Pak. J. Bot., 41(5): 2305-2321, 2009.

PLANT DIVERSITY AND CONSERVATION OF THE NORTH-EAST PHRYGIA REGION UNDER THE IMPACT OF LAND DEGRADATION AND DESERTIFICATION (CENTRAL ANATOLIA, TURKEY)

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Abstract

Plant diversity and ecological structure of an area which is in critical level in terms of land degradation and erosion are quite important. North-east part of the Phrygia Region has densely been under natural and anthropogenic effects since 3000 B.C. In the area, primary vegetation was destroyed in low and high parts around steppe plains and replaced by a secondary vegetation with antropogenic characteristics. These antropogenic effects have still continued in the region. In the course of the present study, vascular plant specimens were collected from the area and 589 species belonging to 314 genera classified within 67 families were identified. Seventy seven (13.1%) taxa are endemic to Turkey. When the risk situations of the plant taxa determined in the research area are checked according to IUCN, it can be seen that 56 taxa are in Least Concern, 9 in Near Threatened, 4 in Vulnerable risk categories. The largest family is Asteraceae (72) and the richest genus is *Centaurea* L. (13) in the area. Distributions of the plant taxa in terms of phytogeographical regions are as follows: Irano-Turanian elements: 123 (20.9%), Euro-Siberian elements: 36 (6.1%), Mediterranean elements: 33 (5.6%). Dominant biological types in the area are Hemicryptophytes (37%) and Therophytes (29.9%). A long term unsystematical use of mountain pastures leads a serious degradation. Therefore, determining the variation in the floristic composition of plant communities gives monitoring opportunity of land degradation in the region.

Introduction

Land degragation and desertification are both a natural and man-induced phenomenon, widely occuring within the Mediterranean basin. Therefore, projects related to monitoring of land degregation, erosion and desertification specifically in the Mediterranean countries including Turkey and determining bioindicator plants are of great importance (Anon., 2005; Dregne, 2002; Geist & Lambin, 2004). Central Anatolia is the far-west part of steppe and desert zones of Middle Asia and also Irano-Turanian phytogeographical region (Abahussain *et al*., 2002; Amin, 2004).

Turkey, located at the temperate region of the World, has quite rich habitat diversity because of its geomorphologic, topographic and climatic characteristics. However, natural structure of Anatolia, connected with three continents (Europe, Asia and Africa) and located at the intersection of three phytogeographical regions (Euro-Siberian, Irano-Turanian and Mediterranean), has been changed under long term natural and anthropogenic effects (Harris *et al*., 2003; Özgül & Öztaş, 2002). When the civilizations and their life spans in Anatolia are considered, it can easily be seen that plant diversity of Turkey has been under permanent effects of uncontrolled land use, overgrazing and mining activities (Küçüködük & Çetik, 1984; Uslu, 1959; Zaady *et al*., 2001). Grazing and land use are generally considered to be the most economical way of utilizing rangeland vegetation (Manzano *et al*., 2000). However, these effects always reduce plant

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cover that protects the soil and generally result in soil erosion and compaction (Blanca *et al*., 1998; Ghazanfar, 1998; Logakanthi *et al*., 2000; Bouchard *et al*., 2003; Victor & Dold, 2003). Soil properties and vegetation can also be altered over time under different land uses, management systems and soil erosion (Branson *et al*., 1981; Villamil *et al*., 2001; Harris *et al*., 2003; Rowntree *et al*., 2004; Villamil *et al*., 2001). For instance, due to the soil erosion, which is a serious problem in many countries, over 500 million tons of productive soil and large amounts of plant nutrients remove every year in Turkey (Öztaş *et al*., 2003).

Unsystematical use of an area leads to its degradation (Le Houerou, 2002). On measure of the pressure, increasing following three stages are consecutively changed: destruction of plant cover, soil cover and the lithosphere. This requires the differentiated approach to the performance of plant cover and soil-ecological monitoring of these degregation processes (Li *et al*., 2004). The set of such monitoring indices could include the most following important indicators: Floristic composition, stocks and structure of the biomass (Jauffret & Lavorel, 2003; Logakanthi *et al*., 2000; Mamytov, 1985; Teague *et al*., 2004; Vladychenskiy, 2002).

For sustainable land use, it is necessary to control the state of soil and plant cover to prevent their irreversible degradation by special monitoring systems. The main objects of monitoring are the consequences of the negative processes in ecosystem, connected with plant and soil covers. Analysis of plant diversity and ecological structure of an area which is in critical level in terms of land degragation and erosion are quite important (Macdougall *et al*., 1998; Skapetas *et al*., 2004; Vladychenskiy, 2002).

In the research area, it is quite difficult to determine the changes in plant diversity because there is no detailed study carried out before. Therefore, it is thought that the present study, aimed to determine structural components of the plant diversity of the region, will serve as a database to monitor the changes in positive or negative way and monitoring opportunity of the plant species will be able to help to know characteristics of plant diversity and preserve the gene sources.

General characteristics of the study area: North-east part of the Phrygia Valley, the study area, is located at the city borders of Eskişehir and Ankara in Central Anatolia region (Sevin, 2001), (Fig. 1). The highest points of the region belong to Sivrihisar and Arayıt mountains. Ankara-Eskişehir road and railway are also located at the region. The altitutional range of the area changes between 950 and 1800 m. The region lies in B3 square according to Davis's Grid System (1965).

Climate: Annual precipitation (mm) and precipitation regime types of city Eskişehir and county Sivrihisar are given in Table 1. Both of these areas are in semi-arid Mediterranean bioclimate zone. Table 2 summarizes the results of bioclimatic analysis based on meteorological data of Eskişehir and Sivrihisar according to Emberger method (1952).

Ombrothermic diagrams of Eskişehir and Sivrihisar are given in Figs. 2, 3 (Cireli *et al*., 1983). Dry period covers the beginning of June to October in Eskişehir and the end of May to middle of September in Sivrihisar.

Geology: Geological evolution of the region started in Paleosoic age and has still been continued. So, there are Paleosoic, Mesozoic and Quaternary aged rocks in the region (Atalay, 1987; Kulaksız, 1981).

Table 1. Annual precipitation (mm) and precipitation regime types of city Eskişehir and county Sivrihisar according to data obtained from Eskişehir and Sivrihisar meteorology stations.

Station	Spring (Sp)	Summer (S)	Fall (F)	Winter (W)	Annual	Precipitation regime
Eskişehir	120,7	54,2	71,8	127,1	373,8	W.Sp.F.S.
Sivrihisar	134,3	55,3	74,3	129,7	393,6	Sp.W.F.S.

Table 2. Bioclimatic zones of the study area according to Emberger method (1952).

