

Classification of forest vegetation in Yaralıgöz Education and Observation Forest, Kastamonu, Türkiye

MUSTAFA KARAKÖSE^{1,*}, SALİH TERZİOĞLU²

¹Program Study of Medicinal and Aromatic Plants, Esiye Vocational School, Giresun University. Gaziler, Prof. Ahmet Taner Kışlalı Cd., 28200 Giresun Merkez/Giresun, Türkiye. Tel.: +90-454-3101000, *email: mustafa.karakose@giresun.edu.tr

²Department of Forest Engineering, Faculty of Forestry, Karadeniz Technical University. Karadeniz Teknik Üniversitesi Orman Fakültesi Orman Endüstri Mühendisliği Bölümü 61080, Trabzon, Türkiye. Tel.: +90-462-377-1500

Manuscript received: 5 June 2023. Revision accepted: 20 June 2023.

Abstract. Karaköse M, Terzioğlu S. 2023. Classification of forest vegetation in Yaralıgöz Education and Observation Forest, Kastamonu, Türkiye. *Nusantara Bioscience* 15: 161-171. Forest ecosystems, which contain approximately half of the 12,975 plant taxa known to be distributed in Türkiye, are very important in terms of biological diversity. The fact that forests are seen as wood-producing ecosystems and have been planned for these purposes for many years has resulted in forests being kept away from being evaluated in terms of ecosystem and socio-economic aspects. Today, forest management plans have begun to be prepared in which all components of the forest are considered, and biological diversity is reflected. Based on this understanding, this investigation was performed during 2011-2012 to analyze the forest vegetation of Yaralıgöz Education and Observation Forest. The study area is located in the north-western part of Türkiye within the Euro-Siberian phytogeographic region. Phytosociological studies were carried out using the classical Braun-Blanquet approach, and 51 relevés were collected from the research area. The database contains 184 vascular plant taxa, dominated by the Euro-Siberian elements and Hemicyptophytes. The relevés were classified using the Modified TWINSpan, and the forest vegetation types' distribution was analyzed using non-metric multi-dimensional scaling. A comprehensive comparison among all described syntaxa within the study area and other closely related forests was provided. Topographic factors and mean Ellenberg indicator values were evaluated to interpret the ecological relationships among forest plant associations. Four associations, two (*Daphnopotica-Pinetum hamatae* and *Galio rotundifolii-Abietum equi-trojani*) of which are new syntaxa to science, were defined as belonging to the Euxine Province within *Erico-Pinetea*, *Carpino-Fagetea sylvaticae*, *Quercetea pubescentis*, and *Vaccinio-Piceetea*. The distribution of these four forest associations was mostly affected by light intensity, nutrients, moisture content, and altitude. The results of this vegetation study provided precious knowledge for monitoring vegetation change and nature conservation projects in the Yaralıgöz.

Keywords: Euro-Siberian, Euxine, JUICE, syntaxonomy, TURBOVEG

Abbreviations: Education and Observation Forest (EOF), Ellenberg indicator values (EIVs), Forest Planning Unit (FPU), International Code of Phytosociological Nomenclature (ICPN), Non-metric Multi-Dimensional Scaling (NMDS), PAleontological STatistics (PAST)

INTRODUCTION

Forests are not just made up of trees; they are large and complex ecosystems where shrubs and herbaceous species are supported by soil structure and the abiotic environment. The vegetation types that make up the forests exhibit a dynamic structure and can change as spatiotemporal. Vegetation relevés or plots are used extensively by researchers to study vegetation types. Relevés allow us to have a wealth of basic information to help us understand the vegetation change that has occurred over time, the restoration of a piece of forest that has been destroyed as a result of any disturbance (fire, clear cutting, etc.), or classification of habitats (Chytrý et al. 2020).

Biodiversity is under great threat globally. Incorrect land uses, increased demand for natural resources, and excessive pressure on ecosystems can cause fragmentation of habitats. It also decreased the goods and services obtained from ecosystems. The settlement of alien plants in new ecosystems and global warming make this situation even more dangerous (Karaköse 2019). Therefore, by

allowing researchers to access these databases, it will be easier to detect biodiversity on a global scale, and it will provide important contributions to decision-makers and nature conservationists to create necessary conservation projects, monitor vegetation change, and evaluation studies to identify and to reduce existing threats (Sabatini et al. 2021).

Türkiye is located entirely within the Holarctic realm and has around 12,975 taxa of ferns and seed plants and around 4,157 endemic plant taxa (Güner et al. 2012) and thus, is one of the countries with extraordinarily rich floristic diversity in the world. In Türkiye, the presence of three floristic regions (Euro-Siberian, the Mediterranean, and Irano-Turanian) has been one of the main reasons for the formation of this richness. Each floristic region also has various vegetation types depending on their internal dynamics. In Türkiye, the Euro-Siberian phytogeographic region is represented by the Euxine Province (Quézel et al. 1980). It is floristically closely related to the Central European, Balkans (Illyrian), and the Hyrcanian (South Caspian) provinces (Loidi et al. 2021).

Forests are the climatic vegetation type of the Euxine Province and occur throughout the Black Sea, Istranca Mountains of Thrace, and in Marmara Regions. Humid-temperate broad-leaved forests exist in the northern exposures at low altitudes, and humid/sub-humid and winter-tolerating coniferous forests at higher altitudes (Karaköse 2019). The mountainous vegetation structures of Türkiye, with their enormous and unique diversity, have aroused much interest from many vegetation researchers. Foreign researchers conducted the first vegetation studies in the western Black Sea region. Later, many vegetation studies were conducted by Turkish researchers in various regions of Türkiye (Karaköse 2019). Specifically, the research conducted by Akman (1995) and Quézel et al. (1980) is readily accepted as the touchstone of Türkiye's forest vegetation. However, since all of these studies were conducted before (Theurillat et al. 2021), they have some mistakes and deficiencies (Karaköse 2019). But, some of them were typified. The syntaxonomy of the Turkish forest vegetation has not yet been resolved (Akman 1995). However, with new numeric and digital technologies, some of them have been eliminated with the vegetation studies carried out in recent years (Kavgacı et al. 2012; Kenar and Ketenoğlu 2016; Hüseyinova and Yalçın 2018; Çoban and Willner 2019; Karaköse 2019; Yıldırım et al. 2019; Kenar et al. 2020; Tunçkol et al. 2020; Bonari et al. 2021; Çoban et al. 2021; Karaköse and Terzioğlu 2021; Kavgacı et al. 2021; Eminağaoğlu et al. 2022; Yıldırım et al. 2022). However, there are still some scientific gaps in the forest vegetation of Türkiye. For example, although distribution mapping of phytosociological units based on alliance in Europe was made by Preislerová et al. (2022), only the

Thrace (European part) section of Türkiye has been mapped.

The Regional Directorate of Forestry of Kastamonu has created an area (Yaralığöz Education and Observation Forest) for ecotourism purposes in Yaralığöz Mountain and its vicinity (Karaköse and Terzioğlu 2019). With this present study, we aimed to study the forest vegetation of Yaralığöz EOF, and thus the western part of northern Anatolia, and contribute new knowledge to Türkiye's Forest Vegetation Database. Moreover, as a result of this study, the relevés to be obtained about vegetation types will provide valuable information to the forest planners and managers for nature conservation activities.

MATERIALS AND METHODS

Study area

Yaralığöz EOF (in Türkiye), affiliated with the Kastamonu Regional Directorate of Forestry, is located within the boundaries of Devrekani FPU, Şeyhsaban FPU, Tezcan FPU, and Karacakaya FPU. Yaralığöz EOF, found in the eastern of the important plant area of the Küre Mountains as a geographical location, ends at Koru Mountain in the east. Yaralığöz EOF consists of 11,548.2 ha, of which 7,862.8 ha is forested, and 3,685.4 ha is non-forested. Yaralığöz EOF is geomorphologically mountainous and steep terrain; furthermore, the area's elevation varies between 773 and 2,019 meters above sea level/masl (Figure 1).

