Plant communities and habitat types in the protected area of Lake Pamvotis (Epirus, Northwestern Greece)

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Abstract. The vegetation of the protected area of Lake Pamvotis (Epirus, NW Greece) was studied and classified into habitat types according to the Council Directive 92/43/EEC. The main vegetation types encountered in the Ioannina Basin and the south-western part of Mt Mitsikeli are: (1) Quercus coccifera shrublands, (2) degraded deciduous oak forests, (3) Mediterranean arborescent matorrals with Juniperus, (4) Orox-Mediterranean heathlands, (5) willow low open forests, (6) oriental plane woods, (7) plant communities supported by calcareous substrates, (8) aquatic macrophyte assemblages, (9) reed beds and rush meadows. Twenty plant communities belonging to twelve alliances, eleven orders, and ten phytosociological classes were discerned. The Asplenio ceterach-Aurinietum saxatilae is described as a new association and the Eleocharito palustris-Alismatetum lanceolati is reported for the first time from Greece. Eleven habitat types were identified and their conservation status was assessed. Three habitat types (4090, 8210, 91M0) were in favourable conservation status, while one (5210) is in unfavourable-bad conservation status. The rest are in unfavourable-inadequate conservation status, with several pressures and threats recorded.

Keywords: conservation status assessment; cluster analysis; habitat directory; vegetation classification.

Vegetación y tipos de habitats en el área protegida del lago Pamvotis (Epirus, Noroeste Grecia)

Resumen. La vegetación del área protegida del lago Pamvotis (Epiro, noroeste de Grecia) se ha estudiado y clasificado en tipos de hábitat de acuerdo con la Directiva 92/43/EEC. Los principales tipos de vegetación que se encuentran en la cuenca de Ioannina y la parte sureste del monte Mitsikeli son: (1) arbustos de Quercus coccifera, (2) bosques de roble caducifolio degradados, (3) matorrales arborescentes mediterráneos con Juniperus, (4) brezales oromediterráneos, (5) bosques de sauces bajos abiertos, (6) bosques de Platamis orientalis, (7) diversas comunidades vegetales sobre sustratos calcáreos, (8) comunidades de macrofíticas acuáticas, (9) cañaverales y juncales. Se distinguieron veinte comunidades de plantas pertenecientes a doce alianzas, once órdenes y diez clases fitosociológicas. Asplenio ceterach-Aurinietum saxatilae se describe como una nueva asociación y Eleocharito palustris-Alismatetum lanceolati se localiza por primera vez en Grecia. Se identificaron once tipos de hábitat y se evaluó su estado de conservación. Tres tipos de hábitat (4090, 8210, 91M0) están en estado de conservación favorable, mientras que uno (5210) está en estado de conservación desfavorable o muy desfavorable. El resto se encuentra en un estado de conservación desfavorable o inadecuado, y se han registrado diferentes amenazas y presiones de tipo antrópico.

Palabras clave: Estudio del estatus de conservación; análisis de grupos; directorio de hábitats; clasificación de la vegetación.

Introduction

The vegetation of Epirus has been inadequately explored, with the majority of the available data focusing on wetland habitats (Barbéro & Quézel, 1976; Georgiadis et al., 1997; Sarika-Hatzinikolau et al., 2003; Ammanatidou, 2005; Dimopoulos et al., 2005; Sarika et al., 2005; Zogaris et al., 2009; Manolaki & Papastergiadou, 2012). Studies of Ganiatas (1970), Sarika-Hatzinikolau et al. (2003), Stephanides & Papastergiadou (2007) and Papastergiadou et al. (2010) are available for Ioannina basin, while Gerasimidis & Korakis (2006) presented some phytosociological data for Mt Mitsikeli.

The current study provides an inventory of the main vegetation units and the related habitat types within the confines of the protected area of Lake Pamvotis. The dominant plant communities were described and classified into habitat types following the Council Directive 92/43/EEC. A conservation status assessment of the habitat types was performed, based on specific structures and functions, typical species, existing pressures and threats. Identification, mapping, and monitoring of the habitat types took place within areas of the Natura 2000 Network designed as Sites of Community Importance (SCI) and Special Areas of Conservation (SAC) (Dafis et al., 2001).

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Material and Methods

Study area

The study area is located in the Prefecture of Ioannina (Epirus, NW Greece). It occupies the south-western part of Mt. Mitsikeli and almost the entire basin of Ioannina, including the Natura 2000 site Lake Pamvotis (code GR2130005) and partly the site Mt. Mitsikeli (code GR2130008). It stretches over 10 cells of the European Environment Agency (EEA) reference grid of 10 x 10 km (Figure 1). Ioannina basin has a total length of 35 km along its NNW-SSE axis and a width ranging from 3 to 10 km. It lies in an average elevation of about 480 m asl and is surrounded by high mountains. Mt Mitsikeli forms the north-eastern border of the area whilst mount Tomaros rises to the west of it. The most distinctive feature of the basin is Lake Pamvotis - a highly eutrophic aquatic ecosystem that has been suffering from long-lasting anthropogenic pressures (Kagalou et al., 2008). The hydrologic and trophic state of Lake Pamvotis and its conservation value are described in detail by Kagalou et al. (2008) and Chiotelli (2015). Human activity has influenced the natural environment of Ioannina basin profoundly as cultivations and pastures have replaced mainly the preexisting vegetation. In the lower part of Quercetalia pubescenti-petraeae belt (500–650 m asl) heavily grazed Quercus coccifera shrublands expand, while degraded deciduous oak forests can be found within the same belt but in higher elevations (620–900 m asl). Shrubby vegetation of secondary succession dominated by Juniperus oxycedrus subsp. deltoides, and usually emanates from degraded oak forests, develops at elevations spanning 900 m asl and 1300 m asl (Horvat et al., 1974; Raus, 1980; Kariangkaidou-Iatropoulou, 1983; Bergmeier, 1990). At elevations ranging roughly from 1100 m asl to 1700 m asl, oro-Mediterranean heathlands are dominant on the south-western part of Mt Mitsikeli, while beech and

Figure 1. Study area (dashed line), the two Natura 2000 sites: GR2130005 with blue color and GR2130008 with green color, the EEA reference grid 10 x 10 km and the positions of the relevés of the current study (black dots).
fir forests are nowadays present only on north-eastern flanks at elevations up to 1500 m. *Pinus brutia* and *P. nigra* reforestations reforestations, which are scattered at low and moderate elevations were originally planted to control soil erosion in heavily degraded sites.

**Data collection**

The vegetation study was carried out following the Braun-Blanquet floristic-sociological approach (Westhoff & van der Maarel, 1980; Kent & Coker, 1992). Seventy-two (72) vegetation sample plots (relevés) ranging in size from 4 m² to 200 m² were recorded from May to October 2015. The choice of stands for sampling was based on uniformity and distinctiveness so that each of the selected stands is typical of the contextual vegetation type in terms of both floristic composition and physiognomy. The selection of sample plots was based on the following general principles: 1) the plot area is homogenous and large enough to represent the floristic composition of the entire stand, 2) the vegetation in the plot area is as far as possible ecologically intact, 3) sampling sites are not in the vicinity of ecotones. The plot sizes used were harmonized with those suggested by Dimopoulos et al. (2018) for the monitoring and assessment of habitat types’ conservation status on a national level. Our goal was the size and shape of plots to be relatively constant in the stands of the same vegetation type. In each plot, all vascular plants were recorded and their coverage was estimated by using the transformed (9-point) Braun-Blanquet scale (Van der Maarel 1979). These data were used to classify the vegetation units and to identify the habitat types, since the recently proposed revisions of the EUNIS (European Nature Information System) habitat classification system are mainly based on a combination of species occurrence and species cover (Schaminée et al., 2019). In addition, data regarding the sampling locality of each plot was recorded as proposed by Tsiripidis et al. (2018).

**Data analysis**

Plant specimens were identified mainly according to Davis (1965–85), Tutin et al. (1968–80, 1993), Strid (1986), and Strid & Kit Tan (1991, 1997, 2002). The nomenclature of the taxa follows Dimopoulos et al. (2013, 2016). The delimitation of vegetation units (Table 2–7) was made utilizing species groups derived from the Braun-Blanquet tabulation technique. This technique highlights species concentrated to particular relevé clusters (character species) or species delimiting differentiated subtypes within a cluster of closely related relevés (differential species). These groups of differentiating species are considered as diagnostic because their presence in particular relevé clusters separates vegetation into discrete units (Müller-Dombois 1984; Chytrý et al., 2002). Following this concept and using as a guide taxa that prefer specific relevé clusters and are considered as diagnostic of the high-rank syntaxa listed in the EuroVegChecklist (Mucina et al., 2016), we classified the separate vegetation units into phytosociological classes, orders, and alliances. The procedure followed for the assessment of diagnostic species is that proposed by Westhoff & van der Maarel (1980). The reader can find a detailed description of how this process was applied to the present study by referring to Sarika (2012). The characteristic species of each class and the nomenclature of the high-rank syntaxa listed in Table 1, as well as of those involved in the text, follow Mucina et al. (2016). At the association level, names previously defined according to the formal syntaxonomic code (Weber et al., 2000), were adopted.

To classify the dataset and to identify differences among vegetation types, we used the two-way indicator species analysis (TWINSPAN) (Hill, 1979). TWINSPAN pseudospecies cut levels for species abundances were set to 0 and 25% cover, while only three division levels were applied, to avoid resulting in groups with a small number of relevés (Sarika et al., 2018). Subsequently, different division levels were accepted, resulting in nine groups characterized by the presence or absence of 12 indicator species (Hill & Smilauer, 2005).

Visualization and interpretation of classification results were performed using non-metric multidimensional scaling (NMDS), based on the Bray-Curtis dissimilarity index. The ordination analysis was performed using the ‘vegan’ package and the function ordispider (Oksanen et al., 2019) in R statistical software platform (R Core Team, 2017). Function ordispider draws a ‘spider’ diagram showing each ordinated element connected to the respective group centroid (Oksanen et al., 2019).

The interpretation of habitat types was mainly achieved through the concept of indicator species (diagnostic, constant, dominant), following the phytosociological approach (Schaminée et al., 2019). Many of the diagnostic species that differentiate the vegetation of the study area into discrete units and species that are constantly present in these units (constant species) are listed as *indicator species* of particular habitat types of the EUNIS classification system (Schaminée et al., 2013, 2014, 2019).

A crosswalk between EUNIS habitat types and the recognized alliances of the EuroVegChecklist was used as a means of identifying habitat types for which certified lists of indicator species have not yet been published. Nowadays, changes and revisions in EUNIS (Schaminée et al. 2012, 2014, 2019) and the development of the EuroVegChecklist hierarchical syntaxonomic system (Mucina et al., 2016) permit a valid crosswalk between alliances and the EUNIS habitat types and vice versa. The correspondence of the habitat types found in the study area with the MAES (Mapping and Assessment of Ecosystems and their Services) ecosystem categories and types (Maes et al., 2018) is presented in Table S1 (Supplementary Material), according to the typology proposed by Kokkoris et al. (2018). Habitat type names and codes are also listed in Table S2 (Supplementary Material).
| Taxonomy                                      | EUNIS       | Annex | NI   |
|----------------------------------------------|-------------|-------|------|
| Quercetea pubescentis                        |             |       |      |
| Quercetalia pubescenti-petraeae              |             |       |      |
| Quercetalia ilicis                           |             |       |      |
| Juniperus oxycedrus subsp. deltoides         |             |       |      |
| Juniperus oxycedrus subsp. deltoides         |             |       |      |
| Quercus coccifera                            |             |       |      |
| Juniperus oxycedrus subsp. deltoides         |             |       |      |
| Daphno-Festucetalia                          |             |       |      |
| Astragalo angustifoliis-Seslerion coerulantis|             |       |      |
| Astragalus angustifolius community            |             |       |      |
| Onosmetalia frutescens                       |             |       |      |
| Campanulion versicoloris                     | H3.2        | 8210  |      |
| Aspleno ceterach-Aurinietum saxatilae        |             |       |      |
| Drypidetalia spinosa                         |             |       |      |
| Silenion caesae                              | H2.6        | 8140  |      |
| Drypis spinosa community                     |             |       |      |
| Salicetalia purpureae                        |             |       |      |
| Salicetalia purpureae                        |             |       |      |
| Salicion albae                               | T11-[G11]   | 92A0  |      |
| Salicetum albo-fragilis                      |             |       |      |
| Potamogetonetalia                            |             |       |      |
| Potamogetonion                               | C1.3        | 3150  | 72A0|
| Stuckenia pectinata community                |             |       |      |
| Nymphaeion albae                             | C1.3        | 3150  | 72A0|
| Nymphaeum albo-lutae                         |             |       |      |
| Nymphaceum minoris                           |             |       |      |
| Nymphoidetum peltatae                        |             |       |      |
| Phragmitetalia                               | D5.1        | 72A0  |      |
| Phragmition communis                         |             |       |      |
| Typhetum angustifolae                        |             |       |      |
| Scirpetum lacustris                          |             |       |      |
| Oenanthealia aquatica                        |             |       |      |
| Eleocharito palustris-Sagittaria sagitifoliae | D5.1        | 72A0  |      |
| Eleocharito palustris-Alismatetum lanceolati |             |       |      |
| Bolboschoenus maritimus community            |             |       |      |
| Molino-Arrhenatheretalia                      |             |       |      |
| Filipendulo ulmariae-Lotetalia uliginosi     |             |       |      |
| Mentho longifoliae-Juncion inflexi           | R36-[E34b]  | 72B0  |      |
| Juncus inflexus-Juncus effusus community     |             |       |      |
Habitat coding follows Davies et al. (2004), Schaminée et al. (2019), and the Interpretation Manual of EU Habitat types (Anon., 2013), whereas habitat types of national interest follow Dafis et al. (2001). For the assessment of habitat types’ conservation status, both European (Evans & Arvela, 2011) and national guidelines (Kotzageorgis et al., 2014; Dimopoulos et al., 2018; Tsiripidis et al., 2018) have been considered, as proposed by Evans & Arvela (2011) and adopted for Greece (Chrysopolitou et al., 2014), at a local or regional scale (e.g., sampling plot level or Natura 2000 site level). The term conservation degree should be used for the conservation status assessment, while at national or biogeographical scale the term conservation status. This differentiation is essential (Kokkoris et al., 2018; Tsiripidis et al., 2018) and in the current work, the term conservation degree is used both for the assessment of habitat conservation status at the sample plot level (relevés) and for the overall assessment in the Natura 2000 site and the study area. The methodology used follows the procedure developed within the national monitoring project of habitat types for the standardization of the conservation status assessment methods (Dimopoulos et al., 2018; Tsiripidis et al., 2018). In brief, assessment of the conservation degree of each habitat type started at the plot level, with a minimum number of 5 relevés per habitat type, unless this was not possible due to limited habitat size. For each habitat type, different field sheets prepared for the national monitoring project have been used (Dimopoulos et al., 2018). These field sheets include specific variables-criteria for the assessment of conservation status of each habitat type such as structure and functions (including typical species), assessment of trend and future status of the habitats’ structures and functions based on observed pressures and threats alongside their intensity, as well as the presence of positive impacts (Kallimanis et al., 2017; Tsiripidis et al., 2018).

Regarding pressures and threats, we followed the methods proposed by Evans & Arvela (2011), and we used the common list for all EU countries and habitat types available on the web page of the European Environment Agency. To upscale the assessment of the conservation degree from the sample plot level to the Natura 2000 site and then to the study area, we followed the upscaling procedure suggested by Dimopoulos et al. (2018), in which assessment of conservation degree is also performed at the EEA reference grid 10 x 10 km cell level, as an intermediate step. In more detail, for the assessment of the conservation degree of each habitat type, the 75–25 rule was applied (Chrysopolitou et al., 2014; Dimopoulos et al., 2018). For calculating the area covered by each habitat type the vegetation map of the responsibility area of the Management Body was used, as this was updated and modified by the results of the current study.

Results and Discussion

Vegetation classification system

The NMDS revealed nine groups of relevés (Figure 2). Eleven relevés from an average elevation of more than 1000 m asl (up to 1700 m asl) that refer to Drypidetea spinosae, Daphno-Festucetea, and Quercetea pubescentis, form the group 1. Twelve relevés from moderate elevations (500–900 m asl) assigned to the classes Quercetea pubescentis and Quercetea ilicis constitute the group 2. Six relevés form the third group representing the chasmophytic vegetation on rocky cliffs (class Asplenietea trichomanis) of middle and upper slopes of the study area. Twenty-two relevés from wetland and aquatic habitats assigned to the classes Phragmito-Magnocaricetea, Molinio-Arrhenatheretalia and Potamogetonetalia comprise group 4. However, three relevés also belonging to Potamogetonetalia form group 5. These were recorded in open water exposed to wind and wave action, in contrast to those of group 4, which were selected in more sheltered localities. Likewise, two relevés of Phragmito-Magnocaricetea recorded in a temporarily flooded depression form group 6. Group 7 includes four relevés associated with Salicetea purpureae. Group 8, with three relevés, represents Alno glutinosae-Populetalia albae. Salicetea purpureae and Alno glutinosae-Populetalia albae related to riparian habitats were separated into two different groups, since those belonging to the Alno-Populetalia albae are rich in species related to drier environmental conditions. Finally, one relevé dominated by Stuckenia pectinata remains isolated in the diagram (Group 9). This relevé represents the only stand with submerged macrophytes sampled, due to the rarity of this vegetation type within the study area and, to a lesser extent, to accessibility difficulties.

The classification analysis revealed ten associations and ten communities not assigned to the formal rank. The identified vegetation units belong to twelve alliances, eleven orders, and ten phytosociological classes. The complete syntaxonomic scheme is presented in Table 1. A description of plant communities is provided below within the contexts of the highest syntaxonomic units (classes). It is associated with the name and the code of the corresponding habitat type, according to Annex I of the Habitat Directive92/43/EEC or Dafis et al. (2001).
The coordinates given for each relevés in the following tables are according to European Terrestrial Reference System (ETRS89).

Figure 2. Non-metric multidimensional scaling (NMDS) using Bray-Curtis dissimilarity and ordispider function. In brackets the habitat type. Group 1: 11 rel. (5210, 4090, 8140); group 2: 20 rel. (91M0, 93A4); group 3: 6 rel. (8210); group 4: 22 rel. (3150, 72A0, 72B0); group 5: 3 rel. (3150); group 6: 2 rel. (72A0); group 7: 4 (92A0); group 8: 3 rel. (92C0); group 9: 1 rel. (3150).

*Quercetea pubescentis*

Natura 2000 habitat type: 91M0 “Pannonian-Balkanic-turkey oak-sessile oak forests”

Degraded deciduous oak forests dominated mostly by *Quercus frainetto* were recorded in the upper-elevation section of the *Quercetalia pubescenti-petraeae* belt (Table 2, rel. 1–6). The floristic composition of these forests suggests the classification of this brushwood in the *Huetio cynapioidis-Quercetum frainetto* described by Bergmeier & Dimopoulos (2008). This vegetation type is differentiated by undergrowth of *Juniperus oxycedrus, Quercus coccifera, Q. pubescens* and other woody species resilient to browsing.

**Table 2.** *Huetio cynapioidis-Quercetum frainetto* (rel. 1–6), *Quercus pubescens* comm. (rel. 7), *Quercus coccifera* comm. (rel. 8–17).

| Species | Altitude (m asl) | Exposure | Plot size (m²) | Slope (°) | Total cover (%) | Species N. | Relevé N. |
|---------|------------------|----------|---------------|---------|----------------|-----------|-----------|
| Quercus frainetto | 5 5 5 4 3 4 | V | . . . . . . | . . . . . . | . . . . . . | . . . . . . | . . . . . . |
| Quercus pubescens | . . . . 3 3 2b III | 4 | . . . . . . | . . . . . . | . . . . . . | . . . . . . | . . . . . . |
| Quercus coccifera | 3 1 2a 3 5 4 V 2b | 4 3 5 5 4 5 | . . . . . . | . . . . . . | . . . . . . | . . . . . . | . . . . . . |
| **Characteristics of Carpino-Fagetea** | | | | | | | |
| Brachypodium sylvaticum | 1 1 1 2b 2a V 2a . . . + 2a . . 2m . . | III | | | | | |
| Hedera helix | 3 2m 2a + IV . + . . + . + . 2b + | III | | | | | |
| Luzula forsteri | 2m . . . . . I . . . . . . . . . . | | | | | | |
| Aremonia agrimonoides | . . . . + . r II + . . . . . . . . . . | | | | | | |
| Melica uniflora | . . . . . . . . . . . . . . . . . . 2m . . . . | I | | | | | |
| **Characteristics of Quercetea pubescentis** | | | | | | | |
| Ruscus aculeatus | 1 2a + . + 1 V + 3 + 2a 1 r 2a + + . IV | | | | | | |
| Juniperus oxycedrus subsp. deltoides | + . 1 . . 1 III + . . . . + . . . . + 3 1 | | | | | | |
| Species                                    | Code | III | 2m | 1 | + | r | + | I | ... |
|--------------------------------------------|------|-----|----|---|---|---|---|---|-----|
| Cornus mas                                |      |     |    |   |   |   |   |   | III |
| Acer monspessulanum                        |      |     |    |   |   |   |   |   | +   |
| Cyclamen hederifolium                     | 2m   |     |    | I |   |   |   |   | +   |
| Phillyrea latifolia                        |      |     |    |   | I |   |   |   | +   |
| Helleborus odorus subsp. cyclophyllus      |      |     |    |   |   |   |   |   | +   |
| Fraxinus ornus                             |      |     |    |   |   |   |   | r | + II|
| Colutea arborescens                        |      |     |    |   |   |   |   |   | + I |
| Galium laconicum                          |      |     |    |   |   |   |   |   | I   |
| Carpinus orientalis                        |      |     |    |   |   |   |   |   | I   |
| Hippocrepis emerus subsp. emeroideas       |      |     |    |   |   |   |   |   | +   |
| Pistacia terebinthus                       |      |     |    |   |   |   |   |   | + I |

**Characteristics of Quercetna ilicis**

| Species                                    | Code | III | 2a | 1 | + | 2a | + | 2a | + |
|--------------------------------------------|------|-----|----|---|---|----|---|----|---|
| Asparagus acutifolius                      |      |     |    |   |   |    |   |    |   |
| Veronica chamaedrys                         | 2m   |     |    | I |   | +  |   | +  |   |
| Asplenium onopteris                         |      |     |    |   |   |    |   |    |   |
| Clematis flammula                          |      |     |    |   |   |    |   |    |   |
| Helictotrichon convolutum                  |      |     |    |   |   |    |   |    |   |

**Characteristics of Ononido-Rosmarinetace**

| Species                                    | Code | III | 2b | 2m |
|--------------------------------------------|------|-----|----|----|
| Phlomis fruticosa                          |      |     |    | II |
| Teucrium capitatum                         |      |     |    | +  |
| Microseria juliana                         |      |     |    | +  |
| Cistus creticus                            |      |     |    | +  |
| Companions                                 |      |     |    | +  |
| Crataegus monogyna                          |      |     |    | +  |
| Rosa sp.                                   |      |     |    | +  |
| Pteridium aquilinum                        |      |     |    | +  |
| Trifolium ochroleucum                      |      |     |    | +  |
| Potentilla microstachus                     |      |     |    | +  |
| Poa trivialis                              |      |     |    | +  |
| Dioscorea communis                         |      |     |    | +  |
| Vicia villosa                              |      |     |    | +  |
| Geum urbanum                               |      |     |    | +  |
| Rubus sp.                                  |      |     |    | +  |
| Asplenium trichomanes                      |      |     |    | +  |
| Asplenium ceterach                         |      |     |    | +  |
| Dactylis glomerata                         |      |     |    | +  |
| Geranium robertianum                       |      |     |    | +  |
| Achnatherum bromoides                       |      |     |    | +  |
| Sanguisorba minor                          |      |     |    | +  |
| Euphorbia myrsinites                       |      |     |    | +  |
| Campanula spatulata                        |      |     |    | +  |
| Clinopodium vulgare                        |      |     |    | +  |
| Silene italicica                           |      |     |    | +  |
| Digitalis laevigata subsp. graeca          |      |     |    | +  |
| Clematis vitalba                           |      |     |    | +  |
| Geranium lucidum                           |      |     |    | +  |

Other species: Prunus sp. + in 1; Helleborus sp. and Dorycnium sp. + in 3; Cartina corymbosa, Darus carota, Leontodon tuberosus, Trifolium sp. + in 4; Sedum sp. and Lonicera sp. + in 7; Prospero aspideae and Crocus sp. + in 8; Hordeum bulbosum 2a, Sonchus oleraceus s, Acanthus spinosus, Opopanax hispidus, Digitalis laevigata subsp. graeca + in 9; Torilis leptophylla, Rhagadiolus stellatus + in 10; Melittis melissophyllum subsp. albida, Carex spicata, Lamium sp. + in 11; Convolvulus elegansissimus, Chrysogonum gallus, Melica ciliata, Sternbergia sp., Colchican sp., Crocus sp. + in 12; Sambucus ebulus + in 14; Geranium rotundifolium and Viola odorata 2m, Anisantha sterilis, Aetheorhiza bullosa, Briza maxima and Johannia distans + in 15; Galium sp. and Arum sp. + in 16; Saxifraga sp., Saxifraga montana and Luzula sp. + in 17.

Localities: datum ETR89 in all tables (see Figure 1). 1: 20.970572, 39.611305; 2: 20.960356, 39.600; 3: 20.968506, 39.609038; 4: 20.731244, 39.639984; 5: 20.773068, 39.71344; 6: 20.959945, 39.668481; 7: 20.829529, 39.736086; 8: 20.70736, 39.658708; 9: 20.782929, 39.71511; 10: 20.872664, 39.557658; 11: 20.829097, 39.737363; 12: 20.934137, 39.465041; 13: 20.903223, 39.498882; 14: 20.791595, 39.586699; 15: 20.915385, 39.628111; 16: 20.914847, 39.676297; 17: 20.793447, 39.755332.
Vegetation stands dominated by *Quercus pubescens* were also sporadically observed. Their floristic composition was characterised not only by the dominance of *Q. pubescens* in the tree layer, but also by the vigorous presence of *Quercus coccifera* in the shrub layer (Table 2, rel. 7). This fact reveals a gradual replacement of the *Quercus pubescens* community by a partly evergreen shrubland vegetation type (pseudomaquis). The *Quercus pubescens* forests are floristically related to the *Quercetea pubescentis*.

Natura 2000 habitat type: 5210 “Mediterranean arborescent matorral with *Juniperus spp.*”

*Juniperus oxycedrus* subsp. *deltoides* dominated stands are widely distributed in the west and south sides of Mt. Mitsikeli. This vegetation was diversified into two types: one growing on moderate elevations (500–800 m asl), characterised by the constant presence of *Quercus coccifera* (Table 3, rel. 1–2) and another one ascending to higher elevations (1200–1270 m), represented by monospecific formations of *Juniperus oxycedrus* subsp. *deltoides* rich in species of the classes *Festuco-Brometea* and *Daphno-Festucetea* (Table 2, rel. 3–6). The *Juniperus oxycedrus-Quercus coccifera* stands were poor in species of the *Quercetea pubescentis* and are very weakly related to this class. However, it is widely accepted that the *Juniperus oxycedrus-Quercus coccifera* community, frequently reported from Greece (Raus, 1980; Karagiannakidou-Iatropoulou, 1983; Bergmeier, 1990; Chasapis et al., 2004; Fotiadis, 2004), belongs to the order *Querco-Petraeetalia*, even though the presence of character species of the abovementioned syntaxa is often very limited.

Table 3. *Juniperus oxycedrus* subsp. *deltoides* comm. (rel. 1–6), *Astragalus angustifolius* comm. (rel. 7–11).

| Altitude (m asl) | 810 635 491 1270 1200 1220 1656 1678 1560 1500 1451 |
|-----------------|------------------------------------------------------|
| Exposure        | 190 205 175 103 234 245 350 220 285 193 205         |
| Plot size (m²)  | 50 50 50 50 50 50 16 16 16 16 16                   |
| Slope (º)       | 20 15 45 30 25 30 10 30 40 20 45                   |
| Total cover (%) | 60 70 70 60 60 70 90 85 100 80 100                 |
| Species N.      | 18 15 17 27 30 31 20 18 20 22 18                   |
| Group (Figure 2) | 2 2 2 1 1 1 1 1 1 1 1                             |
| Relevé N.       | 1 2 3 4 5 6 7 8 9 10 11                            |

| *Juniperus oxycedrus* subsp. *deltoides* | 3 4 4 4 4 4 | V | . | . | . | + | I |
| *Astragalus angustifolius* s.l.         | . . . . . . . | 3 3 4 3 2a V |
| *Festuca varia* s.l.                  | . . . . . . . | 3 3 3 2b 2b V |
| Characteristics of *Quercetea ilicis*  | . . . . . . . |
| *Quercus coccifera*                   | 2b 2b . . . . III . . . . |
| *Asparagus acutifolius*                | + 2a . . . . III . . . . |
| *Helictotrichon convolutum*            | . 2a . 1 . 2a III . . . . |
| Characteristics of *Quercetea pubescentis* | . . . . . . . |
| *Fraxinus ornus*                      | . + . . . . I . . . . |
| *Galium laconicum*                    | . . . . . . . . + . I |
| *Helleborus odorus* subsp. *cyclophyllus* | . . . + + + III . . . . |
| *Celtis australis*                     | . 1 . . . . I . . . . |
| Characteristics of *Ononido-Rosmarinetea* | . . . . . . . |
| *Phlomis fruticosa*                   | 2a 1 1 + + + I V . . . . |
| Characteristics of *Daphno-Fetucetea*  | . . . . . . . |
| *Rosa pulverulenta*                   | . . . + 1 + III . . . . |
| *Poa thessala*                        | . . . . . . . . + . I |
| *Thymus longicaulis*                  | . 2a + . II 2a 2b + 2a IV |
| *Campanula spatulata*                 | + . . + . . II . . + . I |
| Characteristics of *Drypidetea spinosae* | . . . . . . . |
| *Euphorbia myrsinites*                | + + + + + + V + + + 1 + V |
| Characteristics of *Festuco-Brometea*  | . . . . . . . |
| *Eryngium amethystinum*               | . . . 1 + + III 2a 1 2a 1 + V |
| *Melica ciliata*                      | . + 2a 1 . + V . . . . |
| *Minuartia verna*                     | . . . . . . . + 1 + + . IV |
| *Alyssum montanum*                    | . . . . . . . + + . . II |
| *Sanguisorba minor*                   | . 2m + + III . . . + I |
| *Satureja montana*                    | . 1 1 2a III . . + 1 II |
| *Teucrium chamaedrys*                 | . . 2a 1 II + . . . 1 II |
| *Anthyllis vulneraria*                | . . 2m 2m II . . . . |
| *Brachypodium pinnatum*               | . . + 2m 2m III . . . . |
Although the Juniperus oxycedrus subsp. deltoides monodominant community is scarcely studied, Horvat et al. (1974) mention its secondary nature, while Davies et al. (2004) note that it mostly results from the degradation of broad-leaved evergreen or thermophilous deciduous forests. If we adopt the notion that a thermophilous deciduous forest of the alliance Quercion confertae preexisted in the study area in the sites nowadays colonized by the Juniperus oxycedrus subsp. deltoides stands, as often asserted in the literature for such communities (Horvat et al., 1974; Raus, 1980; Karagiannakidou-Latropoulou, 1983; Bergmeier, 1990), we can include these stands in the Quercion confertae alliance.

**Quercetalia ilicis**

Habitat type of national interest: 934A “Greek Quercus coccifera woods”

*Quercus coccifera* shrublands expand in the lower part of *Quercetalia pubescenti-petraeae* belt. The
height of *Q. cocifera* individuals was in most cases not more than five meters (average height: 4.5 m). In dense stands, *Asparagus acutifolius* was the only characteristic species of the *Quercetalia ilicis* (Table 2, rel. 8–17). Species of the *Quercetalia pubescentis* recorded in a great number of the sample plots, separate the community into a semi-deciduous and an evergreen variant. This affirms previous reports that *Q. cocifera* shrublands in Greece and other adjacent Mediterranean regions are frequently associated with thermophilous deciduous trees such as *Quercus pubescens* and *Fraxinus ornus* (Raus, 1980; Bergmeier, 1990; Jasprica et al., 2015).

Vegetation types of the alliance *Arbuto andrachnes-Quercion cocciferae* recently reported from the Marmara region and the Aegean coast of Turkey (Bergmeier et al., 2018) resemble either the semi-evergreen (Table 2, rel. 8–13) or the evergreen variant (Table 2, rel. 14–17) of *Quercus cocifera* community spreading in the study area. We think both the abovementioned variants possibly belong to the alliance *Arbuto andrachnes-Quercion cocciferae* in which the evergreen mesic kermes oak forests of the Eastern Mediterranean are included. More information concerning *Quercus cocifera* communities across the Mediterranean region can be found in Tsiourlis et al. (2009) and Jasprica et al. (2016).

**Daphno-Festuceta**

Natura 2000 habitat type: 4090 “Endemic oro-Mediterranean heaths with gorse”

*Astragalus angustifolius*-dominated stands were found on Mt. Mitsikeli at or above tree line, spanning an elevation range 1450–1700 m asl (Table 3, rel. 7–11). A taxon belonging to the *Festuca varia* (sensu lato) group was constantly and abundantly present in these stands. *Festuca varia* s.l. is a complex taxonomically group, perhaps in a need of revision (Strid & Kit Tan, 1991) since all the characters used to describe the microspecies distinguished by Markgraf-Dannenberg (1976, 1980) show a wide overlapping (Strid & Kit Tan, 1991; Strid 2016).

Mucina et al. (2016) consider that this group, which is reported to occur in Greece (Strid & Kit Tan, 1991), is represented in the *Daphno-Festuceta* communities most probably (and in most cases) by the species *Festuca clymenica*, while less frequently the species *F. graeca*, *F. penzesii* and *F. kozanensis* might also occur. The material collected from the investigated sample plots was identified as *Festuca* cf. *clymenica*, which is also in accordance with the two species of the group (*F. clymenica, F. graeca*) reported from the area (Dimopoulos et al., 2013). This vegetation type is already reported from Mt. Mitsikeli under the name *Astragalus angustifolius* community (Gerassimidis & Korakis, 2006), which potentially belongs to the *Fagetalia* belt and has probably replaced degraded *Fagus* or *Abies* forests. Since Mt. Mitsikeli consists mainly of limestone (Papadopoulou-Vrioni et al., 2015), we consider the *Astragalus angustifolius* stands as an expression of the alliance *Astragalo angustifolii-Seslerion coerulantis*, which spreads on calcareous substrates (Mucina et al., 2016).

**Asplenietea trichomanis**

Natura 2000 habitat type: 8210 “Calcareous rocky slopes with chasmophytic vegetation”

A floristically homogenous vegetation unit that occurs on middle and upper slopes of cliffs between 600–1400 m asl is described here for the first time as the new association *Asplenio ceterach-Aurinietum saxatilis ass. nova hoc loco* (Table 3, rel. 1–7, holotypus; rel. 2; characteristic taxon: *Asplenium ceterach* and *Aurinia saxatilis* subsp. *orientalis*). It is a thermomesomediterranean chasmophytic vegetation type that develops sparsely on limestone rock crevices. The diagnostic taxa of this association, grow on slopes with an inclination between 70° and 90°, covering only a small percentage of the investigated sample plot surface (>5–25%). In the seven sample plots selected as representative of this vegetation type, 39 taxa were found, while the average number of taxa per sample was 11. Diagnostic taxa of the association are: *Asplenium ceterach, Aurinia saxatilis* subsp. *orientalis*, *Centranthus ruber* subsp. *sibthorpii*, *Campanula versicolor*, *Sedum dasyphyllum* subsp. *dasyphyllum* and *Sedum hispanicum*. Although some diagnostic taxa of this association had higher coverage percentage than that of *Asplenium ceterach* and *Aurinia saxatilis*, the last two were chosen as nominal taxa since they were consistently present in all the investigated stands.

The chasmophytic vegetation of limestone cliffs that occurs at low to moderate elevations (up to 1500 m asl), belongs to the order *Onosmetalia frutescentis* (Dimopoulos et al., 1997; Mucina et al., 2016), which is represented in Greece by the alliance *Campanulion versicoloris*.

**Drypidetalia spinosae**

Natura 2000 habitat type: 8140 “Eastern Mediterranean scree screens”

The communities of montane limestone scree habitats in Greece are well separated from the rock-cliff *Asplenietea trichomanis* vegetation and are classified into the order *Drypetetalia spinosae*, which is characterised by the predominance of Balkan chorotypes (Dimopoulos et al., 1997). A community dominated by *Drypis spinosa* was found on Mt. Mitsikeli. Apart from *Drypis spinosa*, no other species of the *Drypidetalia spinosae* was present in our relevés (Table 4, rel. 8–9). The *Silenion caesiae* is the most widespread alliance of the order *Drypetetalia spinosae* in Greece, comprising calcareous scree communities which are distributed all over the mountain ranges of mainland (Dimopoulos et al., 1997).
Table 4. *Asplenio ceterach-Aurinietum saxatilae ass. nova* (rel. 1–7), *Drypis spinosa* (rel. 8–9).

| Altitude (m asl) | 591 | 465 | 620 | 476 | 811 | 489 | 1376 | 1287 | 1323 |
|-----------------|-----|-----|-----|-----|-----|-----|------|------|------|
| Exposure | 39 | 160 | 167 | 18 | 120 | 210 | 172 | 186 | 275 |
| Plot size (m²) | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 |
| Slope (%) | 85 | 80 | 90 | 90 | 70 | 80 | 90 | 30 | 45 |
| Total cover (%) | 20 | 50 | 25 | 30 | 40 | 20 | 10 | 15 | 10 |
| Group (Figure 2) | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 |
| Species N. | 8 | 11 | 11 | 9 | 13 | 9 | 16 | 11 | 11 |
| Relevé N. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |

**Asplenio ceterach**

1 + + + 2b 1 r V . . .

**Aurinia saxatilis subsp. orientalis**

1 2a + 1 + r V . . .

**Drypis spinosa**

2a 1 V

**Characteristics of Asplenietea trichomanis**

| Centranthus ruber subsp. sibthorpii | r 2a 2a . . . II . . . |
| Campanula versicolor | . . . . 1 2a + . . . 1 III . . . |
| Sedum dasyphyllum | 2a + . . . . III . . . |
| Sedum hispanicum | 1 . + 2m 1 . III . . . |

**Characteristics of Drypidetea spinosae**

| Euphorbia myrsinites | + + r . . + + . IV . . . |

**Characteristics of Festuco-Brometea**

| Satureja montana | . . . + 2a II . + III |
| Teucrium chamaedrys | . . . . . . . . . . + V |
| Sanguisorba minor | . . . . . . . . . . + III |
| Draba lasiocarpa | . . . . . . . . . . r III |
| Melica ciliata | . . + . . . . . I + + V |
| Hypericum rumeliacum | . . r . . . . . I . . . |

**Characteristics of Daphno-Festucetea**

| Cerastium candidissimum | + . . . . . . . . . . I . . . |
| Carum graecum | . . + . . . . . . . . I . . . |
| Carduus imolus | . . . . . . . . . . r III |
| Minuartia attica | . . . . . . . . . . r I . . . |
| Astragalus angustifolius | . . . . . . . . . . . + III |

**Companions**

| Micromeria juliana | 1 1 . . 2a r + IV . . . |
| Sedum acre | 1 . . . . . . . . . . . + III . . . |
| Scrophularia heterophylla | 1 . + 1 . . . . III . . . |
| Sedum album | . . . + 1 . . . . . II . . . |
| Umbilicus rupestris | . + . + . . . . III . . . |
| Parietaria judaica | + . . . . . . . . II . . . |
| Sedum rubens | . . . . . . 1 . . I + + V |
| Galium sp. | . . . . . . . . + I + III |
| Achillea holosericea | . . . . . . . . r I . r III |
| Convolvulus arvensis | . . . . . . . . . . . . + I I . III |

Other taxa: *Verbasum sp., Minuartia sp.+ in 2; Sedum sediforme +, Silene sp. 2a in 3; Dryopteris sp. + in 4; Petrohragia saxifraga +, Trisetum flavescens + in 5; Ephedra foeminea 1 in 6; Melica minuta +, Poa bulbosa r, Silene viridiflora +, Helicotrichon convolutum 1, Leontodon hispidus +, Malcomia sp.+ +, Asyneuma limonifolium subsp. limonifolium r in 7, Malcomia orsiniana +, Nepeta spruneri +, Leontodon crispus +, Crepis dioscoridis + in 8; Centaurea lacerata +, Bromus/Anisantha sp. +, Festuca cf. cyllenica + in 9. Localities: datum ETRS89 (see Figure 1). 1: 20.919176, 39.625156; 2: 20.904675, 39.678073, holotypus ass.; 3: 20.823831, 39.728239; 4: 20.913442, 39.640364; 5: 20.797934, 39.756273; 6: 20.873563, 39.677381; 7: 20.886658, 39.716563; 8: 20.894727, 39.709537; 9: 20.924979, 39.698316.

### Saliceta purpureae

Natura 2000 habitat type: 92A0 “Salix alba and Populus alba galleries”

Associations dominated by the arborescent species *Salix alba* and *S. fragilis* are elements of the riverine vegetation in Greece (Zaimes et al., 2010). However, the distribution of *S. fragilis* in Greece is not fully known because it is often confused with *S. rubens*, probably a hybrid of *S. alba* and *S. fragilis* (Dimopoulos et al., 2013). In all the willow stands sampled, two *Salix* species were co-dominant. Observing the texture of buds, as well as the morphology and texture (glabrous or sericeous) of young and mature leaves in the field,
we were able to distinguish the species *S. alba* and *S. fragilis*. The association *Salicetum albo-fragilis* is the unique representative of the alliance *Salicion albae* (Table 5, rel. 1–4). There are few records of this vegetation type in Greece up to present (Georgiadis *et al*., 1997; Karagianni *et al*., 2008; Sarika *et al*., 2018).

Table 5. *Salicetum albo-fragilis* (rel. 1–4), *Platanus orientalis-Juglans regia* comm. (rel. 5–7).

| Altitude (m asl) | 460 | 469 | 470 | 462 | 470 | 585 | 527 |
|-----------------|-----|-----|-----|-----|-----|-----|-----|
| Plot size (m²)  | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| Total cover (%) | 85  | 100 | 90  | 100 | 100 | 100 | 80  |
| Group (Figure 2) | 7   | 7   | 7   | 8   | 8   | 8   |
| Species N.      | 19  | 18  | 18  | 16  | 13  | 17  | 16  |
| Relevé N.       | 1   | 2   | 3   | 4   | 5   | 6   | 7   |
| *Salix alba*     | 3   | 2a  | 3   | 2b  | V   | .   | .   |
| *Salix fragilis* | 2b  | 4   | 3   | 3   | V   | .   | .   |
| *Platanus orientalis* | -  | -   | -   | -   | -   | -   | -   |
| *Juglans regia*  | -   | +   | 2a  | III | 1   | 2a  | 2a  |

Characteristics of *Alno glutinosae-Populetea albae*

| Characteristic | 2a | + | + | IV | . | . | + | II |
|---------------|----|---|---|----|---|---|---|---|
| *Galium aparine* | 1  | - | - | -  | - | - | - | - |
| *Populus alba* | -  | 1 | 1 | 2a | IV | 1 | . | - |
| *Sambucus nigra* | -  | 2a | 2b | III | . | . | . | . |
| *Humulus lupulus* | -  | 1 | . | . | II | . | 1 | II |
| * Clematis vitalba | -  | 2a | 1 | III | . | . | . | . |
| *Rubus caesius* | -  | - | 2a | 1 | III | . | . | . |

Characteristics of *Melissa officinalis subsp. altissima*

| Characteristic | -  | - | - | + | 2a | IV |
|---------------|----|---|---|---|----|---|
| *Hedera helix* | -  | - | - | - | - | - |

Characteristics of *Eripilobeta angustifoli*

| Characteristic | 3 | + | 2m | V | . | . | + | II |
|---------------|---|---|----|---|---|---|---|---|
| *Calystegia sepium* | + | 2m | . | + | IV | . | . | . |
| *Sambucus ebulus* | -  | 2m | 2m | III | . | . | . | . |
| *Epilobium hirsutum* | -  | + | . | II | . | . | . | . |
| *Conium maculatum* | -  | . | 2m | II | . | . | . | . |
| *Geum urbanum* | -  | . | . | . | - | + | IV | . |

Characteristics of *Crataego-Prunetea*

| Characteristic | 2a | 1 | 3 | V | . | . | . | . |
|---------------|----|---|---|---|---|---|---|---|
| *Prunus cocomilla* | 1  | 2a | 1 | IV | . | . | . | . |
| *Corylus avellana* | -  | + | . | II | r | r | r | V |
| *Rubus sp.* | -  | - | - | 1 | 1 | 3 | V | . |
| *Cornus sanguinea subsp. australis* | -  | - | 3 | II | . | . | . | . |
| *Crataegus monogyna* | -  | . | . | + | . | + | IV | . |

Characteristics of *Phragmito-Magnocaricetea*

| Characteristic | + | 2a | . | III | . | . | . | . |
|---------------|---|----|---|----|---|---|---|---|
| *Phragmites australis* | + | . | - | II | . | . | . | . |
| *Iris pseudacorus* | -  | . | . | + | II | . | . | . |
| *Cicuta virosa* | r  | . | . | II | . | . | . | . |
| *Lycopus europaeus* | .  | + | . | II | . | . | . | . |
| *Helosciadium nodiflorum* | .  | . | 2m | II | . | . | . | . |
| *Equisetum fluviatile* | .  | . | + | . | II | . | . | . |

Characteristics of *Quercetea pubescents*

| Characteristic | . | 1 | . | II | . | . | . | . |
|---------------|---|---|---|----|---|---|---|---|
| *Ruscus aculeatus* | -  | . | . | . | 2b | + | . | IV |
| *Helleborus odorus subsp. cyclophyllus* | -  | . | . | . | . | r | + | IV |
| *Cinopodium vulgar* | .  | . | . | . | . | + | II | . |
| *Celtis australis* | -  | . | 1 | II | . | . | + | II |

Companions

| Characteristic | 2a | 2m | . | III | . | . | . | . |
|---------------|----|----|---|----|---|---|---|---|
| *Anisantha sterilis* | -  | - | . | . | . | . | . | . |
| *Dactylis glomerata* | -  | . | 2m | II | . | . | + | II |
| *Brachypodium sylvaticum* | -  | . | . | . | r | + | V | . |

Other species: *Malva sp.* +, *Alanthus altissima* 1, *Cardhus pyrrocephalus* r, *Rumex conglomerates* 1, *Alyssum sp.* 1, *Avena barbata* +, *Sonchus oleraceus* r, *Poa trivialis* + in 1; *Persicaria lapathifolia subsp. lapathifolia* +, *Equisetum palustre* +, *Holcus lanatus* subsp. *lanatus* +, *Fennica arvensis* +, *Xanthium strumarium* r in 2; *Rumex palustris*, *Helianthus laetiflorus*, *Mentha sp.* 2m in 3; *Geranium dissecutum* +, *Gaulium sp.* 2m, *Silybum marianum* r in 4; *Ulmus sp.* r, *Arun sp.* +, *Quercus sp.* r, *Orobanche sp.* r in 5; *Ficus carica* r, *Castanea sativa* +, *Melica minutula* +, *Polystichum setiferum* +, *Equisetum ramosissimum* r in 6; *Prunus vulgaris* +, *Juncus inflexus* + in 7.

Localities: datum ETRS89 (see Figure 1). 1: 20.872771, 39.684849; 2: 20.91734, 39.649755; 3: 20.775198, 39.610114; 4: 20.775198, 39.742994; 5: 20.938559, 39.656943; 6: 20.966583, 39.610114; 7: 20.958691, 39.61247.
**Alno glutinosae-Populetea albae**

Natura 2000 habitat type: 92C0 “Oriental plane woods (Platanion orientalis)”

Platanus orientalis-dominated stands occur throughout the ravines and streams of Ioannina basin. They are frequently highly disturbed by human activities such as waste disposal, water drilling, and streamflow regulation. Besides the dominant *P. orientalis*, *Junglans regia* was significantly present in the tree layer (Table 5, rel. 5–7). Karetsos (2002) cites similar *Platanus orientalis*-*Junglans regia* community, annotating that it resembles the *Junglando-Platanetum orientalis typicum*, which is mentioned by Horvat et al. (1974) from the former Yugoslav. Later on, Fotiadis (2004) records similar *Platanus orientalis*-*Junglans regia* combinations from the mountains Beles and Krusia, which he attributes to the *Junglando-Platanetum orientalis*, highlighting the intense anthropogenic pressure that this association suffers. The stands reported by Karetsos (2002) and Fotiadis (2004) and those found by us have several species in common with the *Junglando-Platanetum orientalis* typicum and probably represent a local form of it. However, due to the significant geographic distance between Greece and the former Yugoslavian regions and the lack of intermediate sampling stations, we adopt Karetsos’ approach (2002) that all the representatives of this vegetation type in Greece must be registered as a simple community.

**Potamogetonetea**

Natura 2000 habitat type: 3150 “Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation”

The macrophyte vegetation of the *Potamogetonetea* class that is linked to freshwater aquatic and wetland habitats of Ioannina basin has been thoroughly studied in the past (Sarika-Hatzinikolaou et al., 2003). Field observations within the framework of the present study verified that most of the communities of this class recorded in the past are still present in the study area, although their distribution and abundance have been significantly reduced. Furthermore, Stephanides & Papastergiadou (2007) mention that species composition and distribution pattern of the submerged and floating-leaf vegetation have been considerably altered in Lake Pamvotis during the last decades. Some communities of the abovementioned class already known from the area were recorded anew and are cited in the present study (Table 6, rel. 1–7).

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**Table 6. Nymphoidetum peltatae (rel. 1–3), Nymphaeetum albo-lutae (rel. 4–5), Nymphaeetum minoris (rel. 6), Stuckenia pectinata comm. (rel. 7).**

| Altitude (m asl) | 463 | 463 | 456 | 463 | 459 | 460 | 463 |
|-----------------|-----|-----|-----|-----|-----|-----|-----|
| Plot size (m²)  | 16  | 16  | 4   | 10  | 15  | 4   | 4   |
| Total cover (%) | 80  | 80  | 70  | 85  | 90  | 90  | 80  |
| Group (Figure 2) | 5   | 5   | 5   | 4   | 4   | 4   | 9   |
| Species N.      | 1   | 3   | 3   | 2   | 4   | 3   | 4   |
| Relevé N.       | 1   | 2   | 3   | 4   | 5   | 6   | 7   |
| Nymphoides peltata | 5   | 4   | 3   |     |     |     |     |
| Nuphar lutea     |     |     |     |     |     |     |     |
| Nymphaea alba    |     |     |     |     |     |     |     |
| Stuckenia pectinata |     |     |     |     |     |     |     |
| Characteristics of Potamogetonetea                       |
| Myriophyllum spicatum                                    |
| Potamogeton crispus                                     |
| Character taxa of Lemnetea                               |
| Ceratophyllum demersum                                   |
| Spirodela polyrhiza                                     |
| Characteristics of Phragmito-Magnocariceteta            |
| Phragmites australis                                    |
| Sparganium erectum                                      |
| Veronica beccabunga                                      |
| Eleocharis palustris                                     |
| Mentha aquatica                                          |
| Typha angustifolia                                       |

Other species: Cyperus capitatus + in 2; Paspalum distichum + in 7.
Localities: datum ETRS89 (see Figure 1). 1: 20.915717, 39.673759; 2: 20.92749, 39.667274; 3: 20.872042, 39.648182; 4: 20.873575, 39.684459; 5: 20.77357, 39.749132; 6: 20.85913, 39.562386; 7: 20.86035, 39.687969.

**Phragmito-Magnocariceteta**

Habitat type of national interest: 72A0 “Reed thickets”

All previously reported reed-bed communities of the *Phragmito-Magnocariceteta* (Sarika-Hatzinikolaou et al., 2003) are still present in the study area. Some of them were recorded anew (Table 7, rel. 1–8, 11–15), while the *Bolboschoenus maritimus* community (Table 7, rel. 9–10) and the association *Eleocharito palustris-Alismatetum lanceolati* (Table 8, rel. 5–6) were documented for the first time.
| Characteristics of Phragmitetum communis (rel. 1–8), Bolboschoenus maritimus comm. (rel. 9–10), Typhetum angustifolii (rel. 11–14), Scirpetum lacustris (rel. 15). |
|---|
| **Altitude (m asl)** | 465 | 465 | 465 | 465 | 465 | 465 | 465 | 465 | 462 | 465 | 465 | 465 | 443 | 472 |
| **Plot size (m²)** | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| **Total cover (%)** | 100 | 100 | 100 | 100 | 100 | 100 | 90 | 100 | 100 | 100 | 90 | 100 | 90 | 100 | 80 |
| **Group (Figure 2)** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Species N.** | 9 | 14 | 4 | 4 | 2 | 12 | 1 | 10 | 4 | 14 | 8 | 3 | 6 | 9 | 6 |
| **Relevé N.** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| **Phragmites australis** | 5 | 3 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| **Bolboschoenus maritimus** | 2m | 1 | 5 | 2b | V | 2b | . | . | . | II |
| **Typha angustifolia** | . | . | . | . | . | + | . | . | . | I | III |
| **Schoenoplectus lacustris** | 2m | . | . | . | . | . | I | . | . | . | + | II | 5 |

**Characteristics of Epilobietea angustifolii**

| **Epilobium hirsutum** | 1 | 1 | 1 | . | . | . | . | II | 1 | III | . | I | II |
| **Calystegia sepium** | 2m | 2m | . | 2m | . | + | 2a | III | 2m | III | + | + | IV |
| **Pulicaria dysenterica** | r | . | . | . | . | . | . | . | I | . | . | . | . | . |
| **Urtica dioica** | . | . | . | . | . | + | . | . | . | I | . | r | . | II |

**Characteristics of Phragmito-Magnocaricetae**

| **Mentha aquatica** | 2a | . | . | r | 2b | II | 3 | III | r | + | I | IV |
| **Butomus umbellatus** | r | . | . | . | . | . | . | . | I | . | . | . | . | . |
| **Alisma plantago-aquatica** | + | r | . | . | . | . | . | . | II | . | . | . | . | . |
| **Typha domingensis** | 2m | . | . | . | . | . | I | . | . | . | . | . | . | . |
| **Sparganium erectum** | 2m | . | . | r | . | . | II | 1 | III | . | I | + | III |
| **Lycopus europaeus** | . | + | . | . | . | . | + | II | + | III | . | . | . | . | . |
| **Eleocharis palustris** | r | . | . | . | . | . | I | 2a | . | III | . | . | . | . | . |
| **Solanium dulcamara** | . | . | 2a | 1 | . | . | . | . | II | . | . | . | . | . | . |
| **Cicuta virosa** | . | . | . | 2a | I | . | . | . | II | . | . | . | . | . | . |
| **Iris pseudacorus** | . | . | . | 2m | . | I | . | . | r | . | II | . | . | . | . |
| **Cyperus longus** | . | . | . | . | . | . | . | . | