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ECOLOGICAL LAND CLASSIFICATION AND MAPPING OF YAZILI CANYON NATURE PARK IN THE MEDITERRANEAN REGION, TURKEY

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Abstract. Distinction of lands corresponding to hierarchical sequences of plant communities means hierarchical classification of ecosystems. In this context, it is essential in determining of effective environmental characteristics at each different hierarchic level of vegetation distinction. Thus, a hierarchical mapping including ecological land units can be provided owing to comparison of same hierarchical level of vegetation classes with the land units marked at the hierarchical level of the map. The study was carried out in order to classify and map hierarchically Yazili Canyon Nature Park situated in the Mediterranean region, Turkey. 107 sample plots were selected. TWINSPAN (the two-way indicator test) was applied in order to divide land into units, and chi-square tests were applied for confirmation of the units. Interspesific correlation analysis was also applied to determine the indicator species at each level of division. As a result, six portions were defined at different hierarchical levels in Yazili Canyon Nature Park. Climatic heterogeneity – which originated from the heterogeneous landscape structure of the canyon – plays an important role in this separation.

Keywords: TWINSPAN, hierarchical ecosystem classification, environmental heterogeneity, vegetation–environment relationships.

1. Introduction

In the Mediterranean region of Turkey, two region units have been recognized on the largest scale: the Main Zone under the typical Mediterranean climatic conditions, and the Transition Zone under the impact of a climate prevailing between the Mediterranean and continental climate conditions. These units were subdivided into regional subgroups, i.e. the sub-regional group open to the sea impacts, interior sub-regional group, the Lake District's sub-regional group, and the regional subgroup close to humid and warm air masses coming from the Mediterranean Sea. The vertical distance from the Mediterranean Sea, altitude, aspect, landform characteristics and directions of the mountainous masses by the site of the Mediterranean Sea are the influential factors on distinction of the regional subgroups (Kantarci 1991; Fontaine *et al.* 2007; Ozkan *et al.* 2009).

The Lake District's sub-regional group (LDSG) is located in the transition zone of the Mediterranean region. LDSG covers about 40% of the Mediterranean mountain forests mainly composed of *Pinus brutia* Ten., *Pinus nigra* Arnold supsp. *pallasiana* (Lamb.), *Juniperus* spp. and *Quercus* spp. (Fontaine *et al.* 2007; Ozkan, Kantarci 2008). LDSG also has a rich plant diversity including relic and endemic species. That is the reason there are important natural reserve areas in this sub-regional group (Fakir 2006). One of them is the Yazili Canyon Nature Park.

The Yazili Canyon Nature Richardson 2005). St. Paul Trail passes from the Yazili Canyon as well. Besides, there are various inscriptions on the rocky faces of the Canyon (Demirpolat 2004). That is another reason, the park is important from the historical point of view.

This study was carried out to produce a hierarchical site map of the nature park including geographical information from the ecological point of view, intended for provision of fundamental information in the context of forest management and application, such as restoration, conservation, sustainability and recreation in addition to taking measures against projected climatic change.

2. Material and method

2.1. Site description

The Yazili Canyon Nature Park in Sutculer township of Isparta province from the Mediterranean region, lies between 37° 27' 22" N–37° 29' 37" N latitude and 30° 54' 16" E–30° 58' 26" E longitude. It covers the area of around 600 ha. The nature park is located at a distance of 70 km from Isparta, 120 km from Antalya, the most important touristic city of Turkey.

The Yazili Canyon Nature Park is bounded by Mahmutca Hill on the north, Yukarıduzcalı Hill on the north-west, by Bucakli Hill on the east, Erdasi Hill on the south, and Karacaoren Lake on the south-west I (Fig. 1).