Station	Altitude (m)	P (mm)	PE (mm)	M	m	S (PE/M)	Q	Bioclimate zone
Eskişehir	801	373,8	54,2	28,9	-3,7	1,8	51,9	Semi-dry mediterranean
Sivrihisar	1070	393,6	55,3	28,2	-3,3	1,9	55,3	Semi-dry mediterranean

(**P**: Annual average precipitation (mm/m^2), **PE**: Annual summer precipitation mm/m^2), **M**: Average temperature of the hottest month (^{0}C), **m**: Average temperature of the coldest month (^{0}C), **S**: Value of dry season (PE/M), **Q**: Comparison of temperature-precipitation (2000.P.(M+m+546,4) . (M-m))

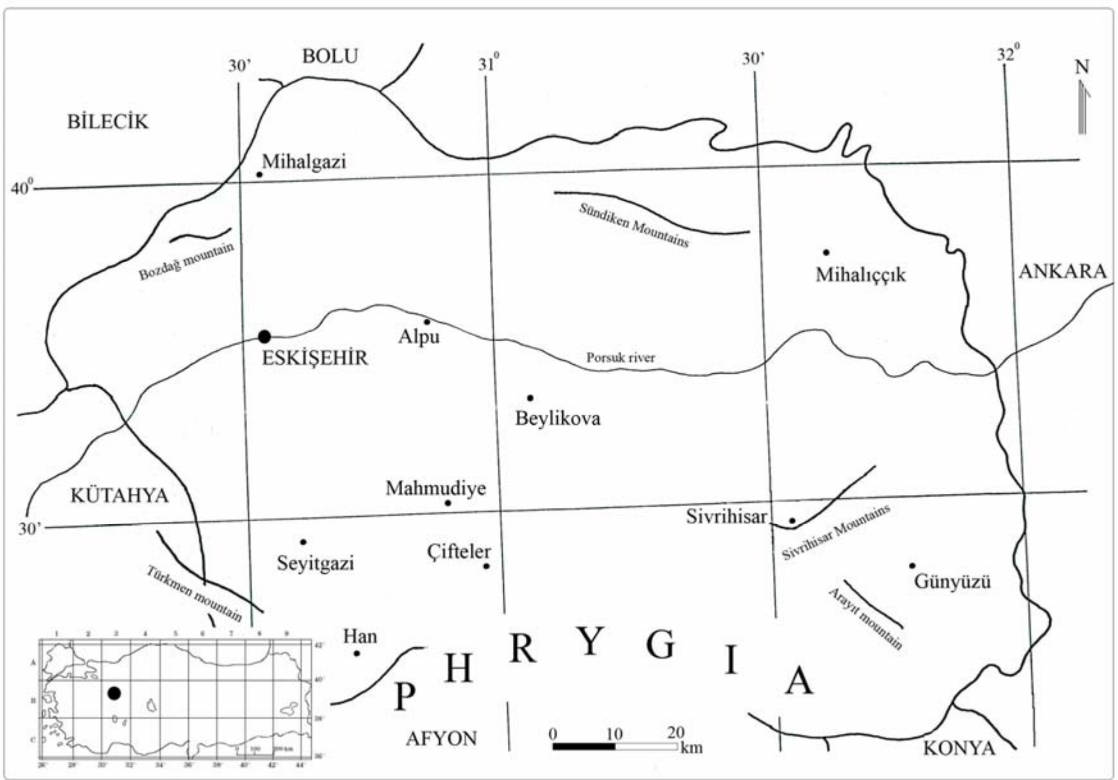

Fig. 1. Location of the study area.

Metamorphic rocks of Paleosoic age are represented as northern units, southern units and a faulted area in between these units. Albite, muscovite, chlorite quartz schist, metaconglomerate recrystallized limestone in the northern whereas talc, chlorite serpentinized schist, micaschist are present in the southern units. All these rock groups belong to Paleozoic age. Mesozoic rock groups overlie Paleosoic basement rocks with an unconformity. Triassic marbles and metadiabases are present in the lower courses. Generally, massive and partially recrystallized, less fossiliferous limestone units of Jurassic-Cretaceous age unconformably overlie Triassic units.

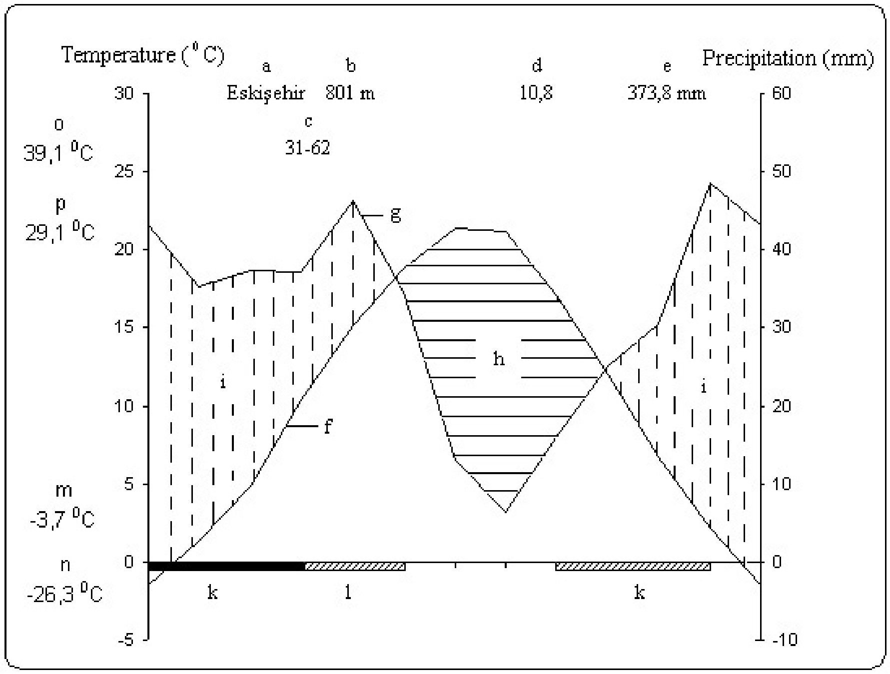

Fig. 2. Ombrothermic diagram of Eskişehir region.
(**a:** City name, **b:** Altitude, **c:** Temperature and observation year number **d:** Mean annual temperature, **e:** Mean annual precipitation, **f:** Mean monthly temperature curve, **g:** Mean monthly precipitation curve, **h:** Dry period, **i:** Rainy period, **k:** Minumum temperature of the coldest month, **l:** Annual absolute minumum temperature, **m:** Absolute maximum temperature, **n:** Maximum temperature of the hottest month)

