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THE INFLUENCE OF ENVIRONMENTAL FACTORS ON THE DISTRIBUTION AND COMPOSITION OF PLANT COMMUNITIES IN KIZILIRMAK VALLEY- BLACK SEA REGION, TURKEY

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RÉSUMÉ.— *Influence des facteurs environnementaux sur la distribution et la composition des communautés végétales dans la vallée de la Kizilirmak, région de la mer Noire, Turquie*.— La présente étude examine le rôle des facteurs environnementaux dans la distribution des associations végétales dans la vallée de la Kizilirmak dans le nord de la Turquie. Elle fournit une analyse quantitative des relations végétation – environnement sur un site de cette vallée. Cent trente parcelles de végétation ont été échantillonnées et analysées à l'aide de TWINSPAN et d'une analyse des correspondances détendancées (DCA) afin d'identifier les principales communautés végétales et de déterminer les gradients environnementaux auxquels elles sont associées. Onze associations et six sous-associations ont été déterminées à l'aide de TWINSPAN dont le dendrogramme individualise trois grands groupes végétaux dans la vallée de la Kizilirmak : les sclérophylles, les xérophylles et les mésophylles. Les principaux axes de la DCA représentent les gradients d'altitude, d'humidité relative et de pH du sol. Des indices de diversité de Shannon et de richesse spécifique ont été calculés pour les associations étudiées.

SUMMARY.— The aim of this study is to explore the influence of environmental factors on the distribution of plant associations in Kizilirmak Valley, in northern Turkey. This paper provides a quantitative analysis of the vegetation–environment relationships for a study site in this valley. 130 vegetation plots were sampled and analysed using two-way indicator species analysis (TWINSPAN) and Detrended Correspondence Analysis (DCA) in order to identify the principal vegetation communities and determine the environmental gradients associated with these. Eleven associations and six sub- associations were found by using TWINSPAN. There were three main vegetation groups, namely sclerophyllous, xerophyllous and mesophyllous according to TWINSPAN dendrogram, in Kizilirmak valley. The principal DCA axes represent gradients of elevation, relative humidity and soil pH. Shannon diversity index and species richness were also calculated for studied plant associations.

It is of vital importance to know the quantitative relationships between plant species and environmental factors in the terrestrial ecosystems. Kent & Coker (1992**)** defined plant community as the collection of plant species growing together in a particular location that showed a definite association or affinity with each other. Vegetation ecology deals with identification of these plant communities and determination of how the plant communities are related to one another and to the environmental factors (Mueller-Dombois & Ellenberg, 2002). Site conditions including topographic and soil characteristics as well as local climate conditions have determinant impacts on plant distribution (Davies *et al.,* 2007). Distribution of plant species in an ecosystem can be viewed as a continuum, because plant species respond to environmental factors that vary continuously in time and space (Gleason, 1926). Consequently, plant community ecologists are concerned with patterns of species response to environmental gradients (Pausas & Austin, 2001). Because the interactions of plants with both biotic and abiotic environmental factors are thought to lead to the establishment of structural patterns that reflect community organization (Sebastiá, 2004), ecological research has generally concentrated on different vegetation types that are assumed to be homogeneous.

Establishment, growth, regeneration, and distribution of the plant communities in the river valleys are controlled by many factors such as geographical position, physiographic features, and human impact (Abdel Khalik *et al.*, 2013). Mediterranean sclerophyllous communities are very important for the explanation of the current phytogeographical structure and paleoecological properties of Turkey, because such communities occur as Mediterranean relicts on the low valley slopes in the Euro-Siberian region (Davis, 1965; Pignatti, 1978; Gemici, 1993; Karaer *et al.,* 2010; Korkmaz *et al.*, 2011). Since BC VII, anthropogenic disturbances occurring on natural forest ecosystems of the Kizilirmak Valley, have still been going on (Yilmaz, 2007). Agricultural activities have caused the destruction of natural floristic and ecological structure of plant associations, leading to land degradations in the study area. As a result of these factors, there are many plant associations which have different phytogeographical characters in the study area. Today, the construction of the large Boyabat hydroelectric dam is threatening the existence of these plant associations in Kizilirmak Valley; morever, it is still not known to what extent it will effect plant communities at larger scale in the study area in the future.

The syntaxonomical status of associations in Kizilirmak Valley were described by the earlier work of Korkmaz *et al.* (2011) but, in the present study, the distribution of these associations is described through numerical methods with the aim to find out which environmental factors are significant for the distribution of plant associations in Kizilirmak Valley.

MATERIALS AND METHODS

STUDY AREA

The study area, located in Kizilirmak valley, which is the longest river of Turkey and situated between Northern and Central Anatolia, has a transitional character and is influenced by oceanic and Mediterranean climates (Fig. 1). Natural floristic structure of the initial vegetation was degraded by human activities (grazing, fire and clear-cutting) in this area, and this high disturbance regime led to the establishment of xerophyllous shrublands (Korkmaz & Engin, 1997; Korkmaz *et al.,* 2011).

Semi-arid Mediterranean climate is seen on the lowest parts of the study area, while cool and rainy climate (oceanic) is widespread on the highest parts. (Akman, 1990). The average annual rainfall and the average annual temperature range from 348.5 to 982.5 mm and from 7.0 to 13.9 $^{\circ}$C, respectively. Meteorological data were calculated for a 10-year period (Turkish State Meteorological Service, 2002).