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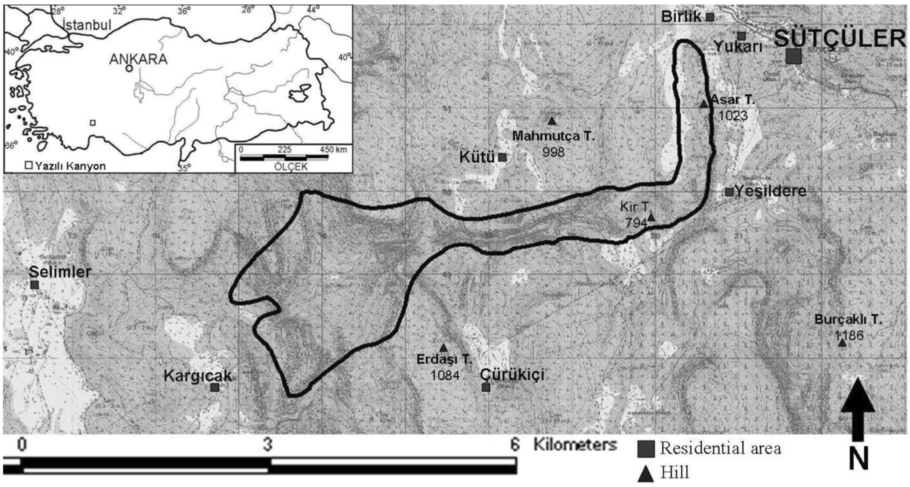

Fig. 1. Location of Yazili Canyon Nature Park in Sutculer Distric

The climate of the area was reviewed using data from the Meteorology Station in Sutculer (DMIGM 2006). The meteorological data were obtained for the years 1975 to 1993 and average annual rainfall in the district was 950.1 mm. The most arid and hottest months were July and August; with the average temperature of 23.3 °C. Annual average temperature was 13.1 °C. The average relative humidity was 54 percent. The minimum relative humidity was 43 present and occurred in August while the maximum was recorded during December with 66 percent. Heavy rain occurred in November, December, January, and February, while the dry period extended from the beginning June until the end of October. The typical climate of the Mediterranean predominates, characterized by hot and dry summers, and rainy winters in the district. Water deficit was registered for about 4.5 months in a year according to Thornthwaite method as shown in Fig. 2 (Gulsoy 2006).

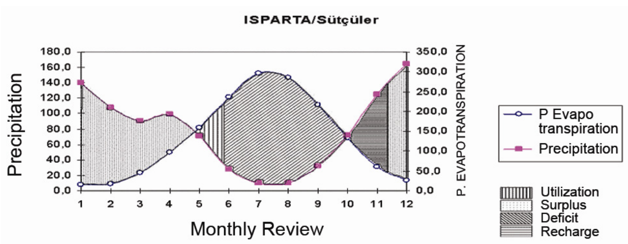

Fig. 2. Water balance diagram of Sutculer District

The Yazili Canyon, a deeply cut valley, consists of coarse limestone from the Cretaceous period (JEO-TEK and UTTA 2006). Altitudinal difference of the Canyon between the base and the ceiling ranges from 100 m to 400 m.

Negative sloping places developed by water and plants on the wall of the canyon are remarkable. Additionally, conglomerate appears in the northern lower slope of the park. The land surface is characterized by irregular topography. There is only one stream that springs out of Sutculer's environs and joins the Aksu River in the Nature Park and the stream flows during all seasons. On other hand, the Yazili stream is uninterrupted unlike typical streams in karstic areas. The length of the stream is about 10.4 km along the park. The soils derived from limestone ranges from very shallow to middle depth. The soil on the surface of limestone is slightly undulating with levelled or bedded surfaces and weak zones on the rugged and inclined surfaces. For this reason, although soil does not develop on the inclined surface of karstic terrains, it forms a weak zone of the lime stone. Hence, the soil is well drained. There are three soil types that are found through the Nature Park. These are: brown forest soil, reddish-brown Mediterranean soil and reddish Mediterranean soil. The remaining area is occupied by colluvial deposits, rocky and rubble material (Ozkan, Suel 2009).