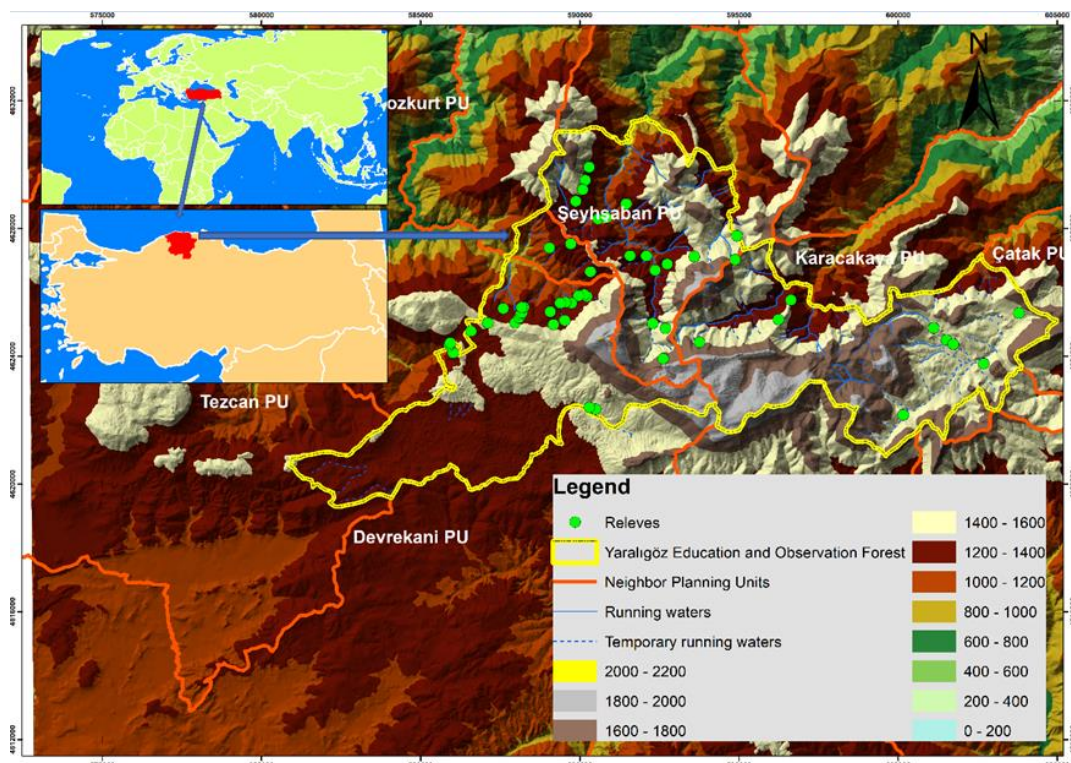


Figure 1. Location of the study area in Yaralığöz EOF, Türkiye

Yaralıgöz EOF is located along the A5 square according to the western Black Sea region's grid system (Davis 1965). The research area has no ready weather network to ensure that climate characteristics are examined according to elevation and aspect variations. Closest to the study area are Devrekani (1,050 m), Turkeli (50 m), and Bozkurt meteorological stations (167 m), where long-term observations and measurements were made (Karaköse and Terzioğlu 2019). The average annual temperature for the research area is 7.6°C in Devrekani, 13.5°C in Turkeli, and 12.9°C in Bozkurt. Devrekani, Turkeli, and Bozkurt's mean annual precipitation values are 533.1 mm, 743.4 mm, and 1,259.1 mm, respectively. According to Devrekani, Turkeli, and Bozkurt meteorological data, precipitation regimes in the study area are identified as Spring-Summer-Fall-Winter (semi-continental), Fall-Winter-Summer-Spring (oceanic type 1), and Fall-Winter-Spring-Summer (west Mediterranean). Considering the meteorological data close to the study area, there is a transition climate where Mediterranean, oceanic, and continental climates are felt in Yaralıgöz EOF (Karaköse and Terzioğlu 2019).

Field sampling and data assessment

Relevés were taken between 2011 and 2012 to determine the vegetation structures in the study area. The relevés were sampled using the Braun-Blanquet method (Guarino et al. 2018). For vegetation studies, 51 relevés were applied in Yaralıgöz EOF from areas homogeneous enough in floristic composition and structure. Minimum area sizes have been determined as 20×20 m (Akman 1995). Flora of Turkey and the East Aegean Islands (Davis 1965) and Turkish Plant List (Güner et al. 2012) were used to identify, nomenclature, and determine the phytogeographic regions of plant taxa. In addition, life forms of plant taxa were determined according to the system of Raunkiaer (Raunkiaer 1934). Field data for the vegetation analyses were first stored to TURBOVEG vegetation database management program (Hennekens and Schaminée 2001). The data set was later exported and uploaded to the JUICE program for hierarchical classification and ordination analysis. For the hierarchical classification and for the analysis of heterogeneity of

vegetation types, the Modified TWINSpan package program integrated into the JUICE program was used. Pseudospecies cut levels were set to five (0, 2, 5, 10, and 20) and with Whittaker's beta diversity. Diagnostic and character species were determined by taking into account the fidelity values of vegetation types based on the cluster dendrogram created using the JUICE program. The diagnostic species for particular vegetation types were calculated with the help of presence/absence data using the phi-coefficient (threshold value of $\phi=0.40$).

The hierarchical classification result was transferred to an ordination plane using NMDS. Ordination was calculated using the R program (version 3.6.1) and vegan package (version 2.5-6) integrated into the JUICE program. Original EIVs were assigned to the species data in the JUICE program. Mean EIVs of vegetation types were compared using the Modified Permutation Test script using the JUICE-R function (Zelený and Schaffers 2012). Ellenberg Indicator Values (EIVs) were used to determine the ecological differences of the identified vegetation types. Similarities between the newly detected vegetation types in terms of floristic composition were compared with the help of Sorensen's similarity index. Upper syntaxonomic groups of the identified vegetation types and their character species were mainly determined according to the following articles (Akman 1995; Mucina et al. 2016; Çoban and Willner 2019; Kavgacı et al. 2021). The nomenclature of vegetation types newly detected in Yaralıgöz EOF was made according to the ICPN (Theurillat et al. 2021).

RESULTS AND DISCUSSION

Within the scope of this vegetation study, 51 relevés consisting of 184 vascular plant taxa were sampled from the woodlands in the study area (supplementary material). Using cluster analysis, TWINSpan distinguished four vegetation types into three generally interpretable main groups. Classification analysis results are summarized in the dendrogram (Figure 2).

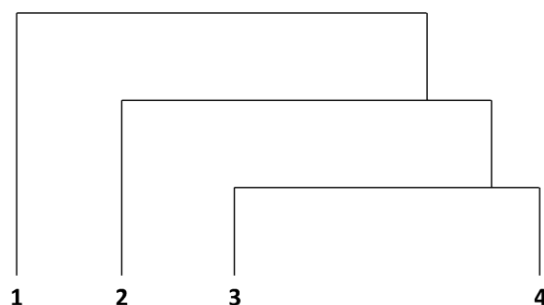


Figure 2. Dendrogram of the clusters in Yaralıgöz EOF, Türkiye. Cluster 1. *Juniperus oxycedrus* subsp. *oxycedrus*-*Pinus nigra* subsp. *pallasiana* vegetation type; Cluster 2. *Daphne pontica*-*Pinus sylvestris* var. *hamata* vegetation type; Cluster 3. *Galium odoratum*-*Fagus orientalis* vegetation type; Cluster 4. *Galium rotundifolium*-*Abies nordmanniana* subsp. *equi-trojani* vegetation type

It is possible to read the dendrogram in 2 parts. The first cluster on the left is the *Pinus nigra* subsp. *pallasiana* (Lamb.) Holmboe, and the three clusters on the right represent the *Pinus sylvestris* var. *hamata* Steven (2. cluster), *Fagus orientalis* Lipsky (3. cluster), and *Abies nordmanniana* subsp. *equi-trojani* (Asc. & Sint. ex Boiss.) Coode & Cullen (4. cluster) vegetation types, respectively. The NMDS ordination also reflects this division (Figure 3). The NMDS diagram indicates that the four clusters have a minimum overlap (stress 0.18).

