PLANT DIVERSITY AND NATURE CONSERVATION IN KOZIAKAS NATURA 2000 (NETWORK) SITE, CENTRAL GREECE

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ABSTRACT

In order to apply a sustainable management on the natural ecosystems it is necessary to record their plant diversity since it comprises, from ecological point of view, a key factor in the ecosystem stability. In the framework of the project Natura 2000 the region of Koziakas in Central Greece, which is covered by productive forest ecosystems, was studied. 422 taxa were registered in the fifty-four sample plots. In this research the type of habitats, the plant richness, the rare species and the life-form and growth-form of plant species were recorded and analyzed. The results of this research with the application of traditional silvicultural measures enhance the nature conservation of the area.

ΠΟΙΚΙΛΟΤΗΤΑ ΤΗΣ ΒΛΑΣΤΗΣΗΣ ΚΑΙ ΔΙΑΤΗΡΗΣΗ ΤΗΣ ΦΥΣΗΣ ΣΤΗΝ ΠΕΡΙΟΧΗ ΚΟΖΙΑΚΑ ΤΟΥ ΔΙΚΤΥΟΥ ΦΥΣΗ 2000

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ΠΕΡΙΛΗΨΗ

Για την εφαρμογή της αρχής της αειφορίας στα φυσικά οικοσυστήματα είναι απαραίτητη η μελέτη της ποικιλότητας της βλάστησής τους, που εξασφαλίζει την οικολογική τους σταθερότητα με σκοπό τη διατήρησή τους. Στα πλαίσια του Δικτύου Φύση 2000 μελετήθηκε η περιοχή του Κόζιακα , η οποία καλύπτεται από παραγωγικά δάση και βρίσκεται στην κεντρική Ελλάδα. Στις 54 επιφάνειες, που λήφθηκαν καταγράφηκαν 422 φυτικά είδη και μελετήθηκαν οι τύποι των οικοτόπων, η ποικιλότητα των ειδών και τα σπάνια είδη καθώς επίσης και τα φάσματα των οικολογικών και των αυξητικών μορφών. Τα αποτελέσματα έδειξαν μεγάλη ποικιλότητα σε όλους τους φυσικούς οικότοπους της περιοχής.

1. INTRODUCTION

In order to apply a sustainable management to forest ecosystems it is necessary to maintain, conserve and enhance their biodiversity as a basic factor for ecosystem functions and stability [1]. The definition of biodiversity has generated much debate, for example Spellerberg and Sawyer [2] list 16 definitions and there are probably many more. In the past, terms such as wildlife diversity, species diversity and habitat diversity would probably have been used in place of biodiversity. For the purposes of this review the definition used is drawn from that developed by the United Nations Convention on Biodiversity: 'the variability among living organisms from all sources and the ecological complexes of which they are part' [3]. The wildlife within a forest is considered to be partly a product of the vegetation structure [4]. This idea has been developed by Franklin [5] who advocated the use of structural diversity as a mean of maintaining biodiversity in temperate ecosystems. This approach of using simple measures of forest structure as a surrogate for biodiversity has been used by a wide range of authorities [6,7,8,9,10]. In addition, Spellerberg and Sawyer [2] conclude that levels of biodiversity in forests can be increased most easily by changes in structure, age class and ecotope (habitat).

The term of ecotope is used widely in Ecology. A wider meaning of the term "ecotope" is given through the Natura 2000 Network. According to the article 1 of the 92/43/EU Directive, "natural ecotopes" are the terrestrial regions or the wetlands that distinguished because of their biological (biotic) and non biological (abiotic) characteristics and which are either totally natural or semi – natural. The definition "ecotope", which is used by the NATURA 2000 Network, is equivalent the Greek term for the English "habitat", which is the environment defined by biotic and abiotic factors and in which a species lives one phase of its biological cycle. [11]

Koziakas site is located in the central mountainous Greece and is mainly covered by managed forest ecosystems. The goals of this research were the identification and description of the habitats in Koziakas Site and the examination of plant and structural diversity in these habitats, aiming at the maintenance of the diversity, which contributes to the ecological stability of the ecosystems.