2.2. Data set

For selection of sample plots, digital topographic map of the study area was prepared first of all. Aspect groups, slope-degree group and altitude groups were prepared. The study area was observed. Locations of sample plots in the study area were determined on the basis of this knowledge. 107 sample plots (20×20 m) were selected in the Nature Park (Fig. 3) and 183 species were determined. In other words, the matrix consists of 107×183 cells.

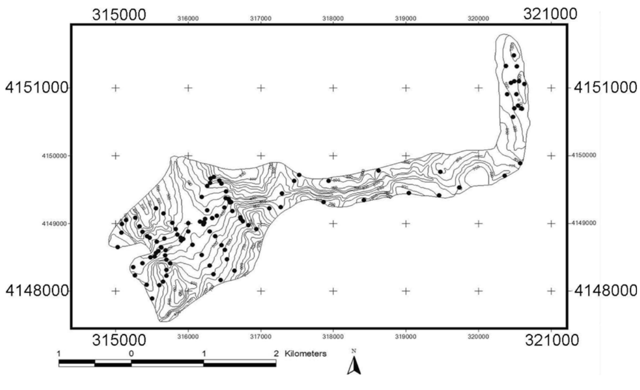

Fig. 3. The location of sample plots in the study area at the Yazili Canyon

Two-by-two divisions at each step were preferred for both floristic and environmental data. The reason for two-by-two divisions of floristic data resulted from possession of equal distance similarity values of the two parts. However generally, divisions by more than two are not the same similar values. In other worlds, one of the groups is more similar than the other. In this situation, the groups that are not at equal distances in terms of floristics are problematic to investigate in respect of environmental characteristics.

2.3. Data analysis

Analytic procedure was applied, following the methods respectively:

1. Vegetation matrix was subdivided into 2 groups by using TWINSPAN by means of presence-absence data.
2. TWINSPAN groups were accepted as a classification variable (CV). Sample plots belonging to TWINSPAN groups (CV) were marked with different colours on the map and discriminators (the most important environmental variables affecting the distribution of vegetation) were evaluated according to spatial distribution of the sample plots.
3. After assessment according to them, the border was drawn and the Yazili Canyon Nature Park was divided into two sites.
4. Sample plots belonging to the two sites of the Nature Park and CV were related to each other by using chi-square test in order to find a significant result at the level of 5% at least. For sites to be accepted, the result of the test had to be less than 5%.
5. After this step (confirmation of the sites) was completed at each site, in order to divide sites into smaller portions, the same procedure were repeated until it was impossible to apply analytic methods because of the decreasing number of sample plots.
6. After finishing the site classification and mapping of the Nature Park, interspecific correlation analysis was applied in order to determine the indicator species of the sites. Thus, characteristic species could be defined and differentiations between the sites could be clarified.
7. In conclusion, site classification and mapping were produced.

TWINSPAN was performed from being originally devised by Hill (Hill 1973). Interspecific correlation analysis was applied according to exact method of Fisher like Cole's preference by using SPSS (Cole 1949).

3. Result and discussions

18 sample plots in Group I and 89 sample plots in group II of 107 sample plots in total taken in the study area were located at the first separation level of the first TWINSPAN (Table 1).

The sample plots were marked in different colours according to their groups on the topographic map of the canyon. It was realized that most of the sample plots of group I were located in immediate environs of the river bank. Therefore, the first separation was done according to the river bank and the other part of the Canyon. In other words, the border was drawn between the river bank site and the other part of the Canyon (Fig. 4).

Thus, after drawing the border, the new groups were determined. Namely, 21 sample plots were identified in the Site A represented Group I and remnant 86 sample plots – in the Site B represented Group II (Table 2).

