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Environmental factors as influencing vegetation communities in Acipayam district of Turkey

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Abstract: *In this study, a data set from Mediterranean mountain forests of southern Anatolia, consisting of species cover and environmental measures in 99 sample plots was analyzed with cluster analysis, indicator species analysis, MRPP, NMDS and sperman rank correlation. Results illustrated two vegetation gradients related to factor complexes of altitude-landform and parent material-land surface smoothness. Axis I of the ordination was strongly related to limestone, serpantine, conglomerate, marl from parent material group, middle slope from slope position group, concave, convex, linear and undulate from landform group, A I, A II, A III and A IV from altitude group, and rocky and erosion pavement from land surface smoothness group. Axis II was strongly related to limestone, serpantine, smooth surface, rocky surface and A III.*

Key words: *Indicator species, Species distribution, Vegetation patterns, Topography, Species groups*

Introduction

The classification of ecological species groups is one of the methods used for discerning vegetation-environment relationships together with an analysis of communities and individual species (Abella and Covington, 2006). Ecological species groups consist of co-occurring plant species sharing similar environmental affinities (Spies and Barnes, 1985; Godart, 1989; Grabherr *et al*., 2003; Ozcelik *et al.,* 2008). Such study identify the environmental gradients correlated with species distributions, classifies species assemblages occupying similar environmental complexes, and relates species distributions to management-oriented variables such as tree growth (Hix, 1988; Host and Pregitzer, 1991). Once species groups are developed for an area, their distribution can be used for inferring soil characteristics and other variables (Pregitzer and Barnes, 1982; Meilleur *et al*., 1992).

Species groups have typically been constructed using combinations of field observations, inspection of tabular species-site matrices, and multivariate analyses such as cluster analysis (Spies and Barnes, 1985; Godart, 1989; Kashian *et al*., 2003). As in many multivariate studies in plant ecology, species groups are hypotheses about species distributions and their relationships to environmental factors. These hypotheses have practical value for estimating site conditions, and are tractable for refinement through experimental research developing causal relationships about species distributions (Pabst and Spies, 1998). On the other hand, different communities are characterized by distinct indicator species which show unique responses to the present environmental gradients. Due to the impossibility to perform complete species inventories in most forest ecosystems, the use of indicator species has been proposed to assess forest biodiversity and the degree of naturalness (Peterken, 1996). An indicator species is any biological species that defines a trait or characteristic of the environment. It may delineate an ecoregion or indicate species competition or climate change. Such species can be among the most sensitive species in a region, acting as an early warning for monitoring. Also, they can be used to predict differences in site index and thus site suitability for some species and can therefore support decision making in forest restoration, management and planning (Fontaine *et al*., 2007). The use of natural vegetation as an indicator for site quality provides good results, due to the close relationship it has with abiotic site characteristics (Wang, 2000; Berge‘s *et al*., 2006; Waring *et al*., 2006).

Mediterranean forests in Turkey have very important position, not only because of their species diversity but also because of their composition and complex structure. One of the components of this complexity is the heterogeneity of habitats, which influences the spatial distribution of plant species. Spatial heterogeneity in the physical environment is an important factor contributing to the commonly high plant species diversity of Mediterranean forests, as variation in resource availability.

The studies carried out by Atalay (1987) and Kantarci (1991) on the forest ecosystems in the Mediterranean region of Turkey have attracted a great attention of the researchers from different disciplines. Latest study on vegetation-environment relationships has been carried out in Aglasun district of this region (Fontaine *et al*., 2007). However, there is a need for more detailed studies.

Acipayam district is located in the Mediterranean region of Turkey. The district has faced intense human activity for hundreds of years for fuel wood, timber and livestock grazing. This long human interference has led to a significant reduction of forest cover while about half of the remaining forest can be considered degraded and unproductive. Therefore, vegetation-environment relationships on Acipayam district will provide more detailed information about Mediterranean ecosystems in Turkey as well as fundamental information in terms of forestry management and applications including restoration, afforestation, conservation, utilization and sustainability.