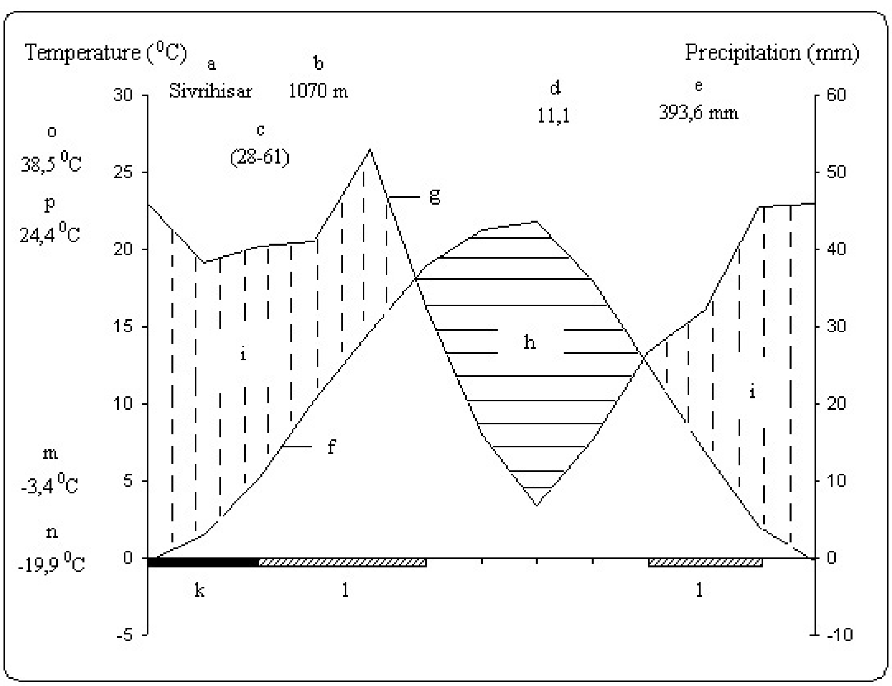

Fig. 3. Ombrothermic diagram of county Sivrihisar (Eskişehir, Turkey).
(**a:** City name, **b:** Altitude, **c:** Temperature and observation year number **d:** Mean annual temperature, **e:** Mean annual precipitation, **f:** Mean monthly temperature curve, **g:** Mean monthly precipitation curve, **h:** Dry period, **i:** Rainy period, **k:** Minumum temperature of the coldest month, **l:** Annual absolute minumum temperature, **m:** Absolute maximum temperature, **n:** Maximum temperature of the hottest month)

Cenozoic units are present over the Mesozoic units with an unconformity. Unconsolidated red green, blue sand and conglomerates of Paleogene age are at the basement; these are followed by lower Neogene aged tuff and metamorphosed volcanics. Clay, sand, unconsolidated conglomerates, volcanic tuff and lacustrine limestone are present in the upper courses of the Neogene. Quaternary units of alluvium, debris flow and their deposits are observable everywhere in the region. Metamorphic rocks in the area seperated by faults from the northern and southern units are in the form of dikes and series of dikes their locations are N 80 E/70-80 NW, N 80 W/89 NE. Alterations are common in the form of extensive serpentinisation. Studies of metamorphic rocks reveal that the grade of metamorphism is at transitional stage from lawsonite-glaucophaneschist facies to glaucophanitic greenschist facies.

Major soil types: When the major soil types in the research area are examined, it is understood that a great many of the types consist of red brown, alluvial and hidromorhpic soils (Anon., 1984). Red brown soil types have undergone erosion as a result of the disappearance of vegetation cover in the study area. Their horizon A's are generally washed, rich in skeleton items and consist of shallow soil. They are on steep slopes and flat areas which have bushes belonging to *Quercus* and *Juniperus* taxa.

They exist over the flat areas which we can call plain that contain mechanical combinations of red brown clay and sticky mud with clay and they are Zonal (mature) soil types. Calcification plays a role in their formation. Their natural drainage is good. Because of the oxidation of the iron in the soil, their colour seems to be red. The upper soil contains low quantities of organic substance. Horizon A is typically reddish brown or red and soft. Horizon B is red or reddish brown, heavier and quite tight. It has horizon C which gradually penetrates to the main material. The area, both on the surface and underneath consists of 10-15% stone and pebble. The main material is marn, chist with clay and chalk. Alluvial soils cover quite a narrow area along small streams in and around the research area. Generally there are no horizons. But there are mineral layers of different characters. They are always or seasonally wet. Hidromorphic alluvial soils are wet and marshy for most of the year because of surface flows. There are generally plants in shallow water.

Mean values of physical and chemical analysis results of the soil samples taken from different vegetation types of the research area are given in Table 3. Soils in the area where shrub vegetation is dominant are heavy textured. pH levels of the soils changes between low and medium basic levels. Soils can be considered as rich in terms of lime and as low in terms of organic matter. Total nitrogen amount is related to total organic matter amount in the soils. Phosphorus is in middle level.

It is determined that the soils taken from the areas where meadow vegetation is dominant are light textured. Soil pH is in middle basic level. Soil solution shows low calcerous characteristics. The soils in the research area which are poor in respect of organic matter and total nitrogen concentration shows difference based on the organic matter concentration. Phosphorus is in middle level.

The soil samples taken from the areas dominated by steppe vegetation are light textured. Soil pH is in middle basic level. Soil solution belonging to shrub is low calcerous. Organic matter is more than in the steppic areas and is in medium level. Total nitrogen amount also shows similarity to organic matter amount.

Table 3. Some physical and chemical analysis belonging to different vegetation types in the study area.

	Depth (cm)	Physical analysis				Chemical analysis					
		Sand (%)	Dust (%)	Clay (%)	Type	pH	$CaCO_3$ (%)	Organic Matter (%)	Nitrogen	P_2O_5 (ppm)	Salinity $EC10^3 25$
Steppe	0-100 cm	83	11,47	5,53	Sand with wet clay	8,3	2,95	1,19	0,06	42	0,4
Meadow	0-100 cm	70,72	19,65	9,62	Sandy wet clay	8,2	2,96	2,78	0,14	231	0,71
Shrub	0-100 cm	37,59	17,59	45,12	Clay	7,9	23,77	3,9	0,19	17	0,32

Materials and Methods

This paper is mainly based on the vascular plant specimens collected from Sivrihisar Mountains and their environs (Eskişehir-Ankara) during the period 2000-2002 (Böcük, 2002) and other related researches carried out in the north-east Phrygia region (Davis, 1965; Davis *et al*., 1988; Türe *et al*., 1996; Güner *et al*., 2000; Türe, 2000). The specimens were identifed mainly by using the Flora of Turkey and the East Aegean Islands (Davis, 1965; Davis *et al*., 1988; Güner *et al*., 2000), some other sources (Altınayar, 1987; Baytop, 1997; Baytop, 1998; Heywood & Tutin, 1963-1980; Ketenoğlu *et al*., 1999; Polunin, 1972; Seçmen *et al*., 2000; Stearn, 1972; Tokur, 1992; Yaltırık & Efe, 1996; Yücel *et al*., 1995). Some of the plant taxa were checked in the herbaria of Anadolu University (ANES), Ankara Univeristy (ANKA) and Gazi University (GAZİ). Threatened categories are proposed according to IUCN risk categories (Ekim *et al*., 2000; Anon., 2001). Phytogeographical regions of the taxa were evaluated according to Flora of Turkey and the East Aegean Islands (Davis, 1965; Davis *et al*., 1988; Güner *et al*., 2000). All plant samples collected from the research area were stored in the herbarium of Science Faculty, Anadolu University (ANES) (Holmgren & Holmgren, 2002).

The analysis techniques for soils were as follows: total organic matter was determined by using the Walkley-Black method; total N by Kjeldahl method; calcium carbonate by Scheibler calsimeter; actual acidity with pure water (1/2.5) by Beckman expanded scale pH meter (±0,01 sensitivity), phosphorus by Olsen method by using spectronic 20D. Physical analysis of soil by Bouyoucos hidrometer method, and classified according to American soil classification triangle (Anon., 1994; Baver, 1956; Black, 1965; Bouyoucos, 1955; Gülçur, 1974; Türe & Bell, 2004).

Results and Discussion

In this study, vascular plant specimens were collected from the research area and 589 plant taxa belonging to 314 genera classifed within 67 families were determined. One species belongs to *Pteridophyta*, 4 species to *Gymnospermae* while the other 584 taxa belong to *Angiospermae*. Seventy seven taxa (13.1%) are endemic for Turkey. When the risk situations of the plant taxa determined in the study area are checked according to the IUCN categories, it can be seen that 56 taxa (51 endemic, 5 non-endemic) are in Least Concern (LC), 9 (endemic) in Near Threatened (NT), 4 (3 endemic, 1 non-endemic) in Vulnerable (VU) risk categories (Ekim *et al*., 2000; Anon., 2001), (Table 4, Fig. 4).

