
7.	Anthus campestris	Tawny pipit
8.	Anthus spinoletta	Water Pipit
9.	Anthus trivialis	Tree pipit
10.	Apus apus	Swift
11.	Apus melba	Alpine swift
12.	Buteo buteo	Buzzard
13.	Buteo rufinus	Long-legged buzzard
14.	Carduelis carduelis	Goldfinch
15.	Carduelis chloris	Greenfinch
16.	Cercotrichas galactotes	Rufous bush-chat
17.	Certhia brachydactyla	Short-toed treecreeper
18.	Cettia cetti	Cetti's warbler
19.	Charadrius dubius	Little ringed plover
20.	Ciconia ciconia	White Stork
21.	Cinclus cinclus	Dipper
22.	Circaetus gallicus	Short-toed eagle
23.	Columba oenas	Stock dove
24.	Columba palumbus	Woodpigeon
25.	Coracias garrulus	Roller

Appendix F (cont'd)

26.	Corvus (corone) corvix	Hooded crow
27.	Corvus corax	Raven
28.	Cuculus canorus	Cuckoo
29.	Delichon urbica	House martin
30.	Dendrocopus leucotos	White-backed woodpecker
31.	Dendrocopus major	Great spotted woodpecker
32.	Dendrocopus medius	Middle spotted woodpecker
33.	Dendrocopus minor	Lesser spotted woodpecker
34.	Dendrocopus syriacus	Syrian woodpecker
35.	Emberiza caesia	Cretzschmar's bunting
36.	Emberiza cia	Rock bunting
37.	Emberiza cineracea	Cinereous bunting
38.	Emberiza cirlus	Cirl Bunting
39.	Emberiza hortulana	Ortolan bunting
40.	Emberiza melanocephala	Black-headed bunting
41.	Eremophila alpestris	Shore lark
42.	Eremophila alpestris	Shore (Horned) Lark
43.	Erithacus rubecula	Robin
44.	Falco cherrug	Saker
45.	Falco peregrinus	Peregrine
46.	Falco subbuteo	Hobby
47.	Falco tinnunculus	Kestrel
48.	Francolinus francolinus	Black francolin
49.	Fringilla coelebs	Chaffinch
50.	Galerida cristata	Crested lark
51.	Garrulus glandarius	Jay
52.	Hieraaetus pennatus	Booted eagle
53.	Hippolais languida	Upcher's warbler
54.	Hippolais olivetorum	Olive-tree warbler
55.	Hippolais pallida	Olivaceous warbler
56.	Hirundo daurica	Red-rumped swallow
57.	Hirundo rustica	Swallow
58.	Irania gutturalis	White-throated robin

Appendix F (cont'd)

59.	Jynx torquilla	Wryneck
60.	Lanius collurio	Red-backed shrike
61.	Lanius minor	Lesser grey shrike
62.	Lanius nubicus	Masked shrike
63.	Lanius senator	Woodchat Shrike
64.	Loxia curvirostra	Common (Red) Crossbill
65.	Lullula arborea	Woodlark
66.	Luscinia megarhynchos	Nightingale
67.	Melanocorypha bimaculata	Bimaculated lark
68.	Merops apiaster	Bee-eater
69.	Miliaria calandra	Corn bunting
70.	Monticola saxatalis	Rock thrush
71.	Monticola solitarius	Blue rock thrush
72.	Montifringilla nivalis	Snowfinch
73.	Motacilla alba	White wagtail
74.	Motacilla cinerea	Grey wagtail
75.	Muscicapa striata	Spotted flycatcher
76.	Oenanthe finschii	Finsch's wheatear
77.	Oenanthe hispanica	Black-eared wheatear
78.	Oenanthe isabellina	Isabelline wheatear
79.	Oenanthe oenanthe	Wheatear
80.	Oriolus oriolus	Golden oriole
81.	Otus scops	Scops owl
82.	Parus ater	Coal tit
83.	Parus caeruleus	Blue tit
84.	Parus lugubris	Sombre tit
85.	Parus major	Great tit
86.	Passer domesticus	House sparrow
87.	Passer hispaniolensis	Spanish sparrow
88.	Petronia petronia	Rock sparrow
89.	Phoenicurus ochruros	Black redstart
90.	Phoenicurus phoenicurus	Redstart
91.	Phylloscopus (bonelli) orientalis	Green Warbler