Furthermore, Figure 3 shows that the changes in vegetation types among the related ones are mainly on the second axis, and the effect of ecological and topographic factors corresponds to the second axis. The order of influence of the topographic factors affecting the plant composition and spatial distribution of the spreading forest vegetation types in the Yeraligöz EOF is altitude, inclination, and aspect. When ecological factors (EIVs) are examined, the impact of temperature and soil reaction is low. However, light intensity, nutrient content, moisture content, and continentality have significant effects (Figure 3).

The *P. nigra* subsp. *pallasiana* vegetation type is markedly separated from the other three vegetation types in the study area regarding floristic composition. This

vegetation type is built of plant taxa with heliophilous, nutrient-poor, xerophilous, and partly continental and thermophilous species such as *Quercus pubescens*, *Clinopodium nepeta* subsp. *glandulosum*, *Teucrium polium*, *Salvia tomentosa*, and *Crataegus orientalis* var. *orientalis*. The *P. sylvestris* var. *hamata* vegetation type is positively associated with light intensity, altitude, and continentality. It consists of more moisture and nutrient-rich taxa such as *Rosa canina*, *Pyrus elaeagnifolia*, *Filipendula vulgare*, *Poa trivialis*, *Dactylis glomerata* subsp. *glomerata*, *Galium verum*, and *Helianthemum nummularium* subsp. *nummularium* than the *P. nigra* subsp. *pallasiana* vegetation type. The *F. orientalis* vegetation type consists of nutrient-poor, heliophilous but thermophilous plant taxa such as *Quercus petraea* subsp. *iberica*, *Galium odoratum*, *Crataegus monogyna* subsp. *monogyna*, *Rhododendron luteum*, *Veronica chamaedrys*, and *Cardamine quinquefolia* at low altitudes. The *A. nordmanniana* subsp. *equi-trojani* vegetation type is positively associated with moisture and nutrients-rich plant taxa such as *Mespilus germanica*, *Lonicera orientalis*, *Helleborus orientalis*, *Ilex colchica*, *Laurocerasus officinalis*, *Lathyrus laxiflorus* and spreads in the northern-facing aspect at the altitude between the *P. sylvestris* var. *hamata* and *F. orientalis* vegetation types (Figure 3).

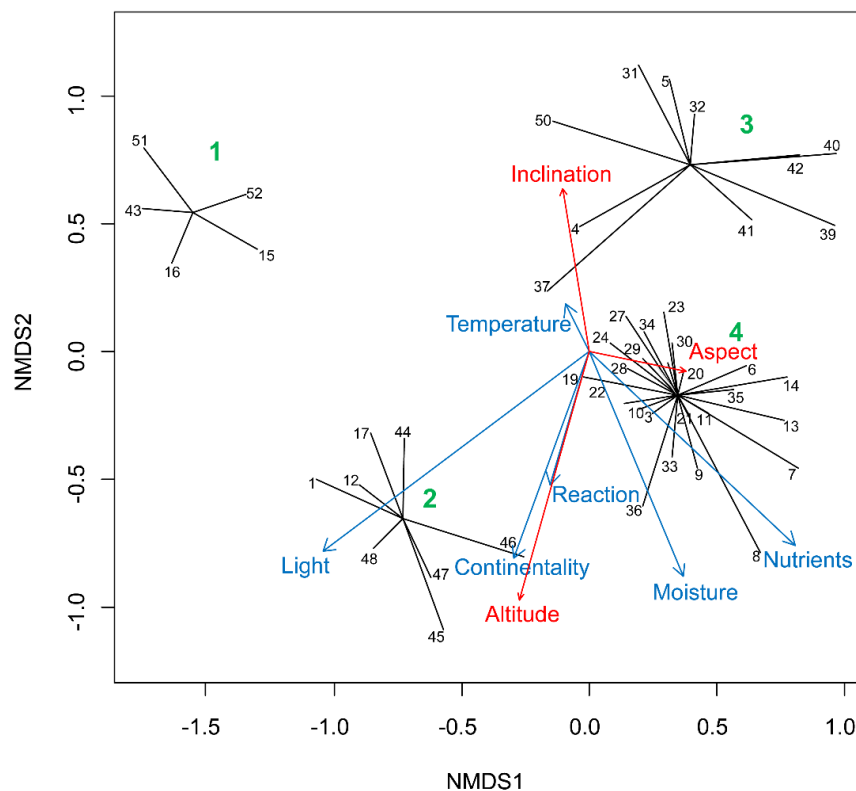


Figure 3. NMDS diagram of clusters. Cluster 1. *Juniperus oxycedrus* subsp. *oxycedrus*-*Pinus nigra* subsp. *pallasiana* vegetation type; Cluster 2. *Daphne pontica*-*Pinus sylvestris* var. *hamata* vegetation type; Cluster 3. *Galium odoratum*-*Fagus orientalis* vegetation type; Cluster 4. *Galium rotundifolium*-*Abies nordmanniana* subsp. *equi-trojani* vegetation type

Cluster 1: *Juniperus oxycedrus* subsp. *oxycedrus*-*Pinus nigra* subsp. *pallasiana* vegetation type

This vegetation type consists of five relevés and 61 vascular plant taxa.

Diagnostic species: *Asyneuma limoniifolium* subsp. *pestalozzae*, *Berberis crataegina*, *C. nepeta* subsp. *glandulosum*, *Campanula rapunculus* subsp. *lambertiana*, *Centaurea urvillei* subsp. *stepposa*, *Clematis vitalba*, *Daphne oleoides* subsp. *oleoides*, *Digitalis lamarckii*, *Globularia trichosantha* subsp. *trichosantha*, *Juniperus oxycedrus* subsp. *oxycedrus*, *Laser trilobum*, *Leontodon hispidus* subsp. *hispidus*, *Medicago lupulina*, *Onosma bornmuelleri*, *Pilosella hoppeana* subsp. *troica*, *P. nigra* subsp. *pallasiana*, *Q. pubescens*, *Salvia sclarea*, *S. tomentosa*, *Sorbus umbellata*, *Tanacetum poteriifolium*, *Taraxacum butleri*, *Teucrium chamaedrys* subsp. *chamaedrys*, *T. polium*, *Thesium arvense*, *Thymus sipyleus*.

Constant species: *Galium paschale*, *L. orientalis*, *Sorbus torminalis* var. *torminalis*.

Dominant species: *P. nigra* subsp. *pallasiana*.

The *P. nigra* vegetation type shows semi-arid semi-continental climate characteristics. This vegetation type has a fragmented distribution with an average inclination of 60-70%, between approximately 1,150 and 1,500 masl altitudes on limestone bedrock in the south-facing slopes in the study area. This vegetation type is partly located in Tezcan FPU, mostly in Devrekani FPU, on the foothills of Yaralıgöz EOF, and around Elmacikkalesi Hill. The vegetation type comprises tree, shrub, and herb layers. The tree layer is represented by *P. nigra* subsp. *pallasiana* has a total coverage of between 70 and 90% and 11-18 m in tall. The shrub layer is 150-300 cm tall, and average cover values vary between 20% and 55%. The overall appearance of the shrub layer is made up of *J. oxycedrus* subsp.

oxycedrus, *B. crataegina*, *Q. pubescens*, *L. orientalis*, *Pyracantha coccinea*, and *Rubus hirtus*. The herb layer is 30-100 cm tall and covers 10-65%. The dominant species in the herb layer are *T. poteriifolium*, *T. chamaedrys* subsp. *chamaedrys*, *S. tomentosa*, *Campanula rapunculus* subsp. *lambertiana*, *T. polium*, *M. lupulina*, and *T. sipyleus*. The vegetation type looks highly affected by anthropogenic effects. The abundance of low-frequency, cosmopolitan / widely distributed plant taxa in the vegetation type supports these anthropogenic effects (Table 1). Although the Hemicryptophytes dominate the vegetation type, Phanerophytes and Chamaephytes indicate that the vegetation type is also rich in woody flora (Table 2).

Cluster 2. *Daphne pontica*-*Pinus sylvestris* var. *hamata* vegetation type

This vegetation type contains eight relevés and 83 vascular plant taxa.

Diagnostic species: *Alchemilla mollis*, *Bromus tomentellus*, *D. glomerata* subsp. *glomerata*, *Daphne pontica*, *Filipendula vulgaris*, *G. verum* subsp. *verum*, *Geranium asphodeloides* subsp. *asphodeloides*, *H. nummularium* subsp. *nummularium*, *Juniperus communis* var. *saxatilis*, *Myosotis arvensis* subsp. *arvensis*, *P. sylvestris* var. *hamata*, *P. trivialis*, *Polygala major*, *Rumex tuberosus* subsp. *horizontalis*, *Trifolium pratense* var. *pratense*.