The largest families according to taxa numbers are as follows: Asteraceae 72, Fabaceae 54, Lamiaceae 46, Poaceae 45, Brassicaceae 41 (Table 5). It matches to the family sequence in the Flora of Turkey. Asteraceae is the largest and most widespread family of flowering plants in the World. Most members of this family protect themselves with their spiny structures. They can distribute their seeds easily and also have a wide ecological tolerance (Türe, 2003). In addition, steppe characteristics of the area and most abundant presence of *Astragalus* (Fabaceae) in steppe areas may contribute to the results cited above. The richest genera in the area are *Centaurea* L. (13), *Alyssum* L. (12), *Salvia* L. (11), *Silene* L. (9), *Galium* L. (9) *Astragalus* L. (7) (Davis, 1985; Davis *et al*., 1988), (Table 6).

Table 4. Risk situations of the plant species.

Plant species	Risk category
Endemic species	
Achillea aleppica DC. subsp. *zederbaueri* (Hayek) Hub.-Mor.	LC
Alyssum pateri Nyâr. subsp. *pateri*	LC
Amblyopyrum muticum (Boiss.) Eig var. *loliaceum* (Jaub. & Spach) Eig	LC
Astragalus micropterus Fischer	LC
Astragalus vulnerariae DC.	LC
Asyneuma limonifolium (L.) Janchen subsp. *pestalozzae* (Boiss.) Damboldt	LC
Asyneuma virgatum (Labill.) Bornm. subsp. *cichoriforme* (Boiss.) Damboldt.	LC
Bolanthus minuartioides (Jaub. & Spach) Hub.-Mor.	LC
Bupleurum heldreichii Boiss. & Bal.	LC
Campanula lyrata Lam. subsp. *lyrata*	LC
Centaurea drabifolia Sm. subsp. *detonsa* (Bornm.) Wagenitz	LC
Consolida raveyi (Boiss.) Schröd.	LC
Convolvulus galaticus Rostan ex Choisy	LC
Crataegus tanacetifolia (Lam.) Pers.	LC
Crepis macropus Boiss. & Heldr.	LC
Digitalis lamarckii Ivan.	LC
Ebenus hirsuta Jaub. & Spach	LC
Erodium absinthoides Willd. subsp. *absinthoides*	LC
Eryngium bithynicum Boiss.	LC
Genista aucheri Boiss.	LC
Gysophylla eriocalyx Boiss.	LC
Haplophyllum mrytifolium Boiss.	LC
Hedysarum cappadocicum Boiss.	LC
Helichrysum arenarium (L.) Moench subsp. *aucheri* (Boiss.) Davis & Kupicha	LC
Hieracium paphlagonicum Freyn & Sint.	LC
Hyacinthella lineata (Steudel) Chouard	LC
Irıs schachtii Markgraf	LC
Jurinea pontica Hausskn. & Freyn ex Hausskn	LC
Linaria corifolia Desf.	LC
Linaria genistifolia (L.) Miller subsp. *confertiflora* (Boiss.) Davis	LC
Linaria iconia Boiss. & Heldr.	LC
Linum hirsutum L. subsp. *anatolicum* (Bois.) Hayek var. a*natolicum*	LC
Minuartia anatolica (Boiss.) Woron. var. *arachnoidea* McNeill	LC
Minuartia erythrosepala (Boiss.) Handz.-Mazz. var. *cappadocica* (Boiss.) McNeill	LC
Nonea macrosperma Boiss. & Heldr.	LC
Onobrychis armena Boiss. & Huet	LC

Table 4. (Cont'd.).

Plant species	**Risk category**
Onobrychis tournefortii (Willd.) Desv.	LC
Onosma bornmuelleri Hausskn.	LC
Onosma bracteosum Hausskn. & Bornm.	LC
Onosma isauricum Boiss. & Heldr.	LC
Oxytropis argyleuca Bornm.	LC
Paracaryum ancyritanum Boiss.	LC
Phlomis armeniaca Willd. Ir.-Tur.	LC
Rhamnus thymifolius Bornm.	LC
Salvia cadmica Boiss.	LC
Salvia cryptantha Montbret & Aucher ex Bentham	LC
Salvia wiedemannii Boiss.	LC
Stachys cretica L. subsp. *anatolica* Rech. fil.	LC
Tragopogon aureus Boiss.	LC
Verbascum cherianthifolium Boiss. var. *asperulum* (Boiss.) Murb.	LC
Veronica multifida L.	LC
Aethionema turcica H. Duman & Aytaç	NT
Alkanna orientalis (L.) Boiss. var. *leucantha* (Bornm.) Hub.-Mor.	NT
Alyssum blepharocarpum Dudley & Hub.-Mor.	NT
Astragalus macrocephalus Willd. subsp. *macrocephalus*	NT
Astragalus melanophrurius Boiss.	NT
Centaurea bornmuelleri Hausskn. ex. Bornm.	NT
Paronychia argyroloba Stapf	NT
Paronychia dudleyi Chaudhri	NT
Sideritis galatica Bornm.	NT
Minuartia anatolica (Boiss.) Woron. var. phrygia (Bornm.) McNeill	VU
Paronychia angorensis Chaudhri	VU
Secale cereale L. var. *ancestrale* (Zhuk.) Kit Tan	VU
Non-endemic species	
Acanthus hirsutus Boiss.	LC
Consolida thirkeana (Boiss.) Schröd.	LC
Crocus ancyrensis (Herbert) Maw	LC
Helianthemum nummularium (L.) Miller subsp. *lycaonicum* Coode & Cullen	LC
Salvia cyanescens Boiss. & Bal.	LC
Thymus leucostomus Hausskn. & Velen. var. *argillaceus* Jalas	VU