Appendix F (cont'd)

92.	Phylloscopus collybita	Chiffchaff
93.	Phylloscopus trochilus	Willow warbler
94.	Picus viridis	Green woodpecker
95.	Prunella collaris	Alpine accentor
96.	Ptyonoprogne rupestris	Crag martin
97.	Pycnonotus xanthopygos	Yellow-vented bulbul
98.	Pyrrhocorax graculus	Alpine chough
99.	Pyrrhocorax pyrrhocorax	Chough
100.	Regulus regulus	Goldcrest
101.	Rhodopechys sanguinea	Crimson-winged Finch
102.	Serinus pusillus	Red-fronted serin
103.	Serinus serinus	Serin
104.	Sitta europea	Nuthatch
105.	Sitta krueperi	Krüper's nuthatch
106.	Sitta neumayer	Rock nuthatch
107.	Streptopelia decaocto	Collared dove
108.	Streptopelia turtur	Turtle dove
109.	Strix aluco	Tawny owl
110.	Sylvia atricapilla	Blackcap
111.	Sylvia cantillans	Subalpine warbler
112.	Sylvia communis	Whitethroat
113.	Sylvia curruca	Lesser whitethroat
114.	Sylvia hortensis	Orphean warbler
115.	Sylvia melanocephala	Sardinian warbler
116.	Sylvia rueppelli	Rüppell's warbler
117.	Troglodytes troglodytes	Winter Wren
118.	Turdus merula	Blackbird
119.	Turdus philomelos	Song Thrush
120.	Turdus viscivorus	Mistle thrush
121.	Upupa epops	Hoopoe

Appendix G

Richness, Evenness, Diversity values of the Sites according to Breeding Bird Data

Num.	Name	Richness	Evennes	Shannon-Weber Diversity	Simpson's
1	Ci1GwcMi	11	0.974	2.336	0.8967
2	Ak3GspAi	13	0.970	2.488	0.9088
3	Cg7GspMi	17	0.991	2.807	0.9381
4	Al1GwMi	19	0.982	2.891	0.9418
5	An1GspMi	13	0.969	2.485	0.9087
6	Ga1GvgAi	9	0.965	2.121	0.8697
7	Da4SEsCa	6	0.955	1.711	0.8075
8	Da5SEsCa	5	0.962	1.548	0.7759
9	Da6SEsOa	5	0.955	1.538	0.7694
10	Da3SEsOa	5	0.974	1.567	0.7835
11	Kp1SEsCa	7	0.957	1.862	0.8296
12	Kd2SEsCa	4	0.906	1.255	0.6797
13	Kd1SEsCa	9	0.940	2.066	0.8553
14	Zi1SEsOa	10	0.980	2.256	0.8898
15	Sa5FDbOh	8	0.933	1.940	0.8386
16	Uc1FDbCh	10	0.926	2.132	0.8678
17	Cr1FDbMh	11	0.971	2.329	0.8949
18	Ci3FEnCb	13	0.962	2.467	0.9063
19	Ci2FEnCb	10	0.972	2.237	0.8867
20	Ak2WEnMb	19	0.981	2.888	0.9409
21	Ak1WEnMb	12	0.966	2.400	0.9021
22	Ky1FEnMb	10	0.924	2.128	0.8602
23	An5FEnMb	10	0.959	2.209	0.8797
24	An2FEnMb	11	0.966	2.317	0.8929

Appendix G (con'd)