2. MATERIALS AND METHODS

2.1 Study area

The study was carried out in Koziakas, central Pindos mountain, central Greece, in the area between the geographical coordinates 39^o 28' to 39^o 42' north and 21^o 27' to 21^o 35' west from Athens. The total area of the Site is 50,431 ha and the forest area 38,671 ha (76.68% of the whole area). The area is a mountainous with medium to intensive slopes in an altitude of 200 - 2050 m asl. The area is covered by productive forest ecosystems where fir stands dominate in the higher altitude and oak stands in the medium altitude. The stands of plane and willow appear along the rivers of the area. Above the treeline the garland grasslands occur on an extensive area. The climate of the area is mountainous Mediterranean with 1610 mm annual precipitation, 8.49^o C mean annual temperature and two months dry period (July - August). The bedrock consists of flysch, limestones and alluvial depositions, while the soils are of medium depth in the forest area on the flysch, high depth on alluvial in grasslands and shallow on the limestones in rocky tops of the mountains [12].

2.2 Sampling and data analysis

For the identification of the habitats and evaluation of plant diversity of the Site, 54 sampling plots were collected along all the forest ecosystems covering the whole forest area, as it was determined by Natura 2000 Network according to 92/43/EU Directive. In detail the following plots, for each

habitat, were collected: three sampling plots of 300 m^2 in Alpine rivers, seven sampling plots of 100 m^2 in Calcifilum steppe, five sampling plots of 100 m^2 in Lowland hay meadow, six sampling plots of 100 m^2 in Balkan screes, six sampling plots of 100 m^2 in Greek calcareous, ten sampling plots of 300 m^2 in Hellenic beech forests, five sampling plots of 300m^2 in Oriental plane woods, five sampling plots of 150 m^2 in Pseudomaquis and seven sampling plots of 300 m^2 at the last habitat of Greek thermothilous oak woods. The plant samples were taken in each habitat, during the summer of the years 1999-2001. In each plot all the species were recorded, after their identification at the species level. Nomenclature is according to Flora Europea [13]. The chorological data were collected from Strid and Strid & Kit Tan [14,15]. For the classification of vegetation, Twinspan's data analysis was used [16]. In each plot altitude, aspect, slope and topography were recorded. The geographical co-ordinates of each plot were identified by a GPS; afterwards the plots were located on a map in a scale 1:20,000. Species richness (S) and rare taxa were estimated as the cumulative number of recorded species in the sample units [17,18] of each habitat, which were pooled at random. Also, a vertical projection of the vegetation was recorded for estimation of structural diversity by dividing the stands in three layers, tree layer (high canopy) in a height above 4 m from the ground, shrub layer (0.5 – 4 m) and ground – flora layer. The analysis of the flora based on Raunkiaer's [19] classification gives the life-form spectrum and growth-form spectrum. Statistical analysis was used to compare the average number of species between the different nature habitats using the SPSS 9.1 for Windows statistical package and ANOVA procedure with the Duncan test for comparison means [20].

3. RESULTS

3.1 Types of habitats

Field research and classification of vegetation data led to the identification and description of the following habitats in the Koziakas Site (The code number for each habitat is according to 92/43/EU Directive [21]):

3.1.1 Alpine rivers and their ligneous vegetation with Salix (code number 3240)

This habitat includes irregular willow stands, which appear in the Aspropotamos river banks at 1,000 – 1,150 m altitude on the alluvial deposites. The relief of the area is flat and the floristic composition consists of *Salix eleagnus, Abies borisii regis and Juniperus communis*. The willow stands are even-aged and disturbed by grazing, while the willow takes part in the shrub layer too. The habitat classification based on the floristic elements (syntaxon) is *Salicion eleagno – daphnoides.*

3.1.2. Calcifilum steppe and garland grasslands (code number 6173)

This habitat occurs on a wide area and includes the steppe and garland grasslands in an altitude of 1,600 – 2,050 m asl. The bedrock is calcareous and slopes and tops of mountains are composing the relief with moderate to steep slopes locally. The floristic composition consists of the following characteristic species, which belong only to the ground flora layer: *Erygnium amethistium, Phleum alpinum, Thymus longicaulis, Trisetum flavescens, Digitalis ferruginea, Lotus corniculatus*. The syntaxon of this habitat is *Cardus tmoleus - Thymus longicaulis* - comm.