Constant species: *A. nordmanniana* subsp. *equi-trojani*, *Digitalis ferruginea* subsp. *ferruginea*, *Fragaria vesca*, *G. paschale*, *H. orientalis*, *Knautia involucrata*, *Lapsana communis* subsp. *intermedia*, *R. canina*, *T. chamaedrys* subsp. *chamaedrys*.

Dominant species: *P. sylvestris* var. *hamata*.

Table 1. The dispersion of taxa, according to Raunkiaer's life forms

Vegetation type	Life forms (number / (%))				
	Ph	Ch	H	Cr	Th
<i>Juniperus oxycedrus</i> subsp. <i>oxycedrus</i> - <i>Pinus nigra</i> subsp. <i>pallasiana</i>	15 (24.5)	9 (14.8)	35 (57.4)	0 (0.0)	2 (3.3)
<i>Daphne pontica</i> - <i>Pinus sylvestris</i> var. <i>hamata</i>	14 (17.0)	10 (12.0)	47 (56.6)	3 (3.6)	9 (10.8)
<i>Galium odoratum</i> - <i>Fagus orientalis</i>	14 (22.6)	4 (6.5)	32 (51.6)	9 (14.5)	3 (4.8)
<i>Galium rotundifolium</i> - <i>Abies nordmanniana</i> subsp. <i>equi-trojani</i>	25 (21.7)	3 (2.6)	63 (54.8)	17 (14.8)	7 (6.1)

Table 2. Chorological dispersion of the clusters in the Yaralıgöz EOF, Türkiye

Vegetation type	Phytogeographical regions (Number / (%))			
	Circumboreal	Mediterranean	Irano-Turanian	Widely distributed
<i>Juniperus oxycedrus</i> subsp. <i>oxycedrus</i> - <i>Pinus nigra</i> subsp. <i>pallasiana</i>	19 (31.1)	3 (4.9)	7 (11.5)	32 (52.5)
<i>Daphne pontica</i> - <i>Pinus sylvestris</i> var. <i>hamata</i>	40 (48.2)	3 (3.6)	2 (2.4)	38 (45.8)
<i>Galium odoratum</i> - <i>Fagus orientalis</i>	37 (59.7)	1 (1.6)	2 (3.2)	22 (35.5)
<i>Galium rotundifolium</i> - <i>Abies nordmanniana</i> subsp. <i>equi-trojani</i>	67 (58.3)	1 (0.9)	1 (0.9)	46 (40.0)

The *P. sylvestris* var. *hamata* vegetation type shows semi-humid, semi-arid, and cold climate characteristics. In the study area, it spreads well on conglomerate and limestone bedrock, especially in Karacakaya FPU, around Koru Mountain and İmamçuğu Hill and its surroundings on the south-facing slopes with an average inclination of 15-65% between the altitudes of approximately 1,250 and 1,600 m asl. The vegetation type physiologically shows a three-layered structure consisting of tree, shrub, and herb layers. The tree layer of the vegetation type has an average tall of 10-20 m and covering degrees of 75-95%. The dominant species of the tree layer is *P. sylvestris* var. *hamata*, accompanied by the youth of *A. nordmanniana* subsp. *equi-trojani*. The shrub layer has a 50-200 cm tall, and average cover values range from 15 to 50%. The *J. communis* var. *saxatilis* is dominant on the shrub layer and is accompanied by *D. pontica*, *R. hirtus*, *Rubus idaeus*, *L. orientalis*, *P. coccinea*, and *R. canina*. The herb layer has a 30-50 cm tall and a 15-75% cover. The most common species are *H. orientalis*, *K. involucrata*, *Sanicula europaea*, and *Carex sylvatica* in this layer (supplementary material). The abundance of low-frequency taxa belonging to the vegetation type indicates that the vegetation type is open to human intervention. This disturbance can also explain the high cover-abundance value of *J. communis* var. *saxatilis* within the vegetation type. Most of the taxa that spread in the vegetation type are parallel with the study area in the Euro-Siberian region. In addition, most of the taxa in the vegetation type show the Hemicryptophyte character, and the taxa with Phanerophyte and Chamaephyte characters are also noteworthy (Table 2).

Cluster 3. *Galium odoratum-Fagus orientalis* vegetation type

This vegetation type occurs with 10 relevés and 62 vascular plant taxa.

Diagnostic species: *Cardamine impatiens* subsp. *pectinata*, *Carpinus betulus*, *F. orientalis*, *G. odoratum*, *Pteridium aquilinum*, *Q. petraea* subsp. *iberica*, *Silene vulgaris* var. *vulgaris*.

Constant species: *A. nordmanniana* subsp. *equi-trojani*, *Argyrobium biebersteinii*, *Campanula latifolia*, *C. sylvatica* subsp. *sylvatica*, *Cirsium hypoleucum*, *D. ferruginea* subsp. *ferruginea*, *Dorycnium graecum*, *Euphorbia amygdaloides* var. *amygdaloides*, *L. laxiflorus* subsp. *laxiflorus*, *R. idaeus*, *Salvia forskahlei*.

Dominant species: *F. orientalis*, *Q. petraea* subsp. *iberica*.

The *F. orientalis* vegetation type is perhumid to humid and has cold winter climate characteristics. It is well represented in the vegetation type in the study area between approximately 850 and 1,400 masl, on sandstone, limestone, and rarely serpentine bedrocks on the north-facing slopes with an average inclination of 45-75%, within Şeyhşaban and Tezcan FPU's. This vegetation type also has a three-layered structure. The total coverage of the tree layer ranges from 90 to 100%, and the mean tall is 10-30 m (supplementary material). The dominant taxa of the tree layer are *F. orientalis* and *Q. petraea* subsp. *iberica*, accompanied by *A. nordmanniana* subsp. *equi-trojani*, and

C. betulus. The shrub layer has a 0-400 cm tall, and average cover values range between 0 and 30%. The shrub layer generally consists of *R. hirtus*, *R. idaeus*, *D. pontica*, and *R. luteum*. The total coverage and tall of the herb layer are 10-65% and 30-40 cm, respectively. The *G. odoratum*, *C. impatiens* subsp. *pectinata*, *E. amygdaloides* var. *amygdaloides*, *L. laxiflorus* subsp. *laxiflorus*, and *D. ferruginea* subsp. *ferruginea* can be seen commonly in the herb layer. The 60.3% of the taxa determined within the vegetation type belong to the Euro-Siberian phytogeographical region (Table 1). However, within the vegetation type, Hemicryptophytes are predominant, and it is a rich vegetation type in terms of woody flora. Cryptophytes are also significant in this *F. orientalis* vegetation type (Table 2).

Cluster 4: *Galium rotundifolium-Abies nordmanniana* subsp. *equi-trojani* vegetation type

It is the most widely distributed forest vegetation type in Yaralıgöz EOF. This vegetation type consists of 28 relevés and 115 vascular plant taxa.

Diagnostic species: *A. nordmanniana* subsp. *equi-trojani*, *Astragalus glycyphylloides*, *C. sylvatica* subsp. *sylvatica*, *C. hypoleucum*, *Euonymus latifolius* subsp. *latifolius*, *Galium rotundifolium*, *Lilium martagon*, *S. europaea*, *Valeriana alliariifolia*, *Viola sieheana*.

Constant species: *Clinopodium grandiflorum*, *C. latifolia*, *D. pontica*, *E. amygdaloides* var. *amygdaloides*, *F. vesca*, *G. odoratum*, *H. orientalis*, *L. orientalis*, *P. sylvestris* var. *hamata*, *R. hirtus*, *S. forskahlei*.