VEGETATION SAMPLING

Taxonomic nomenclature followed was that of Davis (1965-1985), Davis *et al*. (1988), Tutin & Heywood (1964-1980), Güner *et al.* (2000) and Güner *et al.* (2012). 130 plots were selected from floristically and structurally homogeneous places according to the minimal area concept (Westhoff & van Der Maarel, 1973). A vegetation relevé was established for each of these plot, and the sizes of plots were selected as 20×25 m, 20×50 m, 10×10 m and 5×10 m for coniferous forests, deciduous forests, maquis and steppe vegetation, respectively. Cover/abundance data for all vascular plants were recorded for each plot using the Braun-Blanquet (1964) scale. The following environmental data were recorded for each plot: altitude (m), inclination (%), exposure, geological substratum, and soil properties by using suitable equipments. Plant associations were named according to the Syntaxonomical Nomenclatural Rules (Weber *et al*., 2000).

SOIL SAMPLING AND ANALYSIS

From each plot, soil samples were taken at a depth of 30 cm from the topsoil. They were then air dried and sieved through a 2 mm mesh prior to analysis. Soil organic matter (%) was determined using the Walkley and Black method (Carter, 1993). Soil texture was determined using the Bouyoucus hydrometer method, and the clay content was expressed as %. The pH values were measured in deionized water (1:1). The $CaCO_3$ (%) concentrations were determined using a Scheibler calcimeter (Allen *et al.*, 1986; Kurucu *et al.,* 1990; Kacar & Katkat, 2006; Kilinc *et al*., 2006; Pansu & Gautheyrou, 2006).

DATA ANALYSIS

Plant communities were separated by using TWINSPAN procedure. To determine what environmental factors were significant we also treated our data with Detrended Correspondence Analysis (DCA). Data set (a matrix of 501 species and 130 relevés) was classified by TWINSPAN (Hill, 1979a) using the "Community Analysis Package 1.50 version" software (Henderson & Seaby, 1999). The pseudospecies cut levels and maximum number of indicators per division were set as 0, 2, 5, 10, 20 and 5 respectively. This calculation was based on the cover–abundance data of species corresponding to the transformations of the Braun-Blanquet scale as proposed by van der Maarel (1979).

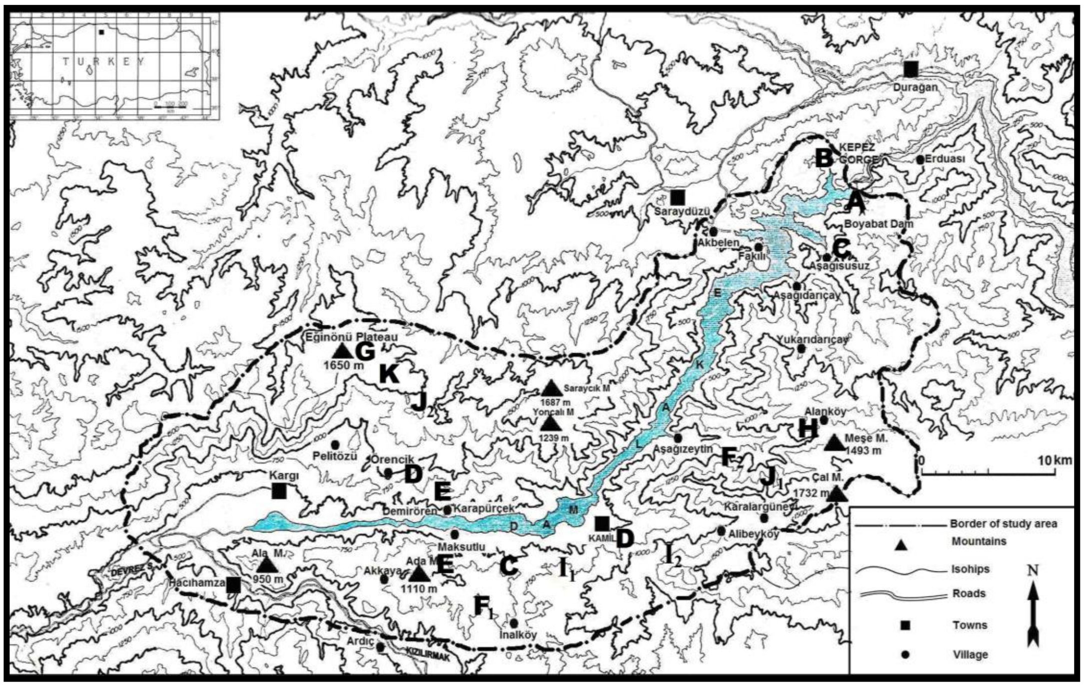

Figure 1.— Topographical map of the study area shows sampling plots locations (modified from Korkmaz *et al*., 2011). (A: *Buxo sempervirentis-Arbutetum unedonis,* B: *Spiraeo crenatae-Oleetum sylvestris,* C: *Cotino coggyriae-Pinetum brutiae*, D: *Rubo sancti-Viticetum agni-casti*, E: *Scutellario pinnatifidae-Juniperetum excelsae,* F: *Linario corifoliae-Astragaletum microcephali*; F_1: *stipetosum arabico*, F_2: *alyssetosum desertorum,* G: *Daphno oleoidis-Astragaletum angustifolii*, H: *Trifolio canescentis-Pinetum caramanicae*, I: *Corno mari-Quercetum cerridis;* I_1: *loniceretosum etrusco*, I_2: *lathyretosum rosei*, J: *Galio odorati-Fagetum orientalis;* J_1: *vicietosum croceo,* J_2: *abietetosum bornmuellerianae*, K: *Rumi scutati-Pinetum hamatae*)

DCA is an indirect gradient analysis technique (Hill, 1979b; ter Braak, 1986) employed for data ordination. DCA was performed to establish the relationships between plant composition, topography and soil factors, with Community Analysis Package 1.50 version (Henderson & Seaby, 1999) which enabled sites to be plotted based on species composition and abundance. Hierarchical clustering method was used in DCA (ter Braak, 1994).