3.1.3. Lowland hay meadows (code number 6510)

This habitat includes grazed mountainous meadows on 1,130 – 1,170 m altitude. These appear on the flat ground around the springs of Aspropotamos River in Pertouli area. The bedrock is alluvial depositions. The characteristic species of the habitat, which belong only to the ground flora layer are: *Filipendula vulgaris, Cynosurus cristatus, Phinanthus sintenisii, Trisetum flavescens.* The floristic classification (syntaxon) is *Trisetum flavescens - Cynosurus cristatus* - comm.

3.1.4. Balkan screes (code number 8140)
This habitat occurs on restricted area in all exposures and on steep and very steep slopes including sporadic ground flora of screes in the subalpine zone in 1,600 – 1,900 m altitude. The bedrock is calcareous and the floristic composition of this habitat, which belong only to the ground flora layer, consists of *Silene faberioides, Rumex scutattus, Sesleria vaginalis, Melica ciliata, Lactuca viminea.* The syntaxon of this habitat is *Rumex scutattus – Silene fabarioides* – comm.

3.1.5. Greek calcareous cliff communities (code number 8216)
This habitat occupies a small area and comprises the steep rocks on an altitude of 400 – 1,200 m asl. It is characterized by thin vegetation of shrubs locally and ground flora of pioneer species on NA, A and N exposures and on very steep slopes. This habitat appears on calcareous bedrock. The characteristic species are the following: *Cercis siliquastrum*, *Quercus coccifera, Pyrus amygdalus, Pistacia terebinthus* in the shrub layer and *Ballota acetabulosa, Ephedra feminea, Melica ciliata, Teucrium flavum* in the ground flora layer. The syntaxon of the habitat is *Ballota acetabulosa – Melica ciliata* – comm.

3.1.6. Hellenic beech forests with *Abies borisii regis* (code number 9272)
This habitat includes the large area of pure fir stands that occupies the main mountainous area in an altitude of 900 – 1,700 m asl, covering the whole area, in all aspects and on moderate to steep slopes. The bedrock is flysch and the floristic composition comprises of the following species: *Abies borisii regis* in the tree layer, *Abies borisii regis, Juniperus communis* in the shrub layer and *Helleborus cyclophyllus, Campanula patula, Campanula spatulata, Sanicula europaea, Geocaryum carpinifolium* in the ground – flora layer. The syntaxon of this habitat is *Abies borisii regis, Campanula abietina*-comm.. The forests of the habitat are productive with pure, even-aged and all-aged fir stands with rich regeneration. The individuals of fir take part in all layers, tree, shrubs and ground-flora.

3.1.7. Oriental plane woods (code number 92C0)
This habitat occurs on riparian places in an altitude of 200 – 900 m, in all aspects and includes irregular plane stands. The bedrock of the area is alluvial depositions and the characteristic species, which appear, are: *Platanus orientalis* in the tree storey and *Carex pendula, Equisetum arvense* in the ground – flora storey. The syntaxon is *Equiseto telmateja – Platanetum orientalis.*

3.1.8. Pseudomaquis (code number 5350)
This habitat comprises the maquis (shrub lands) in low altitude (200 – 700m), in all aspects and in the moderate to high slopes of the area where *Quercus coccifera* dominates and *Carpinus lorientalis* and *Fraxinus ornus* participate. The bedrock is flysch or limestones and the characteristic species are: *Quercus coccifera, Phylirea latifolia, Juniperus oxycedrus.* The syntaxon of the habitat is *Ostryo-Carpinion orientalis.*

3.1.9 Greek thermophilous oak woods (code number 924A)
This habitat occupies a large area and consists of uneven-aged, coppice oak stands (mostly *Q. frainetto* and in small places *Q. cerris*), with the participation of *Fraxinus ornus* and *Carpinus orientalis.* The coppice forests of oak are relatively degraded, because of grazing, so the necessity of their conversion to high forests is imminent. The habitat appears in moderate to high slopes and on bedrock of flysch. The characteristic species are *Quercus frainetto* and *Quercus cerris.* The syntaxon of this habitat is *Quercus frainetto– cerris – macedonicum.*

3.2 Species richness and structural diversity

As shown in Table 1, the willow habitat exhibits the highest cumulative plant species richness with a total number of 126 plant species, which is mainly due to the wide variety of environment gradients of the area occupied by willow. The oak habitat follows with 122 species while the Balkan screes habitat is the poorest with only 35 species. The fir and plane habitats exhibit an intermediate plant richness of 115 and 113 species, respectively. Statistical analysis by ANOVA (Duncan test) revealed statistical differences in species richness (per plot) between the different natural habitats. The total number of plant species recorded in all habitats is 422.