Table 1. Outputs of TWINSPAN

Division levels	Number of Analysis	Groups	Sample plots
First division Yazili Canyon	I	I	25, 26, 70, 72, 76, 78, 89–91, 93, 94, 97–100, 103, 105–107
		II	1–24, 27–69, 71, 73–75, 77, 79–88, 92, 95, 96, 101, 102, 104.
Second division in Site B	II	I	70, 72, 76, 78, 79, 82, 83, 90, 91, 93, 94
		II	1–24, 33–43, 46–69, 71, 73,-75, 77, 80, 81, 84–88, 92, 96, 101, 102
Third division in Site B.D	III	I	20, 21, 33, 34, 36–43, 54
		II	1–19, 22–24, 35, 46–53, 55–69, 71, 74, 75, 77, 81, 84–88, 96, 101, 102
Fourth division in Site B.D.F	IV	I	20, 21, 52–55, 57, 59, 64, 65, 67, 68, 69, 71, 74, 75, 81, 87, 88
		II	1–19, 22–24, 46–51, 56, 58, 60–63, 66, 77, 84–86, 96, 101, 102
Fifth division in Site B.D.F.G	V	I	1–8, 10, 14, 16–22, 24, 62
		II	9, 11–13, 15, 23, 46–51, 61, 63, 96, 101, 102

Table 2. Determined groups of sample plots (mapping units)

Division level	Determined groups	Sample plots
First division	Site A Map unit	25–32, 44, 45, 89, 95, 97–100, 103–107
	Site B	1–24, 33–43, 46–88, 90–94, 96, 101, 102
Second division B	Site B.C Map unit	70, 72, 73, 76, 78–80, 82, 83, 90–94.
	Site B.D	1–24, 33–43, 46–69, 71, 74, 75, 77, 81, 84–88, 96, 101, 102
Third division B.D	Site B.D.E Map unit	33–43
	Site B.D.F	1–24, 46–69, 71, 74, 75, 77, 81, 84–88, 96, 101, 102
Fourth division B.D.F	Site B.D.F. H Map unit	52–60, 64–69, 71, 74, 75, 77, 81, 84–88
	Site B.D.F.G	1–24, 46–51, 61–63, 96, 101, 102
Fifth division B.D.F.G	Site B.D.F.G.K Map unit	3–12, 14–24
	B.D.F.G.L Map unit	1, 2, 13, 46–51, 61–63, 96, 101, 102

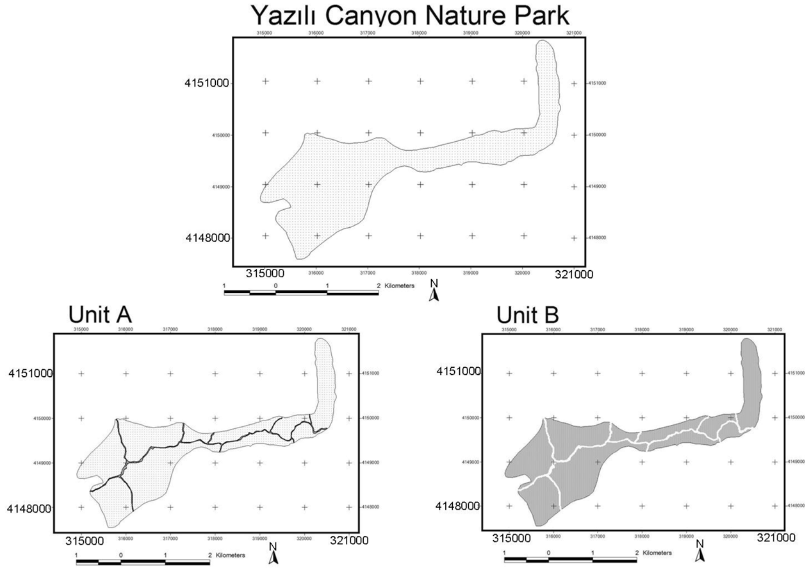

Fig. 4. Division of Site unit A and Site unit B

Chi-square test was applied for TWINSPAN groups and determined groups in order to understand the validity of the map units and the result of the test was significantly at the level of 1% ($\chi 2 = 21.448$) (Table 3). Thus, the first mapping stage was performed successfully.

The same processes were applied to the other separation (Tables 1–3), and the ecological units of the Nature Park were obtained and illustrated in Fig. 5.

Interspecific correlation analysis results for determination of the indicator species of the sites was given in Table 4 as well.