Dominant species: *A. nordmanniana* subsp. *equi-trojani*

The *A. nordmanniana* subsp. *equi-trojani* vegetation type shows perhumid to humid and very rainy-cool climate characteristics. It develops optimally on sandstone and conglomerate bedrocks on humid north-facing slopes with an average inclination of 10-75% between 1,050 and 1,750 masl (supplementary material). A good formation of this forest vegetation type is observed around Yaralıgöz EOF and its vicinity. However, this vegetation type is well represented in the vicinity of Koru Mountain, Mamatlar Village, and Gümüş Hill. The vegetation type physiologically shows a three vertical-layered structure consisting of tree, shrub, and herb layers. The tree layer of this vegetation type has a coverage of 85-100 m, and the tall of the tree layer varies from 12 to 25 m. The *A. nordmanniana* subsp. *equi-trojani* is the dominant species of the tree layer and, depending on the altitude, forms mixed forests with *P. sylvestris* var. *hamata* and *F. orientalis*. The scrub layer has a 30-400 cm tall, and coverage values range from 5 to 45%. Physiognomically, the shrub layer comprises *L. orientalis*, *R. hirtus*, *D. pontica*, and *R. idaeus*, but some shrub species are also included in the vegetation type with a low frequency. The herb layer is quite rich and has a 30-150 cm tall and a 40-80% coverage. The *G. rotundifolium*, *S. europaea*, *C. sylvatica*, *G. odoratum*, *C. grandiflorum*, *C. hypoleucum*, *V. sieheana*, *H. orientalis*, *E. amygdaloides*, and *F. vesca* are commonly found on the herb layer. The vast majority (57.4%) of the taxa that make up the vegetation type are in the Euro-Siberian floristic region (Table 1). Although

Hemicryptophytes are observed as the majority in this vegetation type, it is rich in woody flora as in the *P. nigra* vegetation type. Cryptophytes also have found the opportunity to spread within the vegetation type (Table 2).

Discussion

According to Quézel et al. (1980), Yaralığöz EOF has located within mountain pre-pontic and Euxinian hilly belts; these are also affected by the pre-pontic supra-Mediterranean belt. In this study, four forest vegetation types were defined in the Yaralığöz EOF with their effect on the climate condition depending on the altitude. This definition is compatible with some studies conducted in Türkiye (Kurt et al. 2015; Sezer et al. 2015; Korkmaz et al. 2016; Kavgacı et al. 2017; Özdeniz et al. 2017). In the Yaralığöz EOF, the sub-Euxine dry *J. oxycedrus-P. nigra* subsp. *pallasiana* vegetation type spreads between the elevation of about 1,150 and 1,500 masl. The *J. oxycedrus-P. nigra* subsp. *pallasiana* association was first identified from Kunduz forests in Samsun-Vezirköprü (Özen and Kılınç 2002), and the floristic similarity with the association was found to be 23.1% in this study. This low similarity rate is because the research conducted in the Kunduz forests was conducted in a different climate type in the lower elevation zone. In Türkiye, *P. nigra* associations in terms of phytosociology are linked with the orders of *Quercus cerridis-Carpinetalia orientalis* Akman, Quézel and Barbéro 1980 and *Quercus pseudocerridis-Cedretalia libani* Barbéro, Loisel and Quézel 1974 within the class of *Quercetalia pubescentis* Doing-Kraft ex Scamoni et Passarge 1959 (Akman 1995). Indeed, when phytosociological studies on *P. nigra* in the west and central Black Sea regions were examined, *Quercus-Carpinetalia orientalis* was mostly preferred under the *Q. pubescentis* class. In addition, in a study conducted in Köroğlu Mountain, *Quercetalia pubescentis* and *Q. pubescentis* order and class were found appropriate (Akman 1995). In all studies in the west and central Black Sea regions, *P. nigra* associations were assigned to the *Carpino betuli-Acerion hyrcani* Quézel, Barbéro and Akman 1978, *Cisto laurifolii-Pinion*

pallasianae Akman et al. ex Quézel et al. 1992, and *Quercion anatolicae* Akman, Barbéro et Quézel 1979. Unfortunately, there are some mistakes and deficiencies in these phytosociological studies conducted in the past (Karaköse 2019). However, with studies conducted in recent years (Kavgacı et al. 2012; Mucina et al. 2016; Çoban and Willner 2019), mistakes in syntaxonomic groups have been corrected. Indeed, it was reported by Çoban and Willner (2019) that the order of *Q. cerridis-C. orientalis* and the *C. betuli-A. hyrcani* were incorrectly named. Within the scope of the same study, the order of *Q. cerridis-C. orientalis* and the alliance of *C. betuli-A. hyrcani* were placed as synonyms of *Quercetalia pubescenti-petraeae* Klika 1933 and *Trachystemono orientalis-Carpinion betuli* Çoban and Willner 2019, respectively.

Therefore, due to some taxa (in addition to *P. nigra* subsp. *pallasiana* and *J. oxycedrus* subsp. *oxycedrus*) belonging to *C. laurifolii-P. pallasianae* such as *B. crataegina*, *T. chamaedrys*, *Asyneuma limonifolium* subsp. *pestalozzae*, *G. trichosantha* subsp. *trichosantha*, *L. trilobum*, *S. tomentosa*, *T. poteriifolium*, and *S. tomentosa* to coordinate with Çoban and Willner (2019) and Kavgacı et al. (2021), the *P. nigra* association determined in the study was linked to the *C. laurifolii-P. pallasianae* and *Erico-Pinetalia* Horvat 1959.

Sub-Euxine *D. pontica-P. sylvestris* var. *hamata* association distributes between 1,250 and 1,600 masl at the supra-Mediterranean and mountain pre-pontic belts in Yaralığöz EOF. The association was first mentioned around the Devrez stream and its vicinity (Kılınç 1985). This association was later determined in Bafra-Nebyan Mountain (Kutbay and Kılınç 1995), Samsun-Kunduz forests (Özen and Kılınç 2002), and Bilecik (Türe et al. 2005). Sorensen similarity rates between *D. pontica-P. sylvestris* var. *hamata* associations were calculated as 24.1% (Kılınç 1985), 26.3% (Özen and Kılınç 2002), 29.4% (Kutbay and Kılınç 1995), and 22% (Türe et al. 2005) (Table 3).

Table 3. The comparison of the vegetation types with similar associations by Sorensen similarities

Defined associations in the study area	<i>Daphno ponticae-Pinetum hamatae</i>	<i>Galio-Fagetum orientali</i>	<i>Galio rotundifolii-Abietum equi-trojani</i>
Related previous studies	Sorensen similarity rates (%)		
Devrez stream and its vicinity (Kılınç 1985)	24.1%		27.9%
Bafra-Nebyan Mountain (Kutbay and Kilic 1995)	29.4%		
Samsun-Kunduz forests (Özen and Kilic 2002)	26.3%	28.3%	
Bilecik (Türe et al. 2005)	22%		
Samsun-Kastamonu, Ilgaz Mountain, Tokat (Quézel et al. 1980)			35.7%-32.7%-22.4%
Tavşan Mountain (Yıldırım et al. 2019)			22.4%
Ayiyaka-Düzce (Çoban and Özalp 2012)			31.9%

Furthermore, the similarity rates show very low similarities with the associations reported from different areas. The study areas are located at different altitudes, and local edaphic and climatic factors vary even at short distances. However, this association was invalidly published (Art. 5) by Kılınç (1985). It was decided to accept the *P. sylvestris* var. *hamata* vegetation type detected in Yaralıgöz EOF as a new association (*Dahpno ponticae-Pinetum hamatae* ass. nova *holotypus hoc loco* description in appendix). In Türkiye, *P. sylvestris* var. *hamata* distributes due to different ecological conditions in wide areas, making its syntaxonomy quite difficult (Karaköse 2019). But it has a limited distribution at semi-continental or Mediterranean-tending transition zones in north-western Anatolia (Akman 1995). Previous *D. pontica-P. sylvestris* var. *hamata* vegetation types were evaluated within two different classes, namely *Quercus-Fagetea sylvaticae* Br.-Bl. et Vlieger in Vlieger 1937 and *Q. pubescentis*. From this point of view, other plant associations identified except for the Kunduz (Özen and Kılınç 2002) region (the order of *Rhododendro pontici-Fagetalia orientalis* within the class of *Q.-F. sylvaticae*) are included in the order of *Q. cerridis-C. orientalis* within the class of *Q. pubescentis*. In all studies except those in Yaralıgöz EOF, *D. pontica-P. sylvestris* var. *hamata* vegetation types were associated with the *C. betuli-A. hyrcani*. However, as mentioned earlier, *Q. cerridis-C. orientalis* and *C. betuli-A. hyrcani* have been incorrectly published (Çoban and Willner 2019). In the *P. sylvestris* var. *hamata* vegetation type, the floristic composition of the understory is richer than that in the *P. nigra*, and the number of species with continental characteristics is increasing. As a result of the decrease in the impact of the oceanic climate, the *P. sylvestris* var. *hamata* vegetation type, compared to *A. nordmanniana* subsp. *equi-trojani* vegetation type has acquired a more arid character in which the semi-continental climate is felt. Accordingly, the influence of the mesophilous *Carpino-Fagetea sylvatica* has also decreased significantly. When the association detected in Yaralıgöz EOF is examined from a floristic point of view, the representation of taxa belonging to the *Vaccinio-Piceetea* Br.-Bl. in Br.-Bl. et al. 1939, and *Q. pubescentis* remains low. On the contrary, within the vegetation type, taxa of heliophilous and continental characteristics belonging to *Erico-Pinetea* due to being located near the transition zone to the Irano-Turanian phytogeographical region and also the sub-alpine region are quite well represented together with the *C. laurifolii-P. pallasianae*. For that reason, the association of *P. sylvestris* var. *hamata* has been linked to *C. laurifolii-P. pallasianae* and *Erico-Pinetea*.