Statistical analysis was performed by using a SPSS (21.0 version) software (IBM Corporation, 2012). The environmental parameters were assessed by Tukey's significant difference (HSD) test to rank the means. The species diversity parameters for the described associations were calculated as Shannon diversity index and species richness (Magurran, 2004) and visualized by a Box-Wishker diagram prepared.

RESULTS

TWINSPAN ORDINATION

Classification by TWINSPAN revealed a total of 17 interpretable clusters, 11 of which are communities, and 6 of which are subcommunities at level 5 and 6 (Fig. 2). TWINSPAN dendrogram has been divided into two main groups, namely semiarid and mesic, which consisted of 80 and 50 relevés, respectively at cut level 2. The mesic group includes forest communities relevés, while the semiarid group mainly consists of schrub and steppe communities relevés.

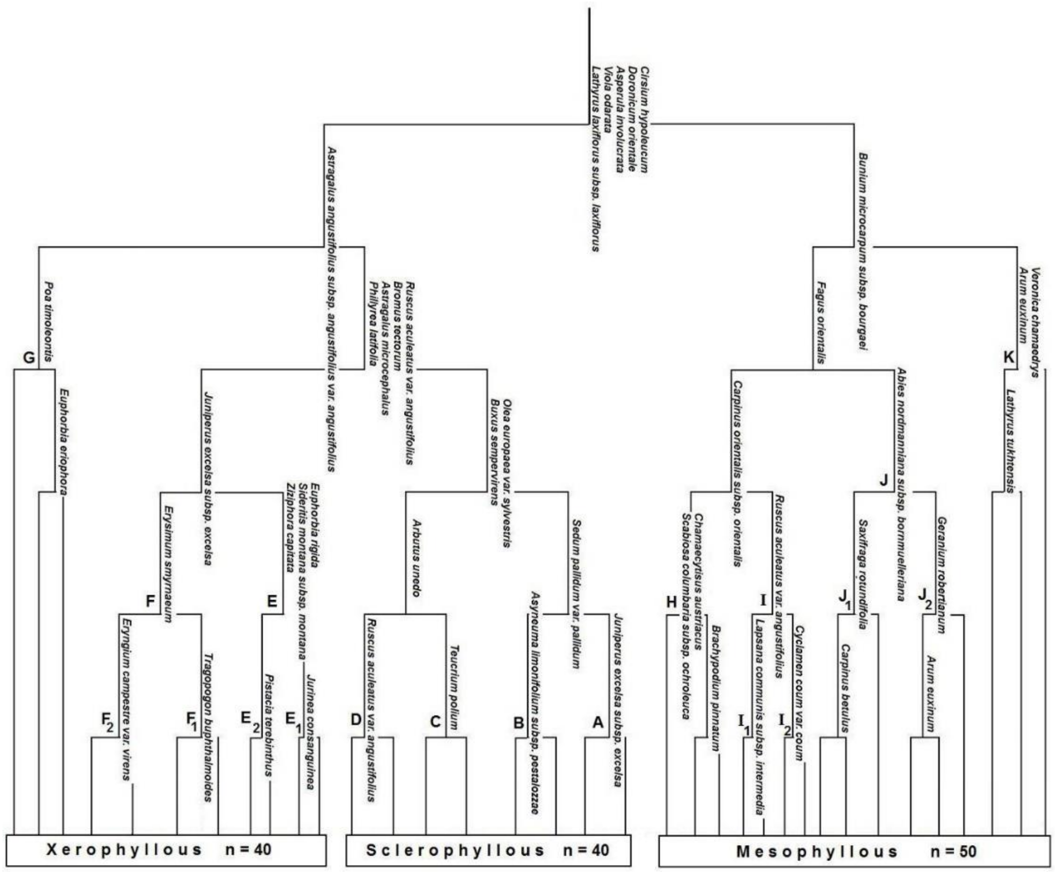

Figure 2.— Dendrogram derived TWINSPAN of 130 relevés, including 501 taxa. (n: number of relevés in each ecological group; the symbol of clusters are the same as in Fig.1).

Semiarid Associations Group

The semiarid groups could be subdivided into two major groups (70 relevés and cluster G; 10 relevés) at the third division level of dendrogram by indicator species *Astragalus angustifolius* subsp. *angustifolius* var. *angustifolius*. The relevés that included G cluster occurred on calcareous bedrocks and southern slopes at 1600-1670 m; they are characterized by subalpinic dwarf-shrub and thorn-cushion steppic communities which were formed as a result of the disturbance of the *Pinus sylvestris* var. *hamata* forests. The dominant species is *Astragalus angustifolius* subsp. *angustifolius* var. *angustifolius* in relevés belonging to community G.

At the sixth division level of the dendrogram two groups are separated: xerophyllous (30 relevés) and sclerophyllous (40 relevés). The sclerophyllous group mainly consists of shrubby relevés, while the xerophyllous group is made up of thorny-cushion forming steppic relevés.