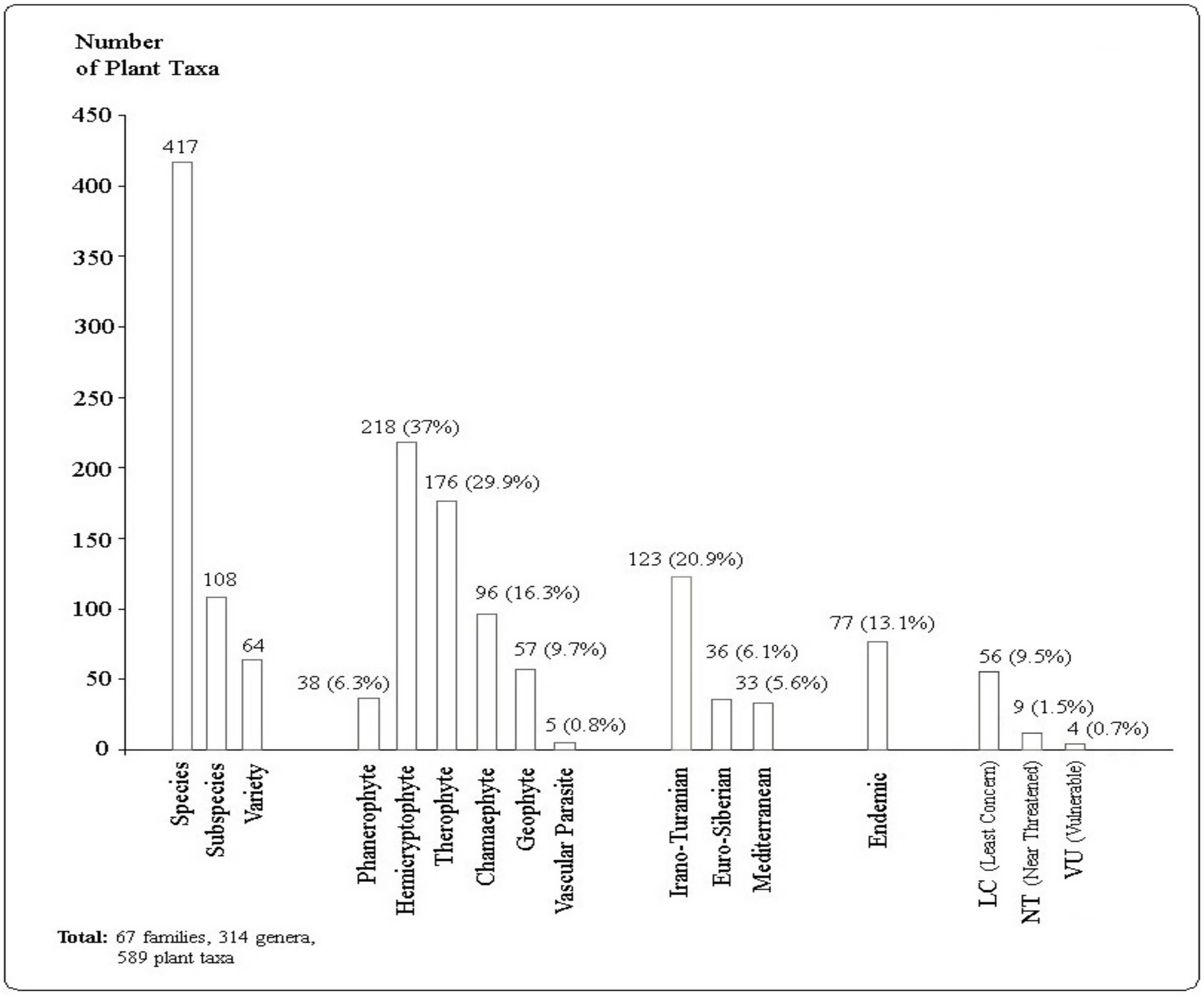

Fig. 4. Some information about the number of plant taxa, life forms, phytogeographical regions, endemism, risk categories of the plant taxa determined in the research area.

Table 5. The largest families in the research area.

Family	Genera	Taxa	Percent
Asteraceae	37	72	12.2
Fabaceae	23	54	9.1
Lamiaceae	20	46	7.8
Poaceae	31	45	7.7
Brassicaceae	24	41	6.9
Caryophyllaceae	13	35	5.9
Boraginaceae	16	29	4.9
Apiaceae	14	20	3.3
Scrophulariaceae	6	18	3.0
Ranunculaceae	8	18	3.0
Rosaceae	14	18	3.0
Liliaceae	9	17	2.9
Other families	99	176	30.3
Total	**314**	**589**	**100**

Table 6. The largest genera in the research area.

Genus	Number of taxa	Percent
Centaurea	13	4.1
Alyssum	12	3.8
Salvia	11	3.5
Galium	9	2.8
Silene	9	2.8
Astragalus	7	2.2
Anchusa	6	1.9
Minuartia	6	1.9
Ranunculus	6	1.9
Verbascum	6	1.9
Others	229	73.2
Total	**314**	**100**

Distributions of the plant taxa determined in the study area in terms of phytogeographical regions are as follows: Irano-Turanian elements: 123 (20.9%), Euro-Siberian elements: 36 (6.1%), Mediterranean elements: 33 (5.6%). The remaining species are either multiregional or of unknown phytogeographical origin (Fig. 4). Location of the area is in the far-west part of steppe and desert border in Central Asia, extending to the west as Irano-Turanian floristic region, Central Anatolia exhibits dominancy of Anatolian endemics and Irano-Turanian elements.

Sylvatic vegetation in the area extends on the mountain and hills formed by volcanic and sedimentary rocks. In some transition zones, it can be seen that the contribution of Mediterranean and Euro-Siberian elements were quite high. Irano-Turanian and Mediterranean elements are generally distributed in open and steppe areas whereas Euro-Siberian elements are found in humid and shady areas, around damp springs and in meadows at high altitudes.

Endemism ratio of the study area (13.1%) is quite high when it is compared with the average endemism ratio of the flora of Turkey (over 30%), (Fig. 4). It is known that the regions which have high endemism ratios are Central Anatolia, East and South Anatolia. However, it is about 5% in Black Sea region as a result of having more homogeneous environmental factors when compared with the Central, Eastern and South Anatolia regions of Turkey (Türe & Tokur, 2000).

Soil and climate are key factors for the vegetation of an area. Actually, the most important indicator of bioclimate in a region are plants and animals (Cioaca & Dinu, 2002). Besides, life forms, floristic elements and various formations are the best indicators of general climate types. Therefore, when life forms of the plant taxa determined in the research area are checked, it can be seen in the following ratios: Therophytes 29.9%, Hemicryptophytes 37.0%, Phanerophytes 6.3%, Geophytes 9.7%, Chameophytes 16.3% and vascular parasites 0.8% (Fig. 4). In these areas, because of the heavy destruction, the ratio of phanerophytes is low but hemicryptophytes and therophytes are quite high. Because therophytes are more resistant to summer drought than the hemicryptophytes, phanerophytes and geophytes, since the former spend the summer in seed form and the latter in the form of vegetative structures. And also, hemicryptophytes protect their productive vegetative parts under ground during difficult conditions (Çetik, 1985; Floret *et al*., 1990; Keshet *et al*., 1990; Türe, 2003).

Xerophytic plants, most common and arid elements, can also be seen in the region and these are surrounded by relatively xerophytic schrub and forest vegetations. These forests are called as “steppe forests” (Podwojewski *et al*., 2002). Low mountain steppes were formed as a result of steppe forest degregation (Kay, 1997; Manzano *et al*., 2000; Peer *et al*., 2001). Tournefort, among the first scientists studied about the flora of Turkey, reported that there were healthy and dense forests between Eskişehir and Ankara nearly 280 years ago (Kuniholm, 1977). According to Zohary (1973), it is thought that real steppe borders widened during a few thousand years under the effects of a climatic variations and changed into low and high mountain steppes. Semi-arid north-east part of Frig Valley under antropogenic pressure are defined as “Xero-Euxinian”. Central Anatolia plain and mountain steppe consist of antropogenic flora and vegetation, so they show secondary characteristics (Harris *et al*., 2003). Here, primer vegetation has a restricted area or no distribution in the important part of low and high mountain zones around plain steppe.

In the region, step forests are dominantly represented by the associations of *Juniperus oxycedrus* L. subsp. *oxycedrus*, *Juniperus excelsa* Bieb. (Harris *et al*., 2003) and *Quercus pubescens* L. Some plant taxa like *Rosa canina* L., *Rhamnus rhodopeus* Velenovsky, *Paliurus spina-christi* Miller are also available in these areas.