Site unit A is a narrow zone, a stream bank site on the valley bottom including interrupted and uninterrupted streams. The site unit is strongly positively associated with the species Alnus orientalis var. pubercens, Cephalanthera rubra, Hedera helix, Mentha spicata var. spicata, Nerium oleander and Platanus orientalis. Pistacia terebinthus is negatively associated with the site (Table 4). Humid climatic conditions prevail in the unit during all of the seasons. The stream maintains the humid climate throughout its bank. The unit is characterized by the absence of soil or little soil, dramatically changing slope degree, big limestone rocks and rough surface because of the rocks or parent material.

Site unit B.C is located in the north-east of the park (Fig. 5). Thermal Mediterranean climate is dominant with shortage of water in the soil during summer period in the unit. The unit can also receive winds coming from the north. Hence, in comparison with other site units, Unit B.C is a little cooler. The unit was subjected to the individual selection and overgrazing. However, goat grazing and individual selection has not taken place for a couple of years. The unit is strongly positively associated with Juniperus *oxycedrus*, *Sideritis pisidica*, *Junglans regia* (human factor) and *Verbascum* spp. (also accepted as indicator species of grazing). *Quercus coccifera* is common in the unit. However, the species isn't an indicator species of Unit B.C. because it appears all over the park. Negative indicator species of the site are *Dapne gnidioides* and *Origanum onites* (Table 4).

Site unit B.D.E is located in the middle zone of E-W direction in the north of the park. The unit is under the impact of humid air masses coming from the Mediterranean Sea via the Kovada Channel. The air masses pass from the Canyon valley and affect the unit. *Calicotome villosa*, *Campanula delicatula*, *Cynoglossum creticum*, *Knautia inteprifolia* var. *bidens*, *Satureja thymbra*, *Tordylium apulum*, *Trifolium campestre* are strongly

Table 3. Outputs of chi-square tests in TWINSPAN groups and determined groups

Attempt	TWINSPAN groups	Confirmed groups	Chi-square	Sig. level (validity)
First division	I.I	Site A MAPUNİT	21.448	0.000
	I.II	Site B		
Second division	II.I	Site B.C MAPUNİT	64.869	0.000
	II.II	Site B.D		
Third division	III.I	Site B.D.E MAPUNIT	46.576	0.000
	III.II	Site B.D.F		
Fourth division	IV.I	Site B.D.F.H MAPUNIT	26.826	0.000
	IV.II	Site B.D.F.G		
Fifth division	V.I	Site B.D.F.G.K MAPUNİT	14.863	0.000
	V.II	Site B.D.F.G.L (the stop point) MAPUNİT		

Table 4. Indicator species of the sites based on interspecific correlation analysis

Site Units	Species	Direction of association	Chi-square	Sig. level
A	*Alnus orientalis* var.*pubercens*	+	36.570	0.000
	Cephalanthera rubra	+	16.355	0.000
	Hedera helix	+	12.120	0.000
	Mentha spicata var. *spicata*	+	12.742	0.000
	Nerium oleander	+	19.998	0.000
	Pistacia terebinthus	-	14.770	0.000
	Platanus orientalis	+	45.589	0.000
B.C	*Dapne gnidioides*	-	17.725	0.000
	Junglans Regia	+	13.539	0.000
	Juniperus oxycedrus	+	30.551	0.000
	Origanum onites	-	20.782	0.000
	Sideritis pisidica	+	14.008	0.000
	Verbascum spp.	+	12.112	0.001
B.D.E	*Calicotome villosa*	+	17.787	0.000
	Campanula delicatula	+	43.103	0.000
	Cynoglossum creticum	+	18.868	0.000
	Knautia inteprifolia var. *bidens*	+	30.450	0.000
	Satureja thymbra	+	75.460	0.000
	Tordylium apulum	+	20.427	0.000
	Trifolium campestre	+	14.058	0.000
B.D.F.H	*Arbutus unedo*	+	10.124	0.001
	Jasminum fruticans	+	12.524	0.000
	Micromeria myrtifolia	+	17.204	0.000
	Olea europaea var. *sylvestris*	+	10.235	0.001
	Quercus infectoria	-	10.471	0.001
B.D.F.G.K	*Cephalanthera rubra*	+	18.028	0.000
	Gladiolus italicus	+	12.640	0.000
	Limodorum abortivum	-	14.221	0.000
	Ornithogalum armeniacum	+	12.742	0.000
	Platanus orientalis	-	8.387	0.004
	Quercus infectoria	+	20.087	0.000
	Silene aegyptiaca subsp. *aegyptiaca*	+	34.775	0.000
	Thalictrum orientale	+	18.960	0.000
B.D.F.G.L	*Cercis siliquastrum*	+	24.473	0.000
	Stachys antalyensis	+	10.052	0.002