Sclerophyllous communities were located on the lowest parts (250-650 m) of the study area which are influenced by semi-arid Mediterranean climate where limestone and schist parent rock are widespread. At 12^{th} level of the dendrogram two main clusters are divided. While the left cluster represents sclerophyllous species (20 relevés; C and D), the right one includes succulent species (i.e *Sedum pallidum* var. *pallidum, Sedum album*) (20 relevés; A and B) in addition to sclerophyllous species.

Sedum pallidum var. *pallidum* is the indicator species at the twenty-fourth division level of the dendrogram. Left cluster (10 relevés; B) differs from right cluster (10 relevés; A) in that it consists of succulent species and occupies rocky places. At the same time the relevés belonging to cluster A occur on north and northwestern slopes at 250-350 m with calcareous parent rock and are dominated by *Arbutus unedo* while the relevés belonging to cluster B occur on southern and southwestern slopes at 250-350 m with calcareous parent rock dominated by *Olea europaea* var. *sylvestris*.

Arbutus unedo is the indicator species at the twenty-fifth division level of TWINSPAN dendrogram. The relevés belonging to cluster C occurred on schist parent rock at 250-650 m dominated by *Pinus brutia* var. *brutia*, while cluster D includes the relevés occurring along the stream banks that dry during summer at 250-350 m and which are dominated by *Vitex agnus-castus*.

Juniperus excelsa subsp. *excelsa* is the indicator species at the thirteenth division level of the dendrogram. Both clusters include xerophyllous relevés, and clusters E and F include the relevés resulting from severe disturbance of climax forests. Cluster E includes the relevés occurring only on calcareous parent rock at 250-300 m and summer-dried river banks, while cluster F includes the relevés occurring on various bedrock and altitudes.

Erysimum smyrnaeum is the indicator species at twenty-seventh division level of TWINSPAN. In cluster F dominant species is *Astragalus microcephalus* and this is a thorny and cushion-forming species. However, the other species in cluster F are xerophyllous but not thorny and cushion-forming species. There are two different “subcommunities” due to different floristic and ecological properties at 550-650 m (10 relevés F_1) and 1200-1350 m (10 relevés F_2), respectively; s*tipetosum arabico* (F_1) subcommunity occurs on southern-facing slopes as a result of the disturbance of *Pinus brutia* forests, and is influenced by semi-arid mediterranean climate, while *alyssetosum desertorum* subcommunity (F_2) occurs on north-facing slopes as a result of the disturbance of *P. nigra* subsp. *pallasiana* var. *caramanica* forests, and is influenced by cool and rainy climate.

Mesic Forest Associations Group

Mesophyllous Euro-Siberian species are common and occur in climax forest stands which are under the influence of oceanic climate and, at the second division level of dendrogram, they can be subdivided into two clusters named mesophyllous (40 relevés) and semi-mesophyllous (K; 10 relevés) at cut level 3. The relevés which form the cluster K are characterized by indicator species *Bunium microcarpum* subsp. *bourgaei* and they occur at 1500-1600 m on south and southeastern slopes, and *Pinus sylvestris* var. *hamata* is the dominant species (community K; 10).

The mesophyllous group (40 relevés) is subdivided into two main groups (20 + 20 relevés) at the fifth division level of dendrogram where the indicator species is *Fagus orientalis*. The seventh, eight and ninth division levels are not significant because the communities are divided into subcommunities according to local variants in the same community.

Abies nordmanniana subsp. *bornmuelleriana* is the indicator species of the tenth division which reveals cluster J (community J; 20 relevés) which is subdivided into J_1 (*vicietosum croceo* subcommunity) and J_2 clusters (*abietetosum bornmuellerianae* subcommunity). The relevés that form cluster J occur at 1100-1500 m and northern stands, and they have been subdivided into J_1 dominated by *Fagus orientalis* (10 relevés; at 1300-1500 m) and J_2 dominated by *A. nordmanniana* subsp. *bornmuelleriana* (10 relevés; at 1100-1300 m).

Carpinus orientalis subsp. *orientalis* is the indicator species at the eleventh division level of dendrogram that has been subdivided into clusters H (10 relevés) and I (20 relevés). The relevés belonging to cluster H occur at 1100-1250 m on northern and northeastern slopes and schist parent rock and moderate mesic stands, and the dominant species is *Pinus nigra* subsp. *pallasiana* var. *caramanica*.

The relevés characterized by indicator species *Ruscus aculeatus* var. *angustifolius* form I cluster, and they occur on southern slopes dominated by *Quercus cerris* var. *cerris* and at 750-1250 m. This cluster is subdivided into two subcommunities I_1 (10 relevés) and I_2 (10 relevés). The relevés belonging to I_1 occur at 750-800 m and are named *loniceretosum etrusco* subcomunity, while the relevés belonging to I_2 occur at 1100-1250 m elevations and are named *lathyretosum rosei* subcommunity.

DETRENDED CORRESPONDENCE ANALYSIS (DCA)

We used Detrended Correspondence Analysis (DCA) as an indirect ordination technique to clarify the underlying environmental gradients which influence vegetation distribution in the study area. Results obtained from DCA are shown in Fig. 3. The eigenvalues of axes 1 & 2, which represent the contribution of each axis to the explanation of the variation in the data, were 88 % and 62 % respectively. These two axes explain 37 % of the variance. Results of the DCA ordination in Fig. 3 display 11 clusters. DCA results agreed with TWINSPAN in that three main groups (sclerophyllous, xerophyllous and mesophyllous) were separated in both analyses.