TABLE 1. Cumulative plant species richness, mean species number per plot, plant species under protection and plant species richness of each layer (as well as the cover of each layer %) in the different habitats of the area.

Code number of habitat		Willow	6173	6510	8140	8216	9272	92C0	5350	924A
Total plant richness		126	52	78	35	46	115	113	78	122
Mean number of plants per plot		79.0a*	29.3c	37.6bc	18.0d	30.2c	47.0b	45.6b	44.7b	41.8b
Plant species under protection		9	7	6	9	3	9	4	5	7
Tree layer (High canopy)										
N (number of plant species)		1	-	-	-	-	1	4	2	3
	Cover (%)	85.0	-	-	-	-	82.0	90.0	1.5	96.0
Shrub layer	N	6	-	-	-	8	9	12	11	11
	Cover (%)	20.0	-	-	-	6.0	18.0	26.0	84.0	11.0
Ground flora layer	N	126	52	78	35	46	115	113	78	122
	Cover (%)	65.0	100	100	6.6	14.0	46.0	42.0	25.0	34.0

* Means in the same row followed by a different index are significantly different at the 0.05 level (Duncan test).

However, only few endemic, rare or threatened plant species (species under protection) were recorded in the forest ecosystems of the area (according to the list of IUCN and other national or international treaties). The total number of plant species under protection reached 39 in the nine habitats.

Concerning the structural diversity, in all the forest habitats of the site, three vertical layers were observed resulting from the applied selective cuttings. The tree layer in all cases consisted of the dominant tree species with a canopy cover, ranged from 80-100%, and with only a few tree species present (1 to 4 per habitat) (Table 1). The shrub layer consists of some young individuals of dominant tree species and some woody shrubs in a cover ranging from 5-85%. The ground flora layer, where all the plant species were recorded with a cover 5-100% (depending on the high canopy cover), consisted of grass species as well as of seedlings of the natural regeneration. A great heterogeneity in stem horizontal distribution was also observed with high irregular tree spacing and ground flora distribution.

3.3 Life–form spectrum of the habitats

The analysis of the flora based on Raunkier's [19] classification gives the following life-form spectrum. The Hemicryptophytes (57.72%) dominate in all habitats with diminishing presence in forest habitats. The Phanerophytes (13.98%) present a very high proportion in forest habitats from 14.63 to 31.63%. It is characteristic the diminishing presence of the Therophytes (12.60%) in the habitats of Balkan screes (6.71%) and calcareous cliffs (5.60%), which is probably due to the harsh soil conditions. The Geophytes (9.59%) present a high proportion in the habitats that appear in the high altitude locations such as the habitats of plane, fir and lowland meadows. The Chamaephytes (6.10%) present a high proportion in the habitats of garland grasslands (11.76%) and Balkans screes (11,11%) (Table 2).

TABLE 2. The life-form spectrum of habitats in the Koziaka Site. Ph=phanerophyte, Ch=chamaephyte, H=hemicryptophyte, G=geophyte, T=therophyte.

a/a	Habitat		Ph	Ch	H	G	T	Total
	Type	Code						
1	Alpine rivers and vegetation with Salix	3240	12.12	9.09	58.59	7.07	13.1	100
2	Calcifilus steppe and grasslands	6173	2.94	11.76	65.41	2.94	16.9	100
3	Lowland hay meadows	6510	1.45	2.90	72.26	10.1	13.2	100
4	Balkan screes	8140	11.11	11.11	71.07	0.00	6.71	100
5	Greek calcareous cliff communities	8216	14.42	14.22	64.06	1.70	5.60	100
6	Hellenic beech forests with fir	9272	14.63	6.10	59.19	12.2	7.88	100
7	Oriental plane woods	92C0	23.81	3.57	45.25	11.9	15.4	100
8	Pseudomaquis	5350	29.63	9.26	48.15	3.70	9.26	100
9	Greek thermophilous oak woods	924A	31.63	1.03	48.98	9.18	9.18	100