related to the unit. In general, these plants in addition to other shrub and herb species appear on stepped and rugged places as well as open and semi-open *Pinus brutia* stands with normal canopy covers. In other words, because of cracked bedrock and in semi-open *Pinus brutia* stands plant diversity in the rough-surface places is richer than in normal canopy covers.

Site unit B.D.F.H including 3 fragments lies from the east to the west in the north of the Park. The site is partly closed to the air masses coming from the south and can receive air masses coming from the north. The site is therefore probably a little cooler compared to other sites except for Unit B.C. *Arbutus unedo*, *Jasminum fruticans*, *Micromeria myrtifolia* and *Olea europaea* var. *sylvestris* are positively associated with the unit. *Quercus infectoria* is a negative indicator species of the site.

Site unit B.D.F.G.K is located on the middle and upper mountainous area in the south of the park (Fig. 5). *Cephalanthera rubra*, *Gladiolus italicus*, *Ornithogalum armeniacum*, *Quercus infectoria*, *Silene aegyptiaca* subsp. *aegyptiaca, Quercus infectoria* and *Thalictrum orientale* are positive indicators whereas *Platanus orientalis* and *Limodorum abortivum* are negative indicators in the unit.

Site unit B.D.F.G.L lies between site unit A and site unit B.D.F.G.K (Fig. 5). The unit is located on the lower slopes of the deep and narrow valley. Therefore, humid climatic conditions prevail in the unit. *Cercis siliquastrum* and *Stachys antalyensis* are strongly associated with the unit. The most productive *Pinus brutia* stands appear in the site. At the same time, rich plant diversity has attracted attention (Fig. 5).

4. Conclusion

The river bank (Unit A) is the first land discriminator of the Canyon. In fact, immediate environs of the river bank are considerably different from the other part of the Canyon because of the local climatic conditions in favour of humidity (moisture) originated from the Yazili river. Characteristic plants of this site are *Alnus orientalis* var. *pubercens* and *Platanus orientalis,* which is a typical river bank vegetation (Fakir 2006).

The positional situation of Unit BC and Unit BD portrays climatic differences between them. The differences of these units probably originated from the relative differences of the north and south climatic impacts between them. Because the location of the units are a good indicator for understanding of the climatic differences