In the graph, the first axis represents the gradient of pH and relative humidity, while the second axis could be interpreted as elevation.

The clusters on the left of the graph correspond to the sclerophyllous and xerophyllous associations which have a semi-arid climate, slightly alkaline and sandy-rich lime soils (Tab. I). Mediterranean sclerophyllous associations include *Buxo sempervirentis-Arbutetum unedonis*, *Spiraeo crenatae-Oleetum sylvestris*, *Rubo sancti-Viticetum agni-casti* and *Cotino coggyriae-Pinetum brutiae*, respectively. Floristic composition of the communities is mainly based on Mediterranean sclerophyllous species and *Cotino coggyriae-Pinetum brutiae* association is mainly characterized by tree species, while shrub species are widespread in other communities. Xerophyllous cluster consists of semi-steppic and steppic associations represented by *Scutellario pinnatifidae-Juniperetum excelsae*, *Linario corifoliae-Astragaletum microcephali* and *Daphno oleoidis-Astragaletum angustifolii* under semi-arid conditions and alkaline soils (Tab. I). The relevés belonging to these communities occur on severely disturbed stands on different parent rocks and different bioclimatic strata. Floristic composition is mainly composed of xerophytic Irano-Turanien species, while *Scutellario pinnatifidae-Juniperetum excelsae* association consists of shrub species. *Daphno oleoidis-Astragaletum angustifolii* and *Linario corifoliae-Astragaletum microcephali* are composed of dwarf-shrub and thorny-cushion form.

The cluster groups on the right of the graph correspond to the associations under a cool and rainy climate and with low soil pH. These groups that represent mesophyllous forest associations include

Corno mari-Quercetum cerridis, *Trifolio canescentis-Pinetum caramanicae*, *Galio odorati-Fagetum orientalis* and *Rumi scutati-Pinetum hamatae*. These associations occur in soils that are low in total $CaCO_3$ (%) content, slightly acidic and loamy (Tab. I). Floristic composition of these associations consists of Euxinian mesophytic trees, shrubs and herbs.

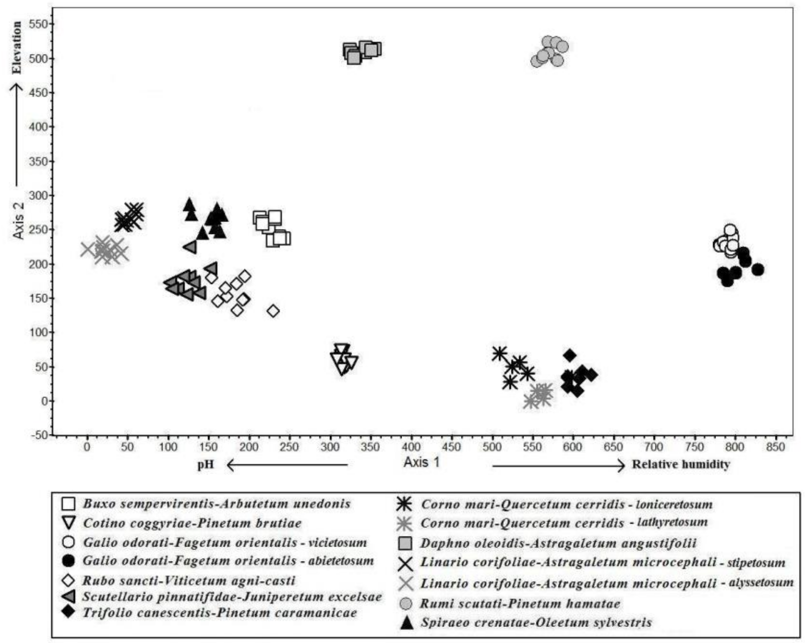

Figure 3.— DCA relevés ordination of Kızılırmak Valley.

TABLE I.

Environmental parameters belonging to the associations (the symbols of clusters are the same as in Fig.1). The exponentials are the number of relevés per cluster. Data are mean ± 1 SE. A difference in letters indicates significant difference between means according to Tukey's (HSD) test (P < 0.05)

	A^{10}	B^{10}	C^{10}	D^{10}	E^{10}	F_1^{10}	F_2^{10}
SAND (%)	46.59±0.56g	51.67±0.25f	56.19±1.21d	57.86±1.34c	63.03±0.42b	77.38±0.61a	43.65±0.60i
CLAY (%)	12.28±0.01fgh	21.56±0.27cde	25.97±0.42bc	13.60±9.57fg	11.17±0.81gh	6.44±0.25h	17.88±0.03def
SILT (%)	41.24±0.41c	25.96±1.11h	17.30±0.07i	30.57±0.30f	25.29±1.27h	16.22±0.22j	38.28±0.03d
pH	7.83±0.12b	7.74±0.05b	7.40±0.03d	7.76±0.22b	7.59±0.19c	8.09±0.05a	8.20±0.03a
$CaCO_3$ (%)	17.06±0.01b	4.87±0.60de	0.60±0.02h	4.20±0.24f	4.67±0.25e	5.06±0.01d	7.85±0.01c
OM (%)	14.92±0.01a	3.33±0.14g	4.22±0.06e	0.86±0.02k	1.35±0.03j	0.45±0.02l	0.93±0.01k
ELEVATION (m)	346.00±42.74ij	348.00±38.52hij	425.00±18.25hi	341.40±42.28j	427.70±116.14h	593.80±46.29g	1268.70±20.71cd
INCLINATION (%)	37.50±8.58ab	35.50±5.50ab	30.50±5.98bc	5.20±1.61g	8.20±3.32fg	39.80±5.67a	40.50±4.30a