On the mountain pre-pontic and the pre-pontic supra-Mediterranean belts of the eu-Euxine and sub-Euxine zones in the Yaralıgöz EOF, *F. orientalis* is represented by the forest vegetation type, thermo to mesophilous, formed with *G. odoratum* at an altitude of 850-1,400 masl. The *G. odoratum-F. orientalis* association was first identified in Kunduz forests in Samsun-Vezirköprü (Özen and Kılınç 2002), and the floristic similarity with the association was found to be 28.3% in this study. This oriental beech

association was later determined by Kavgacı et al. (2013) from the Aladağlar region, and the floristic similarity with this vegetation type was calculated as 12.5%. In previous studies in Türkiye, *F. orientalis* associations are included in the *Quercus-Fagetea* and *Q. pubescentis* classes. The *F. orientalis* associations are linked to the *Pino-Piceetalia* in the eastern Black Sea region (Quézel et al. 1980). It has been evaluated under the order of *Rhododendro-Fagetalia orientalis* and *Q.-C. orientalis* in central and western Black Sea, south Marmara, and Mount Ida (Akman 1995). At the alliance level, there is no representation of the *Quercus-Fagetea* class, while the *Carpino-Acerion* and *Quercion frainetto* were used in the *Q. pubescentis*. On the other hand, in a comprehensive study by Kavgacı et al. (2012), oriental beech associations in the Black Sea region were interpreted under four alliances (*Fa. orientalis*, *Staphyleo-Buxion*, *Violo-Fa. orientalis*, and *Carpinio-Fagion orientalis*). However, the two alliances (*V.-Fa. orientalis* and *C.-Fa. orientalis*) described by Kavgacı et al. (2012) were accepted as synonyms of the *Fa. orientalis* Soó 1964 by Mucina et al. (2016). Kavgacı et al. (2012) suggested that the *F. orientalis* associations on the basic bedrock in the montane Euxine zone be linked to the Euxinian *Fa. orientalis*. The *F. orientalis* associations spreading in Bulgaria were first included in the *Fa. orientalis* Quézel et al. 1992, and later the *V.-Fa. orientalis* and *C.-Fa. orientalis* (Kavgacı et al. 2012). However, *F. orientalis* associations were transferred to *Fa. orientalis* Soó 1964 by Willner et al. (2017). When the vegetation type determined in Yaralıgöz EOF is examined in terms of floristic composition, the mesophilous and nutrient-demanding taxa belonging to the *Fa. orientalis* and *R. pontici-Fag. orientalis* Passarge 1981 such as *G. odoratum*, *C. sylvatica* subsp. *sylvatica*, *Dryopteris filix-mas*, *C. impatiens* subsp. *pectinata*, *Cardamine bulbifera*, and *Geranium robertianum* are represented well. Similarly, under the *Carpino-Fagetea sylvaticae*, there are representations of the *D. pontica*, *S. forskahlei*, and *V. sieheana* belonging to the *T. orientalis-C. betuli*. Although there are several taxa belonging to the *Q. pubescentis*, their representation has remained low in the association. Therefore, this vegetation type determined here was connected to the *Fa. orientalis* and *R. pontici-Fag. orientalis* under *C.-F. sylvaticae*.

The forest vegetation type formed by *A. nordmanniana* subsp. *equi-trojani* with *G. rotundifolium* spreads between 1,050 and 1,750 masl at the mountain pre-pontic and Euxinian hilly belts of the sub-Euxine zone in Yaralıgöz EOF. Numerous forest associations belonging to *A. nordmanniana* subsp. *equi-trojani* (Syn.: *A. nordmanniana* subsp. *bornmuelleriana* (Mattf.) Coode & Cullen) have been previously identified from the western Black Sea and southern Marmara in Türkiye. Floristic similarities between the *A. nordmanniana* subsp. *equi-trojani* vegetation type is defined within the scope of this study, and the other associations vary between 22.4% and 52.7% (Table 3). Forest associations formed by *A. nordmanniana* subsp. *equi-trojani* are mostly very homogeneous in terms of floristic diversity, and the similarity rates have, therefore, been close. The highest similarity rate was calculated with the association (*A. nordmanniana* subsp. *bornmuelleriana*-

Mercurialis perennis recorded by (Yurdakulol et al. 2002). However, the nomenclature of this association was made inappropriately (ICPN-Art. 5) (Theurillat et al. 2021), according to the rules. Similarly, an association (*Saniculo-Abietetum bornmuellerianae*), recorded around Gerze-Boyabat (Özen and Kılınç 1995) close to Yaralıgöz EOF, is also published invalidly (ICPN arts. 4 and 5). In addition, some studies conducted in north-western Anatolia were also published as invalid according to the ICPN (Art. 5) rules (Akman 1995; Çoban and Willner 2019). Based on this information, it was decided to define the *A. nordmanniana* subsp. *equi-trojani* vegetation type identified in Yaralıgöz EOF as a new association (*Galio rotundifolii-Abietum equi-trojani* ass. nova *holotypus hoc loco* description in appendix). There are lots of research in the regions where *A. nordmanniana* subsp. *equi-trojani* taxa spread. The *A. nordmanniana* subsp. *equi-trojani* associations were included in the mostly *Quercus-Fagetum* and *Q. pubescentis* in these previous studies. The *A. nordmanniana* subsp. *equi-trojani* associations were interpreted under *R.-Fag. orientalis*, *Vaccinio-Piceetalia orientalis*, *Fagetalia sylvaticae*, and *Q.-C. orientalis* orders. Akman (1995) drew attention to the difficulty in the phytosociological interpretation of *A. nordmanniana* subsp. *equi-trojani* associations. Akman (1995) stated that, based on local conditions, climate, and bedrock factors in the study areas, *A. nordmanniana* subsp. *equi-trojani* was assigned to the order of *R.-Fag. orientalis* on siliceous bedrock and to the order of *Q.-C. orientalis* on limestone bedrock. Although the connection at the alliance level was low, *Carpino-Acerion*, *Staphyleo-Buxion* Quézel et al. 1992, and *Quercion frainetto* alliances were preferred in some studies (Akman 1995). However, Çoban and Willner (2019) stated that it is not appropriate to classify mesic fir forests within deciduous forests. Mucina et al. (2016) evaluated mesic *Abies* associations on nutrient-rich soils (as in Yaralıgöz EOF) in Europe within the *Vaccinio-Piceetea*. For that reason, within the *Vaccinio-Piceetea*, the order of *Abieti nordmannianae-Piceetalia orientalis* and the *Lonicero caucasicae-Piceion orientalis*, which cover all *A. nordmanniana* associations, were formed by Çoban and Willner (2019). In this direction, when we examine the *A. nordmanniana* vegetation type, the representation of the species belonging to the *L. caucasicae-P. orientalis* alliance and the order of *A. nordmannianae-Pi. orientalis* such as *G. rotundifolium*, *L. orientalis*, *V. alliariifolia*, *Phedimus stoloniferus* (S.G.Gmel.) t Hart, *R. luteum*, and *Vaccinium arctostaphylos* is quite well. Similarly, *C. sylvatica* subsp. *sylvatica*, *S. europaea*, *E. amygdaloides* var. *amygdaloides*, *G. odoratum*, and *C. grandiflorum* belonging to the *Vaccinio-Piceetea* class are also distributed in this vegetation type. Although the *Fa. orientalis* and the *R.-Fag. orientalis* were also found in the vegetation type, their representation remained low. Taxa belonging to the *Q. pubescentis*, *Erico-Pinetea*, *Festuco-Brometea* Br.-Bl. et Tx. ex Soó 1947, and *Astragalo microcephali-Brometea tomentelli* Quézel 1973 em Parolly also spread throughout the vegetation type. As a result, the *A. nordmanniana* subsp. *equi-trojani* vegetation type determined in Yaralıgöz EOF was linked to the *L.*

caucasicae-P. orientalis and the *A. nordmannianae-Pi. orientalis*.