Materials and Methods

Study area: The study area Acipayam forest district is situated in southern Anatolia between 37°45' N, 28°98' E, 400-2000 m above

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sea level according to UTM coordinate system and covers 2365 km^2 (Fig. 1). A cool and sub-humid Mediterranean climate with pronounced winter precipitation and summer drought predominates (Cepel, 1988). From 1970 to 2003 the mean monthly temperature in Acipayam (941m above sea level) ranged from 2°C (January) to 24.4°C (July) and the mean annual precipitation was 520 mm year^{-1} (DMI, 2003).

In the study area, Mesozoic and Paleozoic limestone is predominating. Besides, Mesozoic aged serpentine, Neolithic

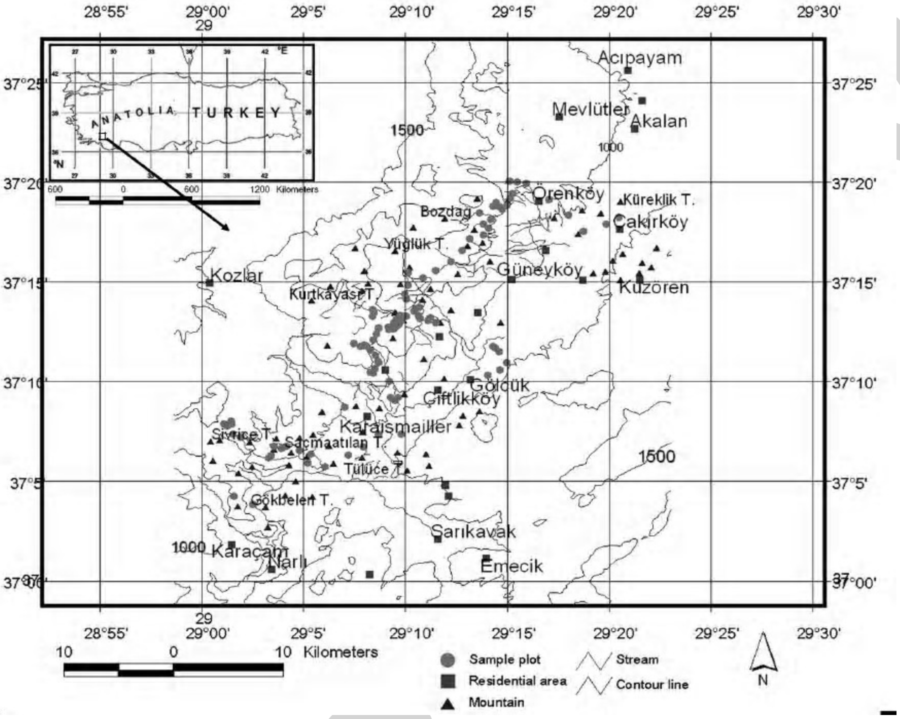

Fig. 1: Location of sample plots in the Acipayam district from Mediterranean region, Turkey