	G^{10}	H^{10}	I_1^{5}	I_2^{5}	J_1^{10}	J_2^{10}	K^{10}
SAND (%)	40.57±0.02j	35.50±0.01k	53.87±0.03e	31.56±0.02l	45.11±0.02h	52.29±0.08f	44.85±0.02h
CLAY (%)	28.06±0.02b	22.21±0.02bcd	15.54±0.02efg	39.89±0.03a	24.56±9.49bc	22.35±0.01bcd	11.43±0.03gh
SILT (%)	31.33±0.02f	42.27±0.01b	30.57±0.03f	28.55±0.01g	33.32±0.03e	25.34±0.02h	43.70±0.04a
pH	7.79±0.02b	6.32±0.03gh	5.69±0.01i	6.75±0.01e	6.54±0.02f	6.41±0.02fg	6.19±0.02h
$CaCO_3$ (%)	30.68±0.04a	0.60±0.01h	0.30±0.01hi	1.44±0.01g	0.25±0.02j	0.50±0.01hi	1.23±0.02g
OM (%)	7.10±0.02b	3.25±0.02g	5.73±0.03c	3.74±0.02f	2.30±0.03h	1.94±0.02i	5.38±0.03d
ELEVATION (m)	1606.10±4.20a	1200.00±57.73de	790.00±41.83f	1180.00±75.82e	1471.40±31.74b	1285.20±38.19c	1636.40±16.41a
INCLINATION (%)	21.20±1.22de	25.10±4.81cd	36.40±4.15ab	36.00±5.47ab	31.10±6.98bc	34.90±3.63ab	16.00±3.49ef

Cluster groups on top of the graph include subalpine dwarf-shrub, thorn-cushion steppic associations and the *Pinus sylvestris* var. *hamata* forests. Steppic associations were formed as a result of the disturbance of the *P. sylvestris* var. *hamata* forests where the dominant species is *Astragalus angustifolius* subsp. *angustifolius* var. *angustifolius. P. sylvestris* var. *hamata* forests occur in Mountain prepontic belt of Kizilirmak Valley and cool and rainy places at highest elevations.

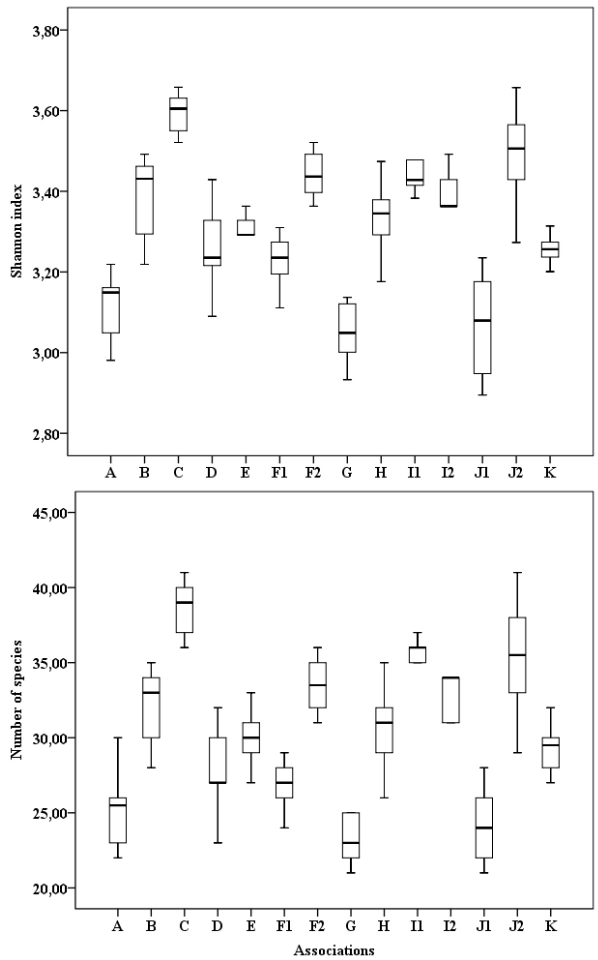

Figure 4.— Diagrams of species diversity (Shannon diversity index at ln base) and species richness (number of species) for each association (the symbol of associations are the same as in Fig.1).

SPECIES DIVERSITY ANALYSIS

The highest Shannon diversity and species richness values were found in *Cotino coggyriae-Pinetum brutiae*, while the lowest values were found in *Daphno oleoidis-Astragaletum angustifolii*. Highly disturbed associations had low species diversity, while undisturbed and intermediately disturbed associations had high species diversity (Fig. 4).

DISCUSSION

Turkey is the meeting ground of three phyto-geographical regions, namely Euro-Siberian, Mediterranean and Irano-Turanian. Their distinctive vegetation reflects differences in climate, geology, topography, soils and floristic diversity, including endemism (Ozkan & Süel, 2008; Sekercioğlu *et al.*, 2011). Scientific and historical studies revealed that about 4000 years ago the Anatolian landscape was covered by 60-70 % forest and 10-15 % steppe vegetation (Davis, 1965-1985). However, due to several disturbance factors, mainly over-grazing, clear-cutting, fires, agriculture facilities and general misuse of the land have caused a decrease of 26 % in forest area, and an increase of 24 % in steppe area (Mayer & Aksoy, 1986). The study area is located in a transition zone between Euro-Siberian and Irano-Turanian (Çolak & Rotherham, 2006).