Dominant plant taxon of steppe is *Artemisia santonicum* in the region. Dominancy of Poaceae (Gramineae) taxa growing in arid environments of steppe vegetation calls attention (Jauffret & Lavorel, 2003; Skapetas *et al*., 2004; Türe & Böcük, 2007). Besides the *Gramineae (Poaceae)* members like *Aegilops triuncialis* L., *Bromus tectorum* L., *Poa pratensis* L. and *Stipa lessingiana* Trin & Rupr., some associations forming by some plant taxa like *Astragalus vulnerariae* DC., *Ononis spinosa* L. subsp. *leiosperma* (Boiss.) Širj., *Peganum harmala* L., *Alyssum sibiricum* Willd., *Globularia orientalis* L., *Eryngium campestre* L. var. *virens* Link, *Teucrium polium* L., *Acantolimon acerosum* L. var. *acerosum* are quite dominant in steppe vegetation. It is seen that wind erosion is very effective on the sandy soils in the region. In the studies, it is reported that *Artemisia santonicum* shows secondary characteristic and replaced after damaging of *Bromus-Stipa* steppe because of uncontrolled land use and overgrazing activities (Peer *et al*., 2001). *A. santonicum* is resistant to the climate of Central Anatolia and grazing because of its hard structure. But, the population of the plant has been decreased by antropogenic effects for the last three or four decades. So, the unpalatable species, *Peganum harmala* and *Alhagi pseudoalhagi* populations have been dominant day by day.

Uncontrolled land usage pressure change the floristic composition of plant communities and decrease the biomass stock (Jauffret & Lavorel, 2003; Logakanthi *et al*., 2000; Shikhotov, 1974; Vladychenskiy, 2002; Vuren & Coblentz, 1987). Antropogenic steppes occured in many areas where arid steppe forests and high mountain forests were destroyed. Agricultural activities are carried out in certain areas like plain and low mountain steppe. Main agricultural plants are barley, wheat, lentil and chickpea. In the region, there are also weeds in important number. Most of these belong to Asteraceae. These are followed by the plant taxa belonging to *Brassicaceae, Poaceae, Lamiaceae, Boraginaceae* families (Türe & Köse, 2000, Türe and Böcük, 2008).

Characteristic plants of meadow vegetation have been destroyed because of overgrazing activities on the areas with relatively higher ground water level. Populations formed by *Hordeum murinum* L. subsp. *leporinum* (Link) Arc. var. *leporinum*, *Cynodon dactylon* (L.) Pers. var. *dactylon*, *Potentilla recta* L., *Turgenia latifolia* (L.) Hoffm., *Trifolium pratense* L. var. *pratense*, *Lamium purpureum* L. var. *purpureum* call attention in the floristic composition of the meadows. Besides some phanerophytic taxa like *Salix alba* L. are seen in some limited wetlands, some other plant taxa like *Typha angustifolia* L., *Phragmites australis* (Cav.) Trin .ex Steudel, *Veronica anagallis-aquatica* L., *Thalictrum lucidum* L., *Lythrum salicaria* L., *Epilobium hirsutum* L., *Scirpoides holoschoenus* (L.) Sojak are distributed in these areas.

General conventional peculiarity of agriculture and overgrazing including pasturage in mountain ecosystems, indicate a prevalence of extensive forms of land use. This is the reason that great quantities of natural resources are involved into agriculture sphere. Limited natural resources in the mountains are under the impacts the high level of anthropogenic pressure (Manzano *et al*., 2000). Landscape is a spatial and temporal result of interacting ecosystems and socio-cultural environment and has a certain structure, function and change trend. Landscape is a dynamic system and it inherently contains "change". However, the acceleration and change of direction of such change by the human influence cause certain negative impacts upon the landscape components and the entire landscape itself (Abahussain *et al*., 2002; Geist & Lambin, 2004).

Although there are no detailed floristic studies carried out in the region, change on vegetation and soil characteristics of the region due to the antropogenic effects in terms of the criterions mentioned above can easily be seen when compared with the vegetation structure and plant diversity of the research area by macro observations of some researchers and protected natural areas around the research area (Harris *et al*., 2003; Li *et al*., 2004).

Plant cover is the most sensitive component to grazing in an ecosystem. Permanent unsystematical use of mountain pastures leads to their degradation seriously. Floristic composition of plant communities is strongly changed. This effect greatly reduces stability of soils because it becomes thinner and less durable (Vladychenskiy, 2002).

If it is thought that nearly half of the people in the region live in rural areas and their main economic sources are pasture, degregated steppe forests and agricultural areas formed by destroying of natural areas (Macleod *et al*., 2004), it can easily be seen the reality that negative antropogenic effects will continue in the region in future.

In order to establish the regain of natural equilibrium in steppe areas, some important measures may be taken as follows: Early and heavy grazing system continuing on the natural pasture areas in the upper part of the mountains must be prevented, the rotational grazing plan should be applied based on herb productivity (Kondoh, 2003). In addition to these, the poisonous and spiny weeds should be removed by the natural competition of the herb species in the protected area. Cutting of oak branches must be prohibited in order to maintain the natural regeneration and the increase of biomass productivity of the steppe forests. The eroded areas must be reforested and afforested. In the reforestation activities, the oak has to be selected as climax species for the region (Atalay, 2002).

The sustainable use of the natural resources, in broad sense including the protection of environment, is dependent on the economic and social development of the rural people (Shelton, 2003). For this reason, some measurements, relating to the education, settlement rehabilitation, innovation in the animal husbandry, marketing, economic aids, various extension etc. should be taken into consideration.

Acknowledgement

Master thesis of H. Böcük is part of this study. Provision of Anadolu University Research Fund (AÜAF 00 10 60) is gratefully acknowledged.

References

Abahussain, A.A., A.S. Abdu, W.K. Al-Zubari, N.A. El-deen and M. Abdul-Raheem. 2002. *Desertification in the Arab Region: analysis of current status and trends*. *J Arid Environs*, 51(4): 521-545.

Altınayar, G. 1987. *Bitki Bilimi Terimleri Sözlüğü (Dictionary of Plant Science Terms).* Devlet Su İşleri, Ankara.

Amin, A.A. 2004. *The extent of desertification of Saudi Arabia*. *Environmental Geology*, 46(1): 22-31.

Anonymous. 1984. *Eskişehir İli Verimlilik Envanteri ve Gübre İhtiyaç Raporu (Report of productivity inventory and manure requirement of Eskişehir)*. T.C. Tarım Orman ve Köyişleri Bakanlığı, Topraksu Genel Müdürlüğü Yayınları, Ankara.

Anonymous. 1994. *Soil Laboratory Tecniques, Turkish Forest Ministry*. Eskişehir Forest Soil Ecology Research Laboratory, Eskişehir.

Anonymous. 2001. IUCN Species Survival Commission. *IUCN Red List Categories, approved by the 51st meeting of the IUCN Council*. Gland, Switzerland.

Anonymous. 2005. *NATO Science, Society, Security News.* No 69, issue 04.

Atalay, I. 1997. *Türkiye Jeomorfolojisi'ne Giriş (Introduction to the Geology of Turkey)*. Ege Üniv. Edebiyat Fak. Yay. No: 9, İzmir.

Atalay, I. 2002. *Sustainable mountain management: A case study from the Malatya Mountains*. Se Taurus International Conference on Sustainable Land Use and Management, Çanakkale, Turkey.

Baver; L.D. 1956. Soil Physics, John Willey and Sons Inc., New York.