3.4 Growth–form spectrum of the habitats

Regaeding the growth-forms of the vegetation, perennial (65.83%) and annual (12.46%) herbs are the commonest types, whereas the proportion of biennials is much lower (6.97%). Among the woody forms, shrubs (9.05%) predominate in relation to the trees (5.69%). In the grassland ecosystems, the perennial species dominate while the presence of annual species is significant. In contrast to the Balkan screes and calcareous cliffs habitats, trees and shrubs appear in a proportion of 12.60% and 16.80% respectively. In the forest habitats the presence of trees and shrubs is high. The proportions of trees and shrubs raise to 31.60% and 33.30% respectively especially in the oak and pseudomaquis habitats (Table 3).

TABLE 3.The growth-form spectrume of the habitats in the Koziakas Site. A=annual, B=biennial, P=perrenial, Fr=shrubs, Ar=trees.

a/a	Habitat		A	B	P	Fr	Ar	Total
	Type	Code						
1	Alpine rivers and vegetation with Salix	3240	14.14	6.06	66.67	9.09	4.04	100
2	Calcifilum steppe and grasslands	6173	15.94	5.88	74.36	3.82	0.00	100
3	Lowland hay meadows	6510	12.25	4.35	81.95	0.00	1.45	100
4	Balkan screes	8140	6.20	3.70	77.78	9.11	3.51	100
5	Greek calcareous cliff communities	8216	5.84	3.70	73.56	9.10	7.80	100
6	Hellenic beech forests with fir	9272	7.60	2.44	74.39	11.19	4.38	100
7	Oriental plane woods	92C0	16.67	9.52	50.00	14.29	9.52	100
8	Pseudomaquis	5350	9.26	7.41	50.00	24.07	9.26	100
9	Greek thermophilous oak woods	924A	9.18	8.16	51.02	17.35	14.29	100

4. DISCUSSION AND CONCLUSIONS

Based on the above results it is apparent that the plant species richness depends on the following factors: the vegetation type, the dominant tree species, the high canopy cover, the environmental factors and the silvicultural interventions. The highest plant diversity was found into willow habitat where 126 plant species were recorded, whereas only 35 plant species were recorded in Balkan screes due to the harsh site conditions, which do not allow the establishment of vegetation. Ganatsas et al., [21] recorded also high diversity in Aspropotamos Site habitats under relatively similar site conditions. Sampling was conducted only in mature forest stands in representative locations of each habitat, excluding the edges, ecotones, road sites and cultivated areas. For this reason, any comparison to floristic studies of the area [22,23,24,25,26] is out of question. Based on the findings of this study and others of the area [22,23,24,25,26] it seems that the area presents high plant diversity. The plant species richness is high especially in forest ecosystems. It can be enhanced by increasing the variability in canopy structure, both in terms of vertical stratification and horizontal patchiness, which is probably of due to the proper applied silvicultural system close

to nature [27]. The "single tree selective" system, which results in the form of all-aged multistorey stands, promotes the diversity and contributes to a sustainable forest management [28].

The Koziakas Site is seriously affected by various human activities and there are certain environmental problems. These activities are: grazing, hunting, skiing, illegal urban development, removal and damage of flora and recreation. Preliminary management proposals are: protection and restoration of all natural habitats of the area instead of the protection of individual species, restriction of grazing and hunting, protection from soil erosion in places around the skiing center by planting local species, development of ecotourism and education of the public about the removal and damage of plants and nature conservation in general. The main land use of Koziakas area will continue to be forestry practiced with selective logging silvicultural methods, which promote the diversity and contribute to a sustainable forest management. Grazing will remain the dominant activity in the sub-alpine grasslands. Finally, a monitoring system for various important factors will be established, including the evolution of forest ecosystems, the dynamics of the avian and mammalian fauna, and the number of people visiting the area.

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