Based on this knowledge, the syntaxonomic info summarizes given below:

Erico-Pinetea Horvat 1959

Erico-Pinetalia Horvat 1959

C. laurifolii-P. pallasianae Akman et al. ex Quézel et al. 1992

i. *Junipero-Pinetum nigrae* Özen et Kılınç 2002

ii. *Daphno ponticae-Pinetum hamatae* Kılınç ex Karaköse et Terzioğlu ass. nova

Syn. *Daphno-Pinetum sylvestris* Kılınç 1985 *nom. inval.* (ICPN Art. 5)

Type: Karaköse et Terzioğlu 2023 (Description in appendix), *holotypus hoc loco*.

Carpino-Fagetum sylvaticae Jakucs ex Passarge 1968

Rhododendro pontici-Fagetalia orientalis Passarge 1981

Fagion orientalis Soó 1964

iii. *Galio-Fagetum orientalis* Özen & Kılınç 2002

Vaccinio-Piceetea Br.-Bl. in Br.-Bl. et al. 1939

Abieti nordmannianae-Piceetalia orientalis Çoban & Willner 2019

Lonicero caucasicae-Piceion orientalis Çoban & Willner 2019

iv. *Galio rotundifolii-Abietum equi-trojani*

Karaköse et Terzioğlu ass. nova

Syn. *Mercurialo-Abietetum bornmuellerianae* Yurdakulol, Demirörs & Yıldız 2002 *nom. inval.* (ICPN Art. 5)

Type: Karaköse et Terzioğlu 2023 (Description in appendix), *holotypus hoc loco*.

Appendix

The nomenclature type of the association. *Daphno ponticae-Pinetum hamatae* ass. nov. *holotypus*: M.Karaköse (21.07.2012), Relevé no: 48, Plot size: 400 m, Altitude: 1,538 m asl, Aspect: NE, Inclination: 21°, bedrock: limestone, N: 34°20'45.62" N, 41°7'44.143" E, Cover tree layer: 90%, Cover shrub layer: 35%, Cover herb layer: 40%.

Tree layer: *P. sylvestris* var. *hamata*: 4.

Shrub layer: *J. communis* var. *saxatilis*: 2, *R. idaeus*: 1, *R. canina*: +, *D. pontica*: +.

Herb layer: *A. limonifolium* subsp. *pestalozzae*: 1, *P. trivialis*: 1, *G. robertianum*: +, *A. biebersteinii*: +, *Vicia cracca* subsp. *tenuifolia*: +, *Trifolium repens* var. *repens*: +, *T. pratense* var. *pratense*: +, *Onobrychis armena*: +, *F. vulgaris*: +, *Microthlaspi perfoliatum*: +, *F. vesca*: +, *Carduus nutans* subsp. *falcato-incurvus*: +, *L. communis* subsp. *intermedia*: +, *H. nummularium* subsp. *nummularium*: +, *Cynoglossum officinale*: +, *T. chamaedrys* subsp. *chamaedrys*: +, *Clinopodium vulgare* subsp. *arundanum*: +, *T. sipyleus*: +, *G. odoratum*: +, *G. verum* subsp. *verum*: +, *G. paschale*: +, *Milium vernale* subsp. *vernale*: +, *V. sieheana*: +, *Dactylis glomerata* subsp. *glomerata*: +.

The nomenclature type of the association. *Galio rotundifolii-Abietum equi-trojani* ass. nov. *holotypus*:

M.Karaköse (08.07.2011), Relevé no: 29, Plot size: 400 m, Altitude:1,134 m asl, Aspect: W, Inclination: 35°, bedrock: sandstone+limestone, N: 34°077448' N, 41°777181' E, Cover tree layer: 100%, Cover shrub layer: 20%, Cover herb layer: 55%.

Tree layer: *A. nordmanniana* subsp. *equi-trojani*: 4, *P. sylvestris* var. *hamata*: 1, *F. orientalis*: +, *Acer heldreichii* subsp. *trautvetteri*: +, *Acer campestre* subsp. *campestre*: +.

Shrub layer: *L. orientalis*: 1, *D. pontica*: 1, *E. latifolius* subsp. *latifolius*: +.

Herb layer: *H. orientalis*: 1, *S. europaea*: 1, *Trachystemon orientalis*: 1, *G. rotundifolium*: 1, *L. martagon*: 1, *C. sylvatica* subsp. *sylvatica*: 1, *C. hypoleucum*: +, *C. latifolia*: +, *Atropa belladonna*: +, *E. amygdaloides* var. *amygdaloides*: +, *A. glycyphylloides*: +, *G. odoratum*: +, *V. sieheana*: +.

ACKNOWLEDGEMENTS

This study is a part of the Ph.D. thesis of the corresponding author. The authors would like to thank the staff of the Kastamonu Regional Directorate of Forestry, Türkiye, for their logistic support and Prof. Dr. Ali İhsan Kadioğulları for the preparation of the map of the study area.