Baytop, A. 1998. İngilizce-Türkçe Botanik Klavuzu (English-Turkish Botanical Guide). İstanbul Üniv. Yay., No: 4058, Eczacılık Fak. Yay. No: 70, İstanbul.

Baytop, T. 1997. Türkçe Bitki Adları Sözlüğü (Dictionary of Turkish Names of Plants). Türk Dil Kurumu Yayınları, 578, Ankara.

Black, C.A. 1965. *Methods of soil analyses*. American Society of Agronomy, Inc. Publisher, Madison, Wisconsin, USA.

Blanca, G., M. Cueto, M.J. Martinez-Lirola and J. Molero-Mesa. 1998. *Threatened vascular flora of Sierra Nevada (Southern Spain)*. *Biol Conserv*, 85: 269-285.

Bouchard, V., M. Tessier, F. Digaire, J.P. Vivier, L. Valery, J.C. Gloaguen and J.C. Lefeuvre. 2003. *Sheep grazing as management tool in Western European saltmarsches*. CR Biol 326: S148-S157.

Bouyoucos, G.J. 1955. *Hidrometer method improved for making particle size analyses*. Soil Agronomy Journal 54: 5.

Böcük, H. 2002. *Investigation of the Floristic and Ecological Characteristics of Sivrihisar Mountains (Eskişehir)*. Master Thesis, Anadolu University Graduate School of Natural and Applied Sciences, Eskişehir.

Branson, F.A., G.F. Gifford, K.G. Renard and R.F. Hadley. 1981. In: *Rangeland Hydrology*, (Ed.): E.H. Reid, 2nd Edition, Society of Range Management, Kendull/Hund Publ. Com., Iowa.

Çetik, A. 1985. Türkiye Vejetasyonu I: İç Anadolu'nun Vejetasyonu ve Ekolojisi (Vegetation of Turkey I: Vegetation and Ecology of Central Anatolia). - Selçuk Üniv. Yay., 7, Fen-Ed. Fak. Yay. 1, Konya.

Cioaca, A. and M. Dinu. 2002. *Torrential Rainfalls in the Semiarid Environment of Dobrogea (Romania)*. International Conference on Sustainable Land Use and Management, Çanakkale, Turkey.

Cireli, B., Ö. Seçmen and M. Öztürk. 1983. *Bitki Ekolojisi Uygulamaları (Applications of Plant Ecology)*. Ege Üniv. Fen Fak. Kitaplar Serisi No: 51, Bornova-İzmir.

Davis, P.H. 1965. Flora of Turkey and the East Aegean Islands. Vol I-IX. - Edinburgh Univ. Press., Edinburgh.

Davis, P.H., R.R. Mill and K. Tan. 1988. *Flora of Turkey and the East Aegean Islands*. Vol X. - Edinburgh Univ. Press., Edinburgh.

Dregne, H.E. 2002. Land degradation in the drylands. - *Arid Land Research and Management*, 16(2): 132-134.

Ekim, T., M. Koyuncu, M. Vural, H. Duman, Z. Aytaç and N. Adıgüzel. 2000. *Red Data Book of Turkish Plants (Pteridophyta and Spermatophyta)*. Türkiye Tabiatını Koruma Derneği-Van Yüzüncü Yıl Üniv. Yayınları, Ankara.

Floret, C., M.J. Galan, E. Lefloch'h, G. Orshan and F. Romane. 1990. *Growth forms and phenomorphology traits along an environmental gradient: tools for studying vegetation*. *J Veg Sci*., 1: 71-80.

Geist, H.J. and E.F. Lambin. 2004. *Dynamic causal patterns of desertification*. *Bioscience*, 54(9): 817-829.

Ghazanfar, S.A. 1998. *Status of the flora and plant conservation in the sultanate of Oman*. *Biol Conserv*, 85: 287-295.

Gülçur, F. 1974. *Toprağın Fiziksel ve Kimyasal Analiz Metodları (Physical and Chemical Analysis Methods of Soil)*. İstanbul Üniversitesi Orman Fak. Yay., İ.Ü, Yay. No: 1970, O.F. Yay. No: 201, İstanbul.

Güner, A., N. Özhatay, T. Ekim and K.H.C. Başer. (eds.) 2000. *Flora of Turkey and the East Aegean Islands (supplement). Vol. 11.* Edinburgh Univ Press., Edinburgh.

Harris, A.T., G.P. Asner and M.E. Miller. 2003. *Changes in vegetation structure after long term grazing in pinyon-juniper ecosystems: Integrating imaging spectroscopy and field studies*. *Ecosystems*, 6(4): 368-383.

Heywood, V.H. and G.T. Tutin. 1963-1980. *Flora Europea*. Vol I-V. Cambridge.

Holmgren, P.K. and N.H. Holmgren. 2002. *Additions to Index Herbariorum (Herbaria).* Edition 8-Twelfth Series, Taxon, 51: 211-216.

Jauffret, S. and S. Lavorel. 2003. *Are plant functional types relevant to describe degradation in arid, southern Tunisian steppes?* J Veg Sci 14(3): 399-408.

Kay, R.N.B. 1997. *Responses of African livestock and wild herbivores to drought*. *J. Arid Environ*., 37: 683-694.

Keshet, M., A. Danin and G. Orshan. 1990. *Distribution of ecomorphological types along environmental gradients in Israel: 1 Renewal bud location and leaf attributes. Ecol. Mediter*, 16: 151-161.

Ketenoğlu, O., M.Ü. Bingöl, K. Güney, F. Geven and T. Körüklü. 1999. *Tohumlu Bitkiler Uygulama Klavuzu (Spermatophyta Application Guide)*. Ankara.

Kondoh, M. 2003. *Habitat fragmentation resulting in overgrazing by herbivores*. *J. Theor. Biol*., 225(4): 453-460.

Kulaksız, N. 1981. *Sivrihisar Kuzeybatı Yöresinin Jeolojik Özellikleri (Geological characteristics of Northwest Part of Sivrihisar)*. Yerbilimi 8: 103-124.

Kuniholm, P.J. 1977. *Türkiye'deki arkeolojik bulgular (Archaeological findings in Turkey).* Ankara.

Küçüködük, M. and R. Çetik. 1984. *Akşehir Gölü ve Kıyılarının flora ve vejetasyonunun incelenmesi (An investigation of the flora and vegatation of Akşehir lake and its environs)*. Selçuk Üniv. Fen Edeb. Fak. Fen Derg. 3.

Le Houerou, H.N. 2002. *Man-made deserts: Desertification Processes and Threats. Arid Land Research and Management*, 16(1): 1-36.

Li, Y., J. Cui, X. Zhao and H. Zhao. 2004. *Floristic Composition of Vegetation and the Soil Seed Bank in Different Types of Dunes of Kerqin Steppe. Arid Land Research and Management*, 18(3): 283-293.

Logakanthi, S., J.R. Banu and K. Manoharan. 2000. *Effect of grazing on biodiversity of a semi-arid grazing land at Alwarkurichi, foothills of Western ghats, Tamilnadu. J. Environ. Biol*., 21(4): 329-332.

Macdougall, A.S., J.A. Loo, S.R. Clayden, J.G. Goltz and H.R. Hinds. 1998. *Defining conservation priorities for plant taxa in southeastern New Brunswick, Canada using herbarium records*. *Biol Conserv*., 86: 325-338.