25	Ax3FEnMb	12	0.949	2.359	0.8922
26	Ax4FEnMb	9	0.932	2.048	0.8524
27	Bs3FEnMf	12	0.949	2.359	0.8961
28	Bs2FEmMn	14	0.965	2.547	0.9157
125	Ax2SDbOo	11	0.978	2.346	0.8997
126	Gy3SDbMo	19	0.977	2.877	0.9400
127	Kk1SEsOo	12	0.978	2.429	0.9062
128	Is2SEsOo	8	0.909	1.890	0.8141
129	Ks4SEsCm	6	0.991	1.775	0.8276
130	Ks3SEsCm	6	1.000	1.792	0.8333
131	Is3FDbMh	10	0.969	2.231	0.8844
132	Ci5GwcMi	12	0.981	2.437	0.9083
133	Ci6FEnMb	12	0.959	2.384	0.8989
134	Ci7FEnMb	8	0.961	1.999	0.8541
135	Be1FDbOl	9	0.965	2.121	0.8702
136	Ze1WEnMj	13	0.971	2.490	0.9110
137	Ze2WEnMj	14	0.977	2.579	0.9199
138	Di3WEnMe	12	0.951	2.363	0.8943
139	Di1GwMi	17	0.980	2.776	0.9342
140	Di4FEnMe	15	0.961	2.602	0.9185
141	Di2GwMi	14	0.972	2.566	0.9179
142	Er1SEsOa	13	0.979	2.510	0.9145
143	In1FEnCc	11	0.943	2.261	0.8828
144	Cv1SEsCa	8	0.989	2.057	0.8693
145	Ol1FEnMe	23	0.966	3.027	0.9458
146	Te1FEnCc	6	0.953	1.708	0.8042
147	Du2FEmMn	13	0.956	2.451	0.9053
148	Du1GhMi	14	0.957	2.526	0.9096
149	Du3FEnj	13	0.963	2.469	0.9075
150	Ey1FEnOn	20	0.967	2.897	0.9395
151	Ge1WEnMj	19	0.964	2.840	0.9342
152	Ar4SEmOu	6	0.982	1.760	0.8229
153	Ge4SEnOj	16	0.974	2.699	0.9280

Appendix G (con'd)

154	Ge3FEnMc	17	0.951	2.695	0.9217
155	Ge2SEsOk	16	0.967	2.682	0.9250
29	Ga2FEnMb	9	0.974	2.140	0.8759
30	Ak4FEnMb	12	0.946	2.350	0.8937
31	Ar1FEnMb	7	0.979	1.904	0.8451
32	Hi1FEnMb	7	0.972	1.891	0.8426
33	Yr1FEnMb	9	0.970	2.132	0.8740
34	Sa3SMbOs	5	0.941	1.515	0.7580
35	Ic1FEnCc	7	0.936	1.821	0.8200
36	Ci4FEnCc	8	0.976	2.029	0.8631
37	Ba2FEnOc	12	0.936	2.327	0.8862
38	Ba1FEnOc	10	0.947	2.181	0.8718
39	Ol4FEnCc	2	0.979	0.678	0.4853
40	Ko2FEnOc	19	0.966	2.846	0.9359
41	Ko1FEnOc	3	0.873	0.960	0.5823
42	Gu2GOi	11	0.952	2.284	0.8848
43	Gu1FEnOc	11	0.961	2.305	0.8897
44	Kz1FEnOc	7	0.952	1.853	0.8244
45	Gu3FEnOn	11	0.914	2.191	0.8690
46	Gn1FEnCc	8	0.972	2.021	0.8580
47	Gn2FEnCc	11	0.952	2.283	0.8859
48	An9FEnc	11	0.963	2.310	0.8922
49	An8FEnc	10	0.956	2.202	0.8776
50	An1FEnMc	15	0.974	2.637	0.9239
51	Ek1FEnMc	14	0.984	2.597	0.9224
52	Dm2FEnMc	12	0.969	2.409	0.9027
53	Bg1FEnc	9	0.964	2.119	0.8689
54	Ch1FEnOc	17	0.956	2.710	0.9259
55	Ca1FEnOc	15	0.970	2.627	0.9216
56	Sa4FEnCc	14	0.956	2.523	0.9115
57	Ar3FEnOc	10	0.980	2.257	0.8909
58	Kh1FEnOc	15	0.966	2.617	0.9207
59	Uc2FEnMc	9	0.944	2.074	0.8601

Appendix G (con'd)