TWINSPAN dendrogram revealed that historical and environmental factors significantly affected the distribution of plant communities in the study area. TWINSPAN also indicated that plant communities in Kizilirmak Valley were divided into three main ecological groups, sclerophyllous, xerophyllous and mesophyllous. These communities cover large areas in the study area, and they are also floristically rich (Korkmaz *et al.*, 2011).

Sclerophyllous associations belong to *Quercetea ilicis*, while xerophyllous and mesophyllous belong to *Astragalo-Brometea*, and *Quercetea pubescentis*, respectively. It has been emphasized that evergreen sclerophyllous vegetation is a characteristic of Mediterranean environments (Box, 1981; Pignatti, 1984). Sclerophyllous Mediterranean communities are widespread in Kizilirmak Valley slopes in a belt at 250-650 m, and this belt is affected by Semi-arid Mediterranean climate (Akman, 1990). Throughout Mediterranean belt on Kizilirmak Valley slopes several sclerophyllous-Mediterranean communities were distributed as secondary subclimax relicts due to local changes in environmental factors (grazing, fire and clear-cutting) and paleoclimatological changes in the past (Davis, 1965; Pignatti, 1978; Gemici & Seçmen, 1987; Gemici, 1993; Korkmaz & Engin, 1997; Karaer *et al.*, 2010). Some communities of sclerophyllous shrub vegetation have been classified, by some researchers, as substitute communities formed as a result of degradation of climax forests (Mesleard & Lepart, 1991; Loidi *et al*., 1994; Korkmaz & Engin, 1997; Torres *et al*., 2002; Clemente *et al*., 2005; Konstantinidis *et al*., 2006). However, these communities have been classified as postglacial relicts by other researchers during more Mediterranean characteristic climate of pre-glacial era (Pignatti, 1978; Kutzbach, 1986; Gemici, 1993; Loidi *et al*., 1994). These communities seem to be well-developed especially on locally occurring limestone parent rock on slightly alkaline soils that are rich in total $CaCO_3$ (%) and anthropogenically destroyed areas. Basophilic macchia community characterized by dominant *Olea europea* var. *sylvestris* and co-dominant species like *Phillyrea latifolia*, *Pistacia terbinthus* subsp. *palaestina* were formed in arid and shallow soils that are low in organic matter in southern slopes. Arid soils are rich in calcium due to low elluviation (Kacar & Katkat, 2006), and in such soils sclerophyllous-basophilous species are dominant (Loidi *et al.*, 1994). On comparatively damp and calcareous sites in the study area a community characterized by dominant *Arbutus unedo* and co-dominant *Buxus sempervirens* is formed in northern and north-western slopes. Furthermore, slightly basophilous species like *Arbutus unedo* are typical Mediterranean species, but they have a lower competitive power against more basophilous species like *Olea europaea* var. *sylvestris* and *Phillyrea latifolia* and they usually have higher cover on acidic soils (Mueller-Dombois & Ellenberg, 2002; Austin, 1990; Loidi *et al.,* 1994). In this connection, *Arbutus unedo* associations were located on north-west exposed slopes and humid soils rich in organic matter in Kepez gorge.

In the study area, maquis and degraded scrub vegetation occupied calcareous substrata which were locally distributed in Kizilirmak Valley. This may be evaluated as an ecological response to the xeric conditions (Loidi *et al*., 1994) because most Mediterranean species (*Arbutus unedo, Olea europaea* var. *sylvestris, Erica arborea,* etc.) are lime tolerant (Villa, 1982; Llusia & Peñuelas, 2000; Torres *et al*., 2002) and have strong resistance to harsh environmental conditions (Gratani & Ghia, 2002; Munné-Bosch & Peñuelas, 2004)**.** The communities characterized by *Vitex agnus-castus* usually occurred at 250-350 m and on summer dried stream banks on sandy soils influenced by semi-arid Mediterranean climate. *V. agnus-castus* is widespread on warm temperate regions in arid and semi-arid Mediterranean and Western Asia (Schopmeyer, 1974). This species generally grows in damp places alongside the banks of streams and in valleys (Dogan & Mert, 1998; Dogan *et al.,* 2011).