Macleod, N.D., A.J. Ash and J.G. Mcivor. 2004. *An economic assesment of the impact of grazing land condition on livestock performence in tropical woodlands*. *Rangeland J*., 26(1): 49-71.

Mamytov, A.M. 1985. *Some ecological aspects of agriculture intensification and connected with them problems of environment in Kirgiziya*. In "Ecological aspects of mountains environment". Ilim, Frunze, 3-10.

Manzano, M.G., J. Navar, M. Pando-Moreno and A. Martinez. 2000. *Overgrazing and desertification in northern Mexico: Highlights on northeastern region. Ann Arid Zone*, 39(3): 285-304.

Özgül, M. and T. Öztaş. 2002. *Overgrazing Effect on Rangeland Soil Properties*. International Conference on Sustainable Land Use and Management, Çanakkale, Turkey.

Öztaş, T., A. Koç and B. Çomaklı. 2003. *Changes in vegetation and soil properties along a slope on overgrazed and eroded rangelands. J. Arid Environ.*, 55: 93-100.

Peer, T., A. Millinger, J.P. Gruber and F. Hussain. 2001. *Vegetation and altitudinal zonation in relation to the impact of grazing in the steppe lands of the Hindu Kush Range (N-Pakistan). Phytocoenologia*, 31(4): 477-498.

Podwojewski, P., J. Poulenard, T. Zambrana and R. Hofstede. 2002. *Overgrazing effects on vegetation cover and properties of volcanic ash soil in the paramo of Llangahua and La Esperanza (Tungurahua, Ecuador). Soil Use Manage*, 18(1): 45-55.

Polunin, O. 1972. *The Concise Flowers of Europae*. Oxford Univ. Press., New York, Toronto.

Rowntree, K., M. Duma, V. Kakembo and J. Thornes. 2004. *Debunking the myth of overgrazing and soil erosion*. *Land Use Manage*, 15(3): 203-214.

Seçmen, Ö., Y. Gemici, E. Leblebici., G. Görk and L. Nekat. 2000. *Tohumlu Bitkiler Sistematiği (Systematics of Spermatophyta)*. Ege Üniv., Fen Fak., Kitaplar serisi No: 116, Bornova, İzmir.

Sevin, V. 2001. *Anadolu'nun Tarihi Coğrafyası (Historical Geography of Anatolia)*. Atatürk Kültür Dil ve Tarih Yüksek Kurumu, Türk tarih Kurumu Yay. VI. Dizi, Sayı 50, Türk Tarih Kurumu Basımevi, Ankara.

Shelton, N. 2003. *Azarbaijan: Environmental conditions and outlook. Ambio*, 32(4): 302-306.

Shikhotov, V.M. 1974. *The Mountain pasture, their use and improvement*. Kyrgyzstan, Frunze, 131 p.

Skapetas, B., D. Nitas, A. Karalazos and I. Hatziminaoglou. 2004. *A study on the herbage mass production and quality for organic grazing sheep in a mountain pasture of northern Greece*. *Livest Prod Sci*., 87(2-3): 277-281.

Stearn, W.T. 1972. *Botanical Latin*. Edinburgh, England.

Teague, W.R., S.L. Dowhower and J.A. Waggoner. 2004. *Drought and grazing patch dynamics under different management*. *J. Arid Environ.*, 58(1): 97-117.

Tokur, S. 1992. *Bitki Tayin Esasları Ders Notları (Principles of Plant identification)*. - Osmangazi Üniv. Fen-Ed. Fak. Yay., Eskişehir.

Türe, C. 2000. *Floristic and General Ecological Characters of Arayıt Mountain and Its Environs (Central Anatolia, Eskişehir-Turkey)*, The Scientific and Pedagogical News of Odlar Yourdu University 4: 108-132.

Türe, C. 2003. *An Investigation on the Weed Diversity in Some Agricultural Fields of Inegöl (Bursa) and its Environments*. *Turkish Weed Science*, 6(1): 48-59.

Türe, C. and H. Böcük. 2007. *An Investigation of Diversity, Distribution and Conservation on Poaceae Growing Naturally in Eskişehir Province (Central Anatolia-Turkey)*. *Pakistan J Bot.*, 39(4): 1055-1070.

Türe, C. and H. Böcük. 2008. *Investigation of Threatened Arable Weeds and Their Conservation Status in Turkey*. *Weed Research*, 18: 289-296.

Türe, C. and R.W. Bell. 2004. *Plant Distribution and its Relationship to Extractable Boron in Naturally-Occuring High Boron Soils Turkey. Israel J Plant Sci*., 52: 125-132.

Türe, C. and S. Tokur. 2000. *The Flora of the Forest Series of Yirce-Bürmece-Kömürsu and Muratdere (Bilecik-Bursa, Turkey)*. *Tr. J. of Bot.*, 24: 47-66.

Türe, C. and Y.B. Köse . 2000. *An investigation on the weed distribution in some agricultural fields of Eskisehir and environs*. *Turk J Agric For*., 24: 327-331.

Türe, C., A. Ocak and H. Mısırdalı. 1996. *Balıkdamı'nın (Gökada) Florası (Flora of Balıkdamı (Gökada))*, Anadolu Univ. J of Sci Fac 2: 55-69, Eskişehir.

Uslu, S. 1959. *İç Anadolu Steplerinin Antropogenik Karakterleri Üzerinde Araştırmalar (Investigations of Anthropogenic Characteristics of Central Anatolia Steppes)*. İst. Üniv., Orman Fak. Yay. 15: 1-48.

Victor, J.E. and A.P. Dold. 2003. *Threatened plants of the Albany Centre of Floristic Endemism, South Africa*. *S Afr. J. Sci*., 99: 437-446.

Villamil, M.B., N.M. Amiotti and N. Peinemann. 2001. *Soil degradation related to overgrazing in the semi-arid southern Caldenal area of Argentia*. *Soil Sci*., 166(7): 441-452.

Vladychenskiy, A.S. 2002. *Soil-Ecological Monitoring of Pasture in Semiarid Mountains*. International Conference on Sustainable Land Use and Management, Çanakkale, Turkey.

Vuren, D.V. and B.E. Coblentz. 1987. *Some ecological effects of feral sheep on Santa Cruz island, California, USA. Biol Conserv*., 41(4): 253-268.

Yaltırık, F. and A. Efe. 1996. *Otsu Bitkiler Sistematiği (Systematics of Herbaceus Plants)*. II. Baskı, İstanbul Üniv. Orman Fakültesi Yay. No: 3940, Orman Fak Yay No: 10, İstanbul.

Yücel, E., F. Yaltırık and M. Öztürk. 1995. *Süs Bitkileri (Ağaçlar ve Çalılar), Ornomental Plants (Trees ans Shrubs).* Anadolu Üniv. Yay. No: 833, Fan Fak. Yay. No: 1, Eskişehir.

Zaady, E., R. Yonatan, M. Shachak and A. Perevolotsky. 2001. *The Effects of Grazing on Abiotic and Biotic Parameters in a Semiarid Ecosystem: A Case Study from the Northern Negev Desert, Israel. Arid Land Research and Management*, 15(3): 245-261.

Zohary, M. 1973. *Geobotanical Foundations of the Middle East*. Vol I-II. - Gustav Fischer-Stutgart.

(Received for publication 8 September 2009)