REFERENCES

- Akman Y. 1995. Turkey Forest Vegetation. Ankara University Faculty of Science, Ankara.
- Bonari G, Fernández GF, Çoban S et al. 2021. Classification of the Mediterranean lowland to submontane pine forest vegetation. *Appl Veg Sci* 24: e12544. DOI: 10.1111/avsc.12544.
- Chytrý M, Tichý L, Hennekens SM et al. 2020. EUNIS Habitat Classification: Expert system, characteristic species combinations and distribution maps of European habitats. *Appl Veg Sci* 23: 648-675. DOI: 10.1111/avsc.12519.
- Çoban S, Özalp G. 2012. The vegetation analysis of mixed Uludağ Fir (*Abies bornmulleriana* Mattf.) forests in Bolu Ayıkaya Region/Turkey. *Bartın Orman Fakültesi Dergisi* 14: 62-73.
- Çoban S, Willner W. 2019. Numerical classification of the forest vegetation in the Western Euxine Region of Turkey. *Phytocoenologia* 49: 71-106. DOI: 10.1127/phyto/2018/0274.
- Çoban S, Yener ŞD, Bayraktar S. 2021. Woody plant composition and diversity of urban green spaces in Istanbul, Turkey. *Plant Biosyst Intl J Dealing Aspects Plant Biol* 155: 83-91. DOI: 10.1080/11263504.2020.1727980.
- Davis P. 1965. Flora of Turkey and the East Aegean Islands. Edinburgh University Press, Edinburgh.
- Eminağaoğlu Ö, Yalçın E, Özkaya MS. 2022. Forest vegetation of the Beşpare ecovillages in the western lesser Caucasus corridor (Artvin/Türkiye). *Rendiconti Lincei Scienze Fisiche e Naturali* 33: 739-756. DOI: 10.1007/s12210-022-01095-4.
- Guarino R, Willner W, Pignatti S, Attorre F, Loidi JJ. 2018. Spatio-temporal variations in the application of the Braun-Blanquet approach in Europe. *Phytocoenologia* 48: 239-250. DOI:10.1127/phyto/2017/0181.
- Güner A, Aslan S, Ekim T, Vural M, Babaç MT, Yıldırım H. 2012. Turkey Plant List (Vascular Plants). ANG Foundation, İstanbul.
- Hennekens SM, Schaminée JH. 2001. TURBOVEG, a comprehensive data base management system for vegetation data. *J Veg Sci* 12: 589-591. DOI:10.2307/3237010.
- Hüseyinova R, Yalçın E. 2018. Subalpine vegetation in Giresun Mountains (Turkey). *Acta Bot Croat* 77: 152-160. DOI:10.2478/botcro-2018-0017.
- Karaköse M, Terzioğlu S. 2019. Flora and botanic tourism potential of Yaralıgöz (Kastamonu) Education and Observation Forest. *Kastamonu Univ J For Fac* 19: 116-136. DOI: 10.17475/kastorman.543547.
- Karaköse M, Terzioğlu S. 2021. Numerical classification and ordination of Finike (Antalya) forest vegetation. *Biologia* 76: 3631-3645. DOI: 10.1007/s11756-021-00910-x.
- Karaköse M. 2019. Numerical classification and ordination of Esenli (Giresun) forest vegetation. *Biologia* 74: 1441-1453. DOI: 10.2478/s11756-019-00321-z.
- Kavgacı A, Arslan M, Bingöl Ü, Erdoğan, N, Čarni A. 2012. Classification and phytogeographical differentiation of oriental beech forests in Turkey and Bulgaria. *Biologia* 67: 461-473. DOI: 10.2478/s11756-012-0029-6.
- Kavgacı A, Balpınar N, Öner HH, Arslan M, Bonari G, Chytrý M, Čarni A. 2021. Classification of forest and shrubland vegetation in Mediterranean Turkey. *Appl Veg Sci* 24: e12589. DOI: 10.1111/avsc.12589.
- Kavgacı A, Sevgi O, Tecimen H, Yılmaz O, Carus S, Dündar T. 2013. Classification and ordination of *Pinus nigra* dominated forests at Alaçam mountains (NW Anatolia-Turkey). *Eur J Forest Sci* 1: 38-50.
- Kavgacı A, Şile U, Başaran S, Marinsek A, Başaran MA, Kosir P, Balpınar N, Arslan M, Ergüler O, Čarni A. 2017. Classification of plant communities along postfire succession in *Pinus brutia* (Turkish red pine) stands in Antalya (Turkey). *Turk J Bot* 41: 299-307. DOI: 10.3906/bot-1609-34.
- Kenar N, Ketenoglu O. 2016. The phytosociology of Melendiz Mountain in the Cappadocian part of Central Anatolia (Nigde, Turkey). *Phytocoenologia* 46: 141-183. DOI: 10.1127/phyto/2016/0065.
- Kenar N, Şekerciler F, Çoban S. 2020. The phytosociology, ecology, and plant diversity of new plant communities in Central Anatolia (Turkey). *Hacquetia* 19: 1-22. DOI: 10.2478/hacq-2019-0014.
- Kılınç M. 1985. Vegetation of the region between Devrez Stream and Kızılırmak in the Central Anatolia-Western Black Sea transition region. *Turk J Bot* 9: 315-357.
- Korkmaz H, Yalçın E, Kutbay HG, Yıldırım C. 2016. The influence of environmental factors on the distribution and composition of plant communities in Kızılırmak Valley-Black Sea region, Turkey. *Revue d'Ecologie, Terre et Vie* 71: 21-34. DOI: 10.3406/rev.2016.1863.
- Kurt L, Ketenoglu O, Akman Y, Özdeniz E, Şekerciler F, Bölükbaşı A, Özbey BG. 2015. Syntaxonomic analysis of the preforest and forest vegetation in the thermo-and eumediterranean zone around Antalya Gulf, Turkey. *Turk J Bot* 39: 487-498. DOI: 10.3906/bot-1402-63. DOI: 10.3906/bot-1402-63.
- Kutbay HG, Kılınç M. 1995. Phytosociological and ecological investigation on the vegetation of Bafra-Nebyan mountain and its environs. *Turk J Bot* 19: 41-63.
- Loidi J, Chytrý M, Jiménez-Alfaro B et al. 2021. Life-form diversity across temperate deciduous forests of Western Eurasia: A different story in the understory. *J Biogeogr* 48: 2932-2945. DOI: 10.1111/jbi.14254.
- Mucina L, Bültmann H, Dierßen K et al. 2016. Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. *Appl Veg Sci* 19: 3-264. DOI: 10.1111/avsc.12257.
- Özdeniz E, Kurt L, Bergmeier E. 2017. Syntaxonomical analysis of the riparian vegetation of the Porsuk River (Eskişehir-Kütahya/Turkey). *Turk J Bot* 41: 609-619. DOI:10.3906/bot-1704-1.
- Özen F, Kılınç M. 1995. The vegetation of the regions between Alaçam-Gerze and Boyabat-Durağan: II-forest and degraded forest vegetations. *Turk J Bot* 19: 87-105.
- Özen F, Kılınç M. 2002. The flora and vegetation of Kunduz forests (Vezirköprü/Samsun). *Turk J Bot* 26: 371-393.
- Preislerová Z, Jiménez-Alfaro B, Mucina L et al. 2022. Distribution maps of vegetation alliances in Europe. *Appl Veg Sci* 25: e12642. DOI: 10.1111/avsc.12642.
- Quézel P, Barbero M, Akman Y. 1980. Contribution à l'étude de la végétation forestière d'Anatolie septentrionale. *Phytocoenologia* 8: 365-519. DOI: 10.1127/phyto/8/1980/365.
- Raunkiaer C. 1934. The Life Forms of Plants and Statistical Plant Geography. Clarendon Press, Oxford.
- Sabatini FM, Lenoir J, Hattab T et al. 2021. sPlotOpen-An environmentally balanced, open-access, global dataset of vegetation plots. *Glob Ecol Biogeogr* 30: 1740-1764. DOI: 10.1111/geb.13346.

- Sezer Y, Altay V, Özyiğit I, Yarcı C. 2015. Woody vegetation of Şile and its environs (İstanbul/Turkey) and destruction of the area. *J Environ Biol* 36: 163-170.
- Theurillat J-P, Willner W, Fernández-González F, Bültmann H, Čarni A, Gigante D, Mucina L, Weber H. 2021. International Code of Phytosociological Nomenclature. 4th Edition. *Appl Veg Sci* 24: e12491. DOI: 10.1111/avsc.12491.
- Tunçkol B, Aksoy N, Çoban S, Zengin H. 2020. Diversity and ecology of forest communities in Küre Mountains National Park of Turkey. *Revista Bosque* 41: 289-305. DOI: 10.4067/S0717-92002020000300289.
- Türe C, Tokur S, Ketenöğlü O. 2005. Contributions to the syntaxonomy and ecology of the forest and shrub vegetation in Bithynia, Northwestern Anatolia, Turkey. *Phyton* 45: 81-115.
- Willner W, Jiménez-Alfaro B, Agrillo E, Biurrun I, Compos JA, Čarni, A, Casella L, Csiky J, Čušterevska R, Didukh YP, Ewald J. 2017. Classification of European beech forests: A Gordian Knot? *Appl Veg Sci* 20: 494-512. DOI: 10.1111/avsc.12299.
- Yıldırım C, Yalçın E, Cansaran A, Korkmaz H. 2019. Syntaxonomic analysis of forests, shrubs, and steppes of Tavşan Mountain (Amasya, Turkey). *Turk J Bot* 43: 409-419. DOI: 10.3906/bot-1809-18.
- Yıldırım C, Yalçın E, Cansaran A. 2022. Syntaxonomy and vegetation-environment relationships in Mount Akdağ (Amasya/Türkiye). *Rendiconti Lincei Scienze Fisiche e Naturali* 33: 673-696. DOI: 10.1007/s12210-022-01091-8.
- Yurdakulol E, Demirörs M, Yıldız A. 2002. A phytosociological study of the vegetation of the Devrekani-İnebolu-Abana area (Kastamonu, Turkey). *Isr J Plant Sci* 50: 293-311. DOI: 10.1560/NQUF-CB48-BYA7-NGVD.
- Zelený D, Schaffers AP. 2012. Too good to be true: Pitfalls of using mean Ellenberg indicator values in vegetation analyses. *J Veg Sci* 23: 419-431. DOI: 10.1111/j.1654-1103.2011.01366.x.