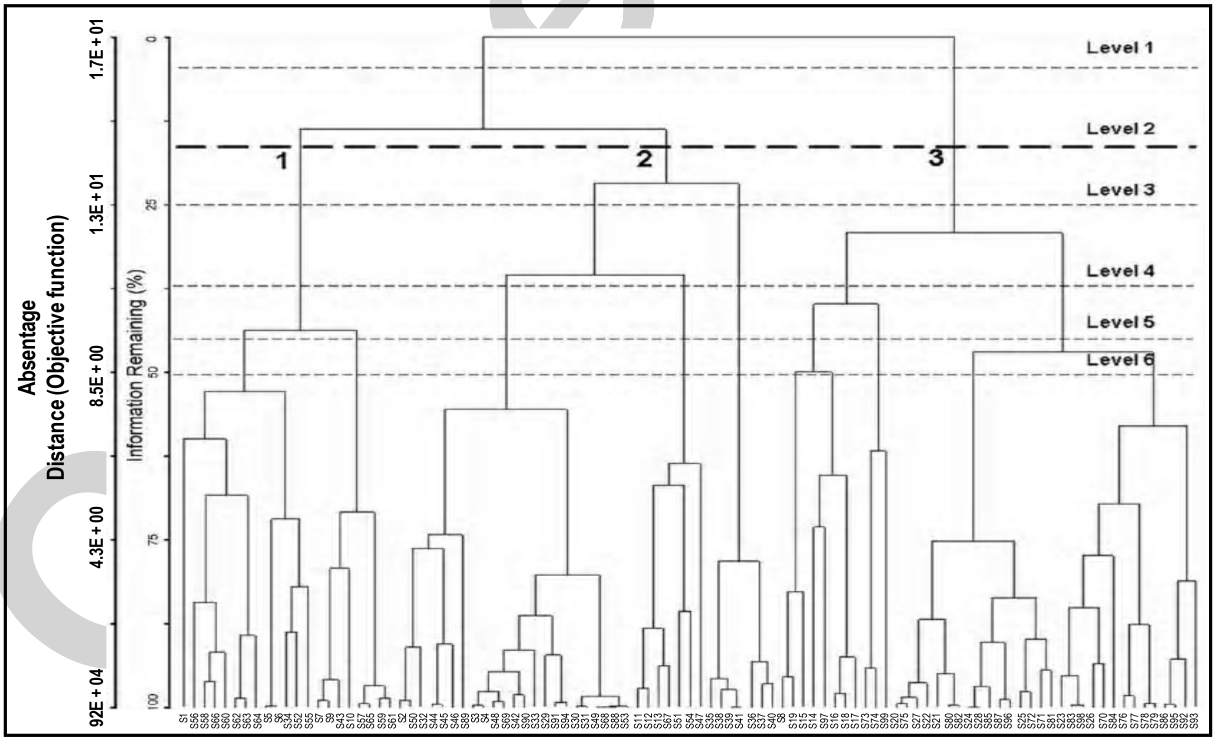

Fig. 2: Classification and cutting levels of sample plots from the Acipayam district in southern Anatolia, Turkey

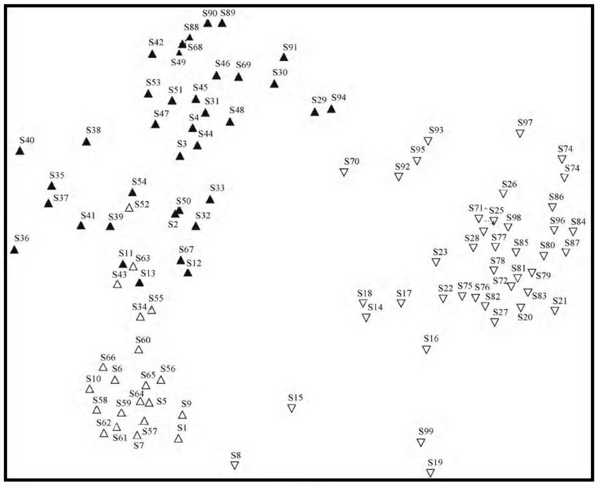

Fig. 3: NMDS ordination of 99 sample plots in the Acipayam district. Sample plots are labeled according to three communities produced by cluster and indicator species analysis: Group I (△); Group II (▲); Group III (▽)

Table - 1: Three plant communities in the Acipayam district in southern Anatolia, Turkey, as determined by indicator species analysis