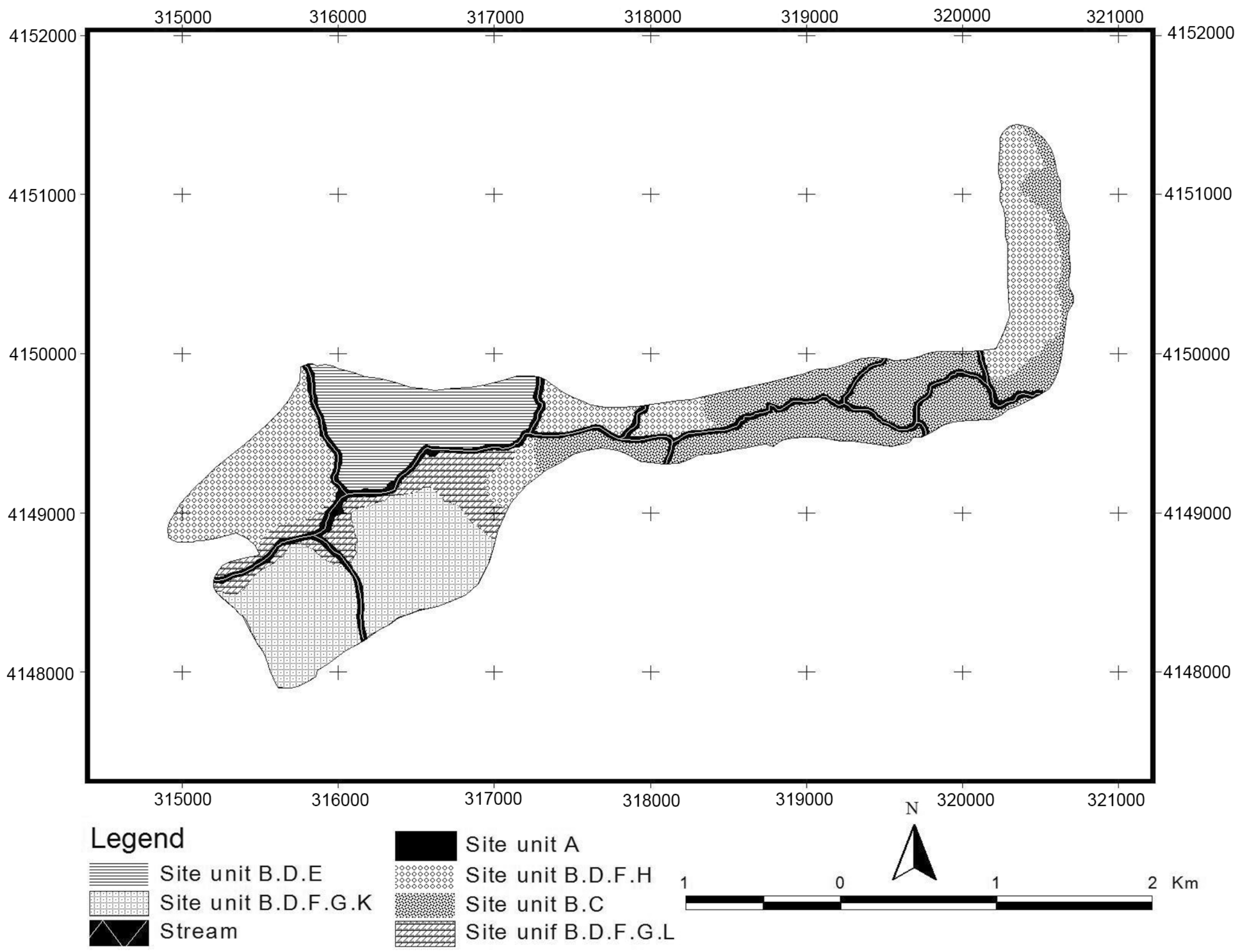

Fig. 5. Site units of the Yazili Canyon Nature Park

between them. Namely, Unit BC is located in the north-east of the park, whilst Unit BD is on the opposite site. This is why Unit BD can receive more humid and warm air masses coming from the Mediterranean Sea along the Kovada Channel compared to unit BC. It must be pointed out that the Kovada Channel is profoundly important for classification of forest sites in the Lake Districts. Kantarci (1991) reported that the Kovada channel is strongly related with ecological land classification of the Egridir Watershed and *Pinus brutia* is widespread in the Watershed because of the Kovada Channel. On the contrary, *Pinus brutia* disappears in the Beysehir Watershed. Because the Beysehir Watershed cannot effectively receive humid and warm air masses coming from the Mediterranean Sea unlike the Egridir Watershed (Ozkan, Kantarci 2008).

The other subunits could be defined due to local and micro climatic differences originated from the topographic variability of the canyon in the study. Presence and spatial distribution of local and micro climatic areas are also important for endemic plant diversity. The Canyon is rich not only in plant species diversity but also in endemic species diversity (Fakir 2006; Ozkan, Suel 2009). This richness is strongly related to landform characteristics (Ozkan, Suel 2009). Because of plant diversity, the diversity of bird and insect species is also considerably rich (Gundogdu *et al.* 2005).