Xerophyllous semi-steppic and steppic associations were widespread in Central Anatolia and entered Euro-Siberian region in Turkey (Akman *et al*., 1984) due to erosion, land degradation and increasing aridity (Karaer *et al.,* 2010). Xerophyllous semi-steppic and steppic associations were also formed as a result of the disturbance of forest communities by antropogenic factors in Kizilirmak Valley (Korkmaz & Engin, 1997). For example, semi-steppic *Juniperus excelsae* community was highly degraded, and as a result the floristic composition of this community comprised many steppic species. Due to high degradation, canopy closure decreased and severe erosion occurred and the number of the steppic species dramatically increased due to high aridity (Korkmaz *et al.,* 2011). Steppic thorny and cushion-forming *Astragalus microcephalus* community was widespread at 550-650 m on schist parent rock in southern slopes, and this community was formed as a result of the destruction of *Pinus brutia* var. *brutia* and *P. nigra* subsp. *pallasiana* var. *caramanica* forests. Similarly *Astragalus angustifolius* subsp. *angustifolius* var. *angustifolius* community occured in southern slopes at 1600-1670 m where *P. sylvestris* var. *hamata* forests were highly degraded. *A. angustifolius* subsp. *angustifolius* var. *angustifolius* is one of the most dominant species of high mountain, alpine and subalpine xerophyllous thorn-cushion steppe vegetation at 1050-2350 m on calcareous parent rock although this species has low ecological tolerance to the changes in elevation (Yildirim & Cansaran, 2010) and usually widespread at high altitudes due to degradation of pre-existing communities such as *P. sylvestris* var. *hamata*. Anthropogenic degradation on natural forest vegetation of Turkey has continued for the last 7000 years (Hafner, 1968; Stewart, 1976; Vermoere *et al.,* 2002). Natural forest vegetation was degraded and changed to steppic vegetation in Kizilirmak Valley (Gemici & Seçmen, 1987; Korkmaz & Engin, 1997). The direction of the prevailing wind in Black Sea is westerly, explaining the mild climate of the region, the evenly distributed high precipitation and the absence of winter frosts (Denk *et al.,* 2001). The dominant climate of the Black Sea region is oceanic although Mediterranean and continental climates are locally seen in places such as river valleys (Akman & Ketenoğlu, 1986). Under oceanic climate, the vegetation is usually dominated by mesopyllous plant communities. This explains why the northern, north-western and southern slopes of the Kizilirmak Valley above 700 m, influenced by oceanic climate, include mesophyllous plant communities. However, human degradation of these mesophyllous forest communities resulted in vegetation changes and discontinuities (Doležal & Šrůtek, 2002) that are described thereafter. *Quercus cerris* var. *cerris* community occurs at 750-1250 m and especially in southern slopes. Thus, *Quercus cerris* var. *cerris* which is a Mediterranean originated species, occurs in Supra-Mediterranean, Sub-Mediterranean and Sub-Euxine zones of Turkey, (Korkmaz *et al.,* 2011) and usually grows in more humid areas and on deeper soils and drought-tolerant (Nardini *et al.,* 1999).

The most typical property of Black Pine, which shows wide variation in Anatolia (Yazgan & Özel, 2013), is that it grows better in extreme climate conditions, in the locations facing against the sea such as south parts in northern and central Anatolia, northern shoulders and narrow valleys in Toros Mountains. It has been shown that *Pinus nigra* shows higher shade tolerance than *P. sylvestris*. (Trasobares *et al*., 2004). As a result of this, *P. nigra* occupied low elevations and northern slopes

(1100-1250 m) in the study area whereas *P. sylvestris* occupied higher elevations and southern slopes (1600-1650 m). The distribution of *P. sylvestris* var. *hamata* forests is mainly restricted to the high mountains of the Mediterranean basin (Castro *et al.,* 2004). *Fagus orientalis* community occurs at 1100-1500 m on northern slopes in the Kizilirmak Valley. Beech forests grow on cool, mesic northern mountain slopes of the Black Sea Region (Eşen *et al.,* 2004; Çolak & Rotherham, 2006).

Environmental factors indeed hierarchically play a key role on distribution and composition of association. So, elevation, relative humidity and soil pH are the primary environmental factors, while aspect, anthropogenic destruction and parent rock are effective as secondary factors on the distribution of associations in the study area. Intermediate and optimal disturbance have positive effects on species diversity of plant communities, whereas those of high disturbance leads are negative (Naveh & Whittaker, 1980; Ramírez-Marcial *et al*., 2001; Bhuyan *et al*., 2003; Blondel, 2006). Many authors have reported that soil characteristics and topographical factors also have a significant effect on vegetation formations (Doležal & Šrůtek, 2002; Kingstone & Waldren, 2003; Bajer, 2003; Härdtle *et al.,* 2005; Xian-Li *et al.,* 2008). It has long been known that elevation has a significant effect on the distribution of plant communities because elevation has a pronounced effect on environmental factors (Fu *et al*., 2004; Randin *et al.,* 2009). We found that elevation was significantly changed among studied communities in the study area. Soil pH is found to be another significant environmental trait to separate plant communities (Rey Benayas, 1995; Llusia & Peñuelas, 2000; Dumortier *et al.,* 2002; Torres *et al.,* 2002; Chytrý *et al.,* 2003). We found that soil pH was decreased from low to high elevations and plant communities were changed alkaline to acidic soils. It has been reported that soil pH decreases along an elevational gradient due to the changes in precipitation regime (Erinç, 1977; Chytrý *et al.,* 2003). Arid soils are rich in calcium due to low elluviation (Kacar & Katkat, 2006). Many of the Mediterranean sclerophyllous communities are lime-tolerant (Pausas & Austin, 2001). DCA diagram also showed that elevation, relative humidity and soil pH were also found to be significant in the study area.

CONCLUSIONS

The Kizilirmak River is the longest river in Turkey with a length of 1355 km. It has a catchment area of 78 000 km^2, which covers approximately 11 % of Turkish territory (Bakan *et al.,* 2010). The North and Middle Basin areas of Kizilirmak River were investigated in the present study and several plant communities were detected. Plant associations in slopes of Kizilirmak Valley reflect a zonal vegetation grouping along an elevation gradient. There is yet no study related to the numerical classification of river valleys in Turkey comparable to other European countries. The present study shows a clear distinction between different community types concerning their soil and environmental properties at local scale. These environmental properties must have influenced the structural differences among vegetation physionomies in Kizilirmak Valley. Furthermore, this study reveals that environmental fluctuations may be very effective on the structure and distribution of plant communities, and anthropogenic factors (i.e dam construction) may have caused long-term dramatic effects on temporal and spatial properties of plant associations along river valleys.

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