60	Yr2FEnMc	10	0.972	2.237	0.8862
61	Em1FEnCc	7	0.951	1.850	0.8292
62	Ba3FEnMe	15	0.961	2.602	0.9181
63	Ba5FEnOe	13	0.961	2.466	0.9060
64	Kn1FEnMe	14	0.927	2.447	0.8939
65	Kn2FEnMe	15	0.942	2.552	0.9094
66	Cg3FEnMe	10	0.959	2.208	0.8795
67	Cg2FEnMe	15	0.952	2.577	0.9147
68	Cg1FEnMe	19	0.956	2.816	0.9326
69	Cg5FEnMe	17	0.965	2.735	0.9286
70	Cg4FEnMe	16	0.956	2.651	0.9207
71	Al3FEnOe	17	0.959	2.717	0.9258
72	Al2FEnMe	15	0.942	2.552	0.9103
73	Gk1FEmMn	8	0.973	2.023	0.8623
74	Bs1WEnMe	9	0.956	2.100	0.8672
75	Am1FEnMe	14	0.948	2.502	0.9088
76	Ak6FEnMe	19	0.955	2.812	0.9321
77	Ko3FEnOy	10	0.941	2.167	0.8698
78	Ko5FEmOn	19	0.978	2.879	0.9403
79	Uc3FDbOo	12	0.944	2.347	0.8930
80	Ha1FDbMo	7	0.952	1.853	0.8244
81	Hs1FDbCw	12	0.979	2.434	0.9068
82	Ar6FEnMf	14	0.966	2.550	0.9146
83	Ar5FEnMf	15	0.945	2.558	0.9119
84	Ax1FEnMf	10	0.952	2.192	0.8764
85	Gy2FEnMf	14	0.945	2.493	0.9068
86	Am2FEnMf	7	0.967	1.883	0.8399
87	Da1AEsCg	5	0.973	1.566	0.7812
88	Ba4WEnMj	11	0.947	2.271	0.8837
89	Cg6GhMi	23	0.965	3.025	0.9455
90	Al5WEnMj	20	0.948	2.839	0.9317
91	Ib2WEnOj	18	0.966	2.791	0.9321
92	Ib1WEnOj	20	0.983	2.943	0.9448

Appendix G (con'd)

93	Ya1WEnj	13	0.980	2.515	0.9153
94	Gb1WEnMj	18	0.953	2.755	0.9260
95	Ka2SEnCk	13	0.963	2.469	0.9076
96	Ka1SEnOk	12	0.939	2.334	0.8843
97	Gz2SEnOk	9	0.974	2.141	0.8746
98	Ta1SEsCk	9	0.964	2.118	0.8703
99	Ta2SEsCk	13	0.970	2.487	0.9106
100	Ay1SEnOk	14	0.952	2.513	0.9073
101	Ki5FDbCq	13	0.964	2.472	0.9057
102	Ki1FDbCq	5	0.967	1.556	0.7784
103	Ki9FDbCq	17	0.981	2.780	0.9345
104	Ki8FDbCq	14	0.955	2.520	0.9110
105	KX1FDbCq	16	0.954	2.646	0.9194
106	Ki4FDbCq	20	0.978	2.930	0.9430
107	KX2FDbCq	14	0.967	2.551	0.9155
108	Ki7FDbCq	13	0.968	2.484	0.9105
109	Ki6FDbCq	13	0.967	2.480	0.9094
110	Kr1FDbCq	5	0.955	1.537	0.7709
111	Al4WDbMd	18	0.980	2.833	0.9375
112	Ye1SEsCk	4	0.968	1.342	0.7287
113	Gm1WEnOe	4	0.955	1.325	0.7182
114	Ks1SEsCk	4	0.956	1.326	0.7192
115	Ks2SEsCk	9	0.956	2.099	0.8647
116	Ko4SEsOa	7	0.963	1.874	0.8343
117	Gz1SEsCk	3	0.987	1.084	0.6569
118	Dm1SEsMm	14	0.984	2.596	0.9224
119	Ya2SEsOk	14	0.975	2.572	0.9181
120	Zi3SEsOk	12	0.974	2.419	0.9056
121	Is1SEsOk	10	0.960	2.210	0.8823
122	Hi2SEsMk	8	0.942	1.959	0.8432
123	Sa2SEsOk	7	0.930	1.809	0.8142
124	An7SDbOo	10	0.936	2.155	0.8667