Species	Group	Value	Mean	SD	p
Junexc	1	77.1	21.7	4.35	0.001
Taxbac	1	28.3	6.5	3.00	0.001
Phlarm	1	53.7	12.2	3.94	0.001
Euhorb	1	44.7	14.4	3.77	0.001
Lonetr	1	28.6	5.6	2.61	0.002
Roscan	1	12.8	4.5	2.42	0.008
Poptre	1	14.3	4.2	2.34	0.009
Acansp	1	18.5	6.7	3.03	0.012
Junfeo	1	22.9	12.1	3.67	0.012
Bercra	1	21.3	10.8	3.87	0.013
Verbas	1	31.4	20.4	4.29	0.021
Acemon	1	12.0	4.5	2.37	0.023
Pinnig	2	87.9	21.9	4.15	0.001
Cedlib	2	23.8	8.6	3.21	0.004
Amyori	2	23.3	10.2	3.49	0.007
Junoxy	2	29.9	20.2	4.50	0.038
Carnut	2	17.7	10.2	3.13	0.032
Pinbru	3	95.4	20.9	4.14	0.001
Quecoc	3	46.4	17.7	4.64	0.001
Styoff	3	36.6	10.5	3.99	0.001
Cotcog	3	27.8	11.5	3.68	0.001
Pister	3	26.8	8.7	3.54	0.003
Queile	3	21.4	10.2	3.48	0.008
Cersil	3	17.1	6.2	2.83	0.007
Queinf	3	24.4	12.4	4.33	0.018
Plaori	3	14.6	6.6	3.07	0.021
Pirela	3	12.2	5.2	2.56	0.030
Astmic	3	14.6	6	2.69	0.010

aged marl and conglomerate are also present. There is also undifferentiated formation; described as Paleozoic comprehensive series which contains detract rock lenses with fine-course grain and clayey-siliceous schist (MTA, 1974). Soil depth, moisture content and stoniness vary with parent material and topography. Most soils can be classified as leptosols, regosols or cambisols (FAO *et al.,* 1998) depending on shallowness and stoniness.

The study area is covered by Mediterranean mountain forests (about 40%) mainly composed of *Pinus brutia* Ten. (Brutian pine) and *Pinus nigra* Arn. ssp. *pallasiana* (Lamb.) Holmboe (Crimean pine) together with the species of *Quercus* and *Juniperus*. The remaining part of the area consists of agricultural land. It has a long history of human settlement and forest utilization, including a high grazing pressure.

Data collection and statistical analysis: Ninety nine sample plots were selected. Cover estimates were made for vascular plant species using Braun Blanquet scale Braun-Blanquet (1932) in each plot. The species were coded and are given in Table A1. Braun Blanquet scores were transformed to relative cover (r: 0.01; +: 0.02; 1: 0.04; 2: 0.15; 3: 0.375; 4: 0.625 and 5: 0.875) (Fontaine *et al.*, 2007). Altitude, slope degree, slope position, aspect, landform, parent material, and land surface smoothness were recorded. Altitude and slope degree have numerical values. The others have qualitative values. Hence, all environmental characteristics were categorized for application analytical methods and coded (Table A2). Thus, all environment data matrix was converted to"0" and "1" values. The sample plots were coded from the first sample plot to the last one as S1 to S99.

The 99 sample plots of vegetation matrix were repeatedly clustered into 2-10 groups using a Sorensen distance measurement and flexible beta linkage (β=-0.25) (Mc Cune and Mefford, 1999). Indicator species analysis (Dufrene and Legendre, 1997) was applied to determine the optimal number of groups and indicator species of these groups. For each run, indicator values of each species and the overall average p-value were calculated. To avoid creating additional groups that only marginally improved the overall significance, the last cluster step > 0.05 significance to the average p-value was selected as the most informative number of groups. Differences in community composition between groups were tested with a multi responsible permutation procedures (MRPP) test using the Sorensen distance measure and a natural group weighting factor $n_i \Sigma n_i$ (n_i is the number of sample plots in each group). Non-metric multi dimensional scaling (NMDS) was used to investigate indirect gradients effecting species distribution. NMDS was run on the vegetation data using the Sorensen distance measure. Selection of dimension, iteration and instability criterion wasn't done. Autoplot mode (medium) was preferred in place of them (McCune and Mefford, 1999). Nonparametric Sperman rank correlation was performed between NMDS axes values and categorized environmental variables to determine the most important environment factors influencing vegetation distribution. Classification, MRPP, indicator species analysis and NMDS were conducted using PC-ORD 4.0 for Windows (McCune and Mefford, 1999). Nonparametric Sperman rank correlation coefficients were calculated using SPSS 13.0 for Windows (SPSS Inc., Chicago, IL).

Table - 2: Sparman rank correlation coefficients between 36 categorized environmental variables and the scores of axes I and axes II of NMDS

Environmental characteristics	Axis I		Axis II	
	Coefficients	p	Coefficients	p
LIMSTN	-0.708	0.000	-0.207	0.040
SERPAN	0.383	0.000	0.265	0.008
CONMER	0.339	0.001	-0.041	0.684
MARN	0.289	0.004	-0.053	0.600
PACOMS	0.157	0.120	0.070	0.491
BOTTOM	0.018	0.863	-0.070	0.489
LOWER	-0.102	0.315	-0.040	0.697
MIDDLE	0.245	0.015	-0.043	0.672
UPPER	-0.124	0.222	0.115	0.259
RIDGE	-0.145	0.152	-0.110	0.280
N	-0.145	0.151	0.023	0.818
S	0.032	0.757	0.078	0.444
SE	0.110	0.279	-0.170	0.093
SW	0.075	0.458	0.065	0.521
NW	0.038	0.711	0.095	0.347
NE	-0.018	0.861	0.076	0.455
E	-0.094	0.354	0.059	0.562
W	0.109	0.283	-0.170	0.093
CONCAV	-0.287	0.004	-0.125	0.218
CONVEX	-0.242	0.016	0.076	0.453
LINEAR	0.475	0.000	0.004	0.970
UNDULE	0.200	0.047	0.134	0.186
FLAT	0.061	0.546	-0.150	0.138
SSLOPE	-0.031	0.760	-0.123	0.225
MSOPE	0.016	0.873	0.061	0.550
STEP	0.032	0.754	0.099	0.331
VSTEP	-0.010	0.926	0.021	0.838
HSTEP	-0.044	0.667	-0.012	0.905
ALT I	0.334	0.001	-0.097	0.342
ALT II	0.652	0.000	-0.068	0.502
ALT III	-0.209	0.037	0.277	0.006
ALT IV	-0.605	0.000	-0.172	0.089
SMSURF	0.312	0.002	0.331	0.001
CRAKED	0.012	0.906	-0.123	0.225
ROCKY	-0.328	0.001	-0.270	0.007
ERZPAV	-0.261	0.009	-0.094	0.356

Results and Discussion

Cluster dendrogram showed the positions of sample plots with respect to vegetation data. Two, three, four, six, eight and ten groups were determined from the first separation (Level 1) upto the last separation (Level 5) respectively (Fig. 2). Optimum classification was obtained by Level 2. The clustering of the sample plots in 3 groups provided the most informative number of clusters with a high separation between groups (MRPP T=-47.638465) and a high level of homogeneity within groups (MRPP A=0.24552669).

Three plant communities were identified with distinct indicator species as hypothesized. Junexc, Taxbac, Phlarm, Euhorb, Lonetr, Roscan, Poptre, Junfeo, Acansp, Bercra, Verbas, Acemon, were strongly related to the Group I. Pinnig, Cedlib, Amyori, Carnut, Junoxy were the indicator species of Group 2. Group 3 was represented to Pinbru, Quecoc, Styoff, Cotcog, Pister, Queile, Cersil, Queinf, Plaori, Pirela and Astmic (Table 1).

The percentage of variance was 71.6 percent in NMDS ordination with two dimensions. The ordination unambiguously partitioned the three communities after rotation (-45°) for maximal group separation. Group 1 and 2 were unmistakably separated from Group 3 along to first axes (explaining 46.0 percent of the variance). The left side of bi-plot was occupied by Group 1 and Group 2; whereas, the right side of bi-plot was occupied by Group 3. Group 1 was separated from Group 2 along the second (25.5 percent) NMDS dimension. The sample plots of Group 1 were positioned in the lower site of bi-plot. The other was in the upper site of bi-plot (Fig. 3).

Relationship between categorized environmental variables and NMSD axes was found in Table 2. Significant positive correlation was found between axis I and serpentine, conglomerate, marl from parent material group, middle slope from slope position group, linear and undulate from landform group, AI and AII from altitude group. Whereas, axis I had negative correlation with limestone, concave, convex, AIII, AIV and land surface smoothness such as rocky and erosion pavement. Categorized variables of slope position, slope degree and aspect were unrelated to axes I. We interpreted axis I as an altitude-landform gradient because of the significant relationships between all altitudes groups, all landform characteristics and axes I. Serpentine and smooth surface were positively related to axes II; whereas, limestone, AIII and rocky surface were negatively related to axes II. The other categorical variables were non-significant. We interpreted axes II as parent material-land surface smoothness.