Although the Canyon covers a small area, it includes many ecological sites because of the local and climatic differences between short distances in the Park. This situation enables rich plant, bird and insects diversities as well. Various studies (Vivian-Smith 1997; Lundholm, Larson 2003; Pausas *et al.* 2003; Dufour *et al.* 2006) have demonstrated that there are strong relations between environmental heterogeneity-living organism diversity. In the context of these literatures, the rich fauna and flora of the Canyon is probably explained with high environmental heterogeneity originated from the karstic and valley structure of the Nature Park. The Yazili Canyon Nature Park not only has rich flora and fauna but also historical (Inscriptions, St. Paul Trail, the legendary Persian Royal Road) and cultural (the people coming from foreign countries to pray in front of the inscriptions including the poem, and walking culture for especially tourists coming from foreign countries) values (Clow, Richardson 2005). Therefore, it can be thought that the status of the canyon could be changed to the natural park status.

Acknowledgements

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EKOLOGINIS TURKIJOS VIDURŽEMIO JŪROS REGIONO YAZILI KANJONO GAMTINIO PARKO ŽEMIŲ KLASIFIKAVIMAS IR KARTOGRAFAVIMAS

K. Ozkan, A. Mert

S a n t r a u k a

Hierarchinis augalijos pasiskirstymas vietovėje lemia hierarchinę augalijos klasifikaciją. Svarbu nustatyti efektyvias aplinkos apsaugos charakteristikas kiekviename hierarchiniame augalijos lygmenyje.
Tyrimas vyko siekiant atlikti hierarchinę ekosistemos klasifikaciją ir sukurti hierarchinį Turkijos Viduržemio jūros regiono Yazili kanjono gamtinio parko žemėlapį. Pasirinkta 107 ploteliai. Skirstant į tam tikrus vienetus, dviem būdais taikytas indikacinis testas (*TWINSPAN*), vienetai įvertinti pagal *chi* kvadrato testą. Abipusės koreliacijos būdu kiekviename lygmenyje nustatyta indikacinės rūšys. Pagal tai skirtinguose Yazili kanjono gamtinio parko hierarchiniuose lygiuose apibrėžtos šešios dalys. Skirstymui didelę įtaką turėjo tokio tipo vietovei būdingas klimato heterogeniškumas, kurį lemia kanjonui būdingas aplinkos heterogeniškumas.

Reikšminiai žodžiai: *TWINSPAN*, hierarchinė ekosistemos klasifikacija, aplinkos heterogeniškumas, augalijos ir aplinkos sąsajos.

ЭКОЛОГИЧЕСКАЯ КЛАССИФИКАЦИЯ ЗЕМЛИ И КАРТОГРАФИЯ КАНЬОНА УАЗИЛИ В НАЦИОНАЛЬНОМ ПАРКЕ СРЕДИЗЕМНОМОРСКОГО РЕГИОНА ТУРЦИИ

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Р е з ю м е

Уникальность местности зависит от иерархического распределения растительности или иерархической классификации экосистемы. В этом контексте важно установить эффективные природоохранные характеристики для каждого иерархического уровня растительности. Настоящим исследованием преследовалась цель классифицировать экосистему и создать иерархическую карту каньона Уазили в Национальном парке Средиземноморского региона Турции. Для этого были выбраны 107 участков. Два способа индикаторного теста TWINSPAN предназначались для распределения по определенным единицам, а тест квадрата chi – для оценки этих единиц. Интерспецифическая корреляция была приспособлена для выявления индикаторных видов на каждом уровне. В результате были установлены шесть частей на разных иерархических уровнях каньона Уазили в Национальном парке. Гетерогенность ландшафтного климата, происходящая из характерного для каньона гетерогенного ландшафта, оказывает большое влияние на такое распределение.

Ключевые слова: TWINSPAN, иерархическая классификация экосистемы, гетерогенность окружающей среды, взаимоотношения между растительностью и окружающей средой.

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