Appendix G (con'd)

156	Ib3FEnMf	19	0.957	2.819	0.9323
157	Ce1FEnMf	11	0.959	2.299	0.8898
158	Ce4GhAi	9	0.986	2.166	0.8813
159	Ce5FEmOn	17	0.949	2.689	0.9224
160	Ce2FEnOz	19	0.971	2.858	0.9371
161	Ce3SDbMx	12	0.943	2.343	0.8881
162	Ar2SEsOk	12	0.961	2.387	0.8960
163	Gi2GhAi	16	0.979	2.715	0.9294
164	Gi3GhMi	27	0.973	3.206	0.9555
165	As1SEnMj	15	0.971	2.629	0.9222
166	Bo1GMi	10	0.952	2.193	0.8760
167	Bo2WEnMf	22	0.966	2.984	0.9439
168	Bo3FEnMn	12	0.961	2.388	0.9014
169	Bo4WDbMo	26	0.971	3.162	0.9536
170	An6FEnMf	8	0.950	1.976	0.8478
171	Kl1FEbOc	15	0.981	2.657	0.9260
172	Um1FEnMj	10	0.954	2.196	0.8781
173	Hc1FEnMb	9	0.965	2.120	0.8708
174	Sa1FEnMb	11	0.959	2.300	0.8904
175	Ul1FEnOc	10	0.955	2.200	0.8788
176	Kg1FEnMb	15	0.943	2.553	0.9116
177	Kg3FEnMe	11	0.958	2.297	0.8904
178	Kg2FEnMc	8	0.977	2.032	0.8627
179	Gl1FEnMe	16	0.964	2.672	0.9238
180	Gl2FEnMf	15	0.958	2.595	0.9169
181	Iv1WEnMj	17	0.964	2.731	0.9281
182	Kc1SEsMo	9	0.957	2.103	0.8678
183	Ad3FEnOc	17	0.967	2.738	0.9298
184	Go1FEnMe	12	0.969	2.409	0.9042
185	Ad2SEsOk	12	0.961	2.387	0.8996
186	Ad1SEsOk	16	0.954	2.646	0.9173
187	Ku1FEnMb	10	0.963	2.218	0.8832

Appendix G (con'd)

188	Do1FDbMh	9	0.974	2.141	0.8752
189	Hl1FEnMf	18	0.972	2.809	0.9355
190	Kt1FEmMn	11	0.950	2.278	0.8861
191	Yv3FEnMe	17	0.969	2.747	0.9301
192	Yv1FEnMe	13	0.945	2.423	0.9004
193	Yv2SEsOm	10	0.927	2.134	0.8537
Averages		12	1 0.961	2.322	0.8822

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EDUCATION

Degree	Institution	Year of Graduation
MS	METU Biological Sciences	1998
BS	METU Biology	1995
High School	Şehremini High School, İstanbul	1987

WORK EXPERIENCE

Year	Place	Enrollment
2006- Present	Nature Conservation Centre	CEO
2004 – 2006	Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitats (TEMA)	Project Manager
1999- 2004	WWF Turkey	Project Officer
1997 – 1999	Ministry of Forestry, General Directorate of National Parks and Game- Wildlife	Ecologist
1994-1996	Bilimce Science Activities Co.	Ecologist

FOREIGN LANGUAGES

Advanced English

PUBLICATIONS

1. Zeydanlı, U., Turak, A., Tuğ, S., Kaya, B., Domaç, A., Çakaroğulları D., Kündük, H., Çekiç, O., "Boşluk Analizi Kılavuzu". Biyolojik Çeşitlilik İzleme Birimi, Ankara, Türkiye, 2005.

2. Zeydanlı, U., Welch, H.J., Welch, G.R., Altıntaş, M. & Domaç, A., Gap Analysis and Priority Conservation Area Selection for Mediterranean Turkey: preliminary technical report Turkish Foundation for Nature Conservation (WWF-Turkey), İstanbul, Turkey, 2005.

HOBBIES

Photography, Reading, Tennis, Traveling, Camping and tracking.