In this study, Group 1 is a mountainous Mediterranean community characterized by *Juniperus excelsa* Bieb., *Taxus baccata* L., *Phlomis armanica* Willd., *Lonicera etrusca* Santi var. *etrusca*, *Rosa canina* L.. Group 2 represents a Supra Mediterranean community between Eu-Mediterranean community and Mountainous Mediterranean community with *Pinus nigra* Arn. ssp. *pallasiana* (lamb.) Holmboe, *Cedrus libani* A. Rich., *Carduus nutans* L., *Amygdalus orientalis* Miller and *J. oxycedrus* L.. The most important characteristic species of Group 3 are *P. brutia* Ten., *Quercus coccifera* L., *Styrax officinalis* L., *Pistacia terebinthus* L., *Cotinus coggyria* Scop., *Q. ilex* L. and *Cercis siliquastrum* L.. These species in Group 3 reflect a Eu-Mediterranean community (Atalay, 1987; Fontaine *et al.,* 2007).

As expected, the most important environmental factor effecting distribution of vegetation communities is altitude as reported by Kantarci (1991) and Fontaine *et al.* (2007) and Sevgi and Akkemik (2007) as well. Landform characteristics are also important for vegetation communities in axes I due to a strong representation of local and micro climate sites.

It was surprising that aspect is not significant on vegetation distribution, although Fontaine *et al.* (2007) stated importance of altitude and aspect gradients for vegetation patterns in Aglasun district, Mediterranean region.

Table - A1: The list and abbreviation of the species and codes from the Acipayam district, Mediterranean region

Species	Codes
Acanthalimon spp.	Acansp
Acer monspessulanum L.	Acemon
Acer spp.	Acersp
Althaea rosea L.	Altros
Amygdalus orientalis Miller.	Amyori
Arbutus andrachne L	Arband
Arum maculatum L.	Arumac
Astragalus microcephalus Willd.	Astmic
Astragalus spp.	AstrSp
Berberis crataegina DC.	Bercra
Bromus spp.	BroSp
Carduus nutans L.	Carnut
Cedrus libani A. Rich.	Cedlib
Cercis siliquastrum L.	Cersil
Cirsium arvense (L.) Scop.	Cirarv
Cistus creticus L.	Ciscre
Cistus salviifolius L.	Cissal
Colutea arborescens L.	Colarb
Cotoneaster nummularia Fisch&Mey.	Cotnum
Cotinus coggyria Scop.	Cotcog
Crataegus monogyna Jacq.	Cremon
Daphne sericea Vahl.	Dafser
Digitalis davisiana Heywood	Digdav
Dryopteris pallida (Bory) Fomin.	Drypal
Echinops viscosus DC. ssp. *bithynicus*	Echvis
Erica verticillata Forsk.	Eriver
Eryngium spp.	Erysp
Euphorbia spp.	Euhorb
Fontanesia philliraeoides Labill ssp. *philliraeoides*	Fonphil
Fraxinus ornus L.	Fraorn
Inula anatolica Boiss	Inuana
Juniperus excelsa Bieb.	Junexc
Juniperus feoettidissima Wild.	Junfeo
Juniperus oxycedrus L.	Junoxy
Liquidambar orientalis Mill.	Liqoir
Lonicera etrusca Santi var. *etrusca*	Lonetr
Marrubium vulgare L.	Marvul
Mentha spicata L.	Menspi
Morus alba L.	Moralb
Ononis spinosa L.	Onospi
Origanum spp.	Orinan
Prunus divaricate Ledep	Prudiv
Paeonia spp.	Paesp
Phlomis armeniaca Willd.	Phlarm
Phlomis grandiflora H.S. Thamson	Phlgra
Pinus brutia Ten.	Pinbru
Pinus nigra Arn. subsp. *pallasiana* (lamb.) Holmboe	Pinnig
Pyrus communis L.	Pircom
Pirus elaegrifolia Wild.	Pirela
Pistacia terebinthus L.	Pister
Platanus orientalis L.	Plaori
Populus tremula L.	Poptre
Prunus spinosa L.	Pruspi
Quercus cerris L. var. *cerris*	Quecer
Quercus coccifera L.	Quecoc
Quercus ilex L.	Queile
Quercus infectoria Olivier	Queinf
Quercus trojana P. B. Webb	Quetro
Rhamnus oleoides L.	Rhaole
Rhus coriaria L.	Rhucor
Rosa canina L.	Roscan
Rubus fruticosus L.	Rubfru
Salix alba L.	Salalb
Salvia officinalis L.	Saloff
Satureja cuneifoll Ten.	Satcun
Scolymus hispanicus L.	Scohis
Spartium junceum L.	Spajun
Styrax officinalis L.	Styoff
Tamarix smyrnensis Bunge.	Tamsmy
Taxus baccata L.	Taxbac
Thymbra spicata L.	Thyspi
Thymus longicaulis Cpresl.	Thylon
Ulmus glabra Hadson	Ulmgla
Urtica diocia L.	Urtdio
Verbascum spp.	Verbas
Vicia sativa L.	Vicsat
Xanthium spinosum L.	Xanspi

Table - A2: Environmental variables, categorized variables and codes from the Acipayam district, Mediterranean region

Environmental variables	Categorized variables	Code
Parent material	Limestone	LIMSTN
	Serpentine	SERPAN
	Conglomerate	CONMER
	Marly (marn)	MARN
	Paleozoic comprehensive series	PACOMS
Slope position	Bottom land	BOTTOM
	Lower slope	LOWER
	Middle slope	MIDDLE
	Upper slope	UPPER
	Ridge	RIDGE
Aspect	North	N
	South	S
	Southern east	SE
	Southern west	SW
	Northern west	NW
	Northern east	NE
	East	E
	West	W
Landform	Concave	CONCAV
	Convex	CONVEX
	Linear	LINEAR
	Undulate	UNDULE
Slope degree	Flat	FLAT
	Slight slope degree	SSLOPE
	Middle slope degree	MSLOPE
	Step	STEP
	Very step	VSTEP
	Very mush step	HSTEP
Altitude	400-800	A I
	800-1200	A II
	1200-1600	A III
	1600-2000	A IV
Land surface smoothness	Smooth surface	SMSURF
	Creaked surface	CRAKED
	Rocky surface	ROCKY
	Erosion pavement	ERZPAV

According to Kantarci (1991) altitude, aspect and vertical distance from Mediterranean sea are important and fundamental factors in the ecosystem classification in the Mediterranean region. Ozkan (2004) also reported the chief factors as altitude, aspect and landform characteristics respectively in Beysehir watershed. Similar results have been reported by Karatepe (2005) in Egidir watershed.

The reason of non significance of aspect is probably due to the dominant winds affecting the Acipayam district. There are two air masses coming from the south and the east influencing the district. The winds coming from the south bring the Mediterranean sea air masses and those coming from east bring the Aegean sea air masses. The humid and warm air masses come from the south and the east. Besides, the north aspects close the air masses originating from the polar region partly in the lower range of the district. That's why aspect variability didn't reflect the vegetation distribution. Aspect and climatic variability are probably independent from each other in the Acipayam district.

Axes II is a parent material-land surface smoothness gradient. Ozkan (2004) and Karatepe (2005) reported that parent material plays an important role effecting vegetation distribution in the same altitude belts, aspects and homogenous topography in the Beysehir watershed and Kasnak oak protection area in the Egirdir watershed. The importance of parent material in the Acipayam district coincides with other studies. There are wide potential afforestation and natural restoration areas being subjected to individual selection and grazing in Acipayam District. Vegetation-environment relationships are thus very important in terms of the management strategies and plans, sustainability, restoration and reforestation of these degraded and forestless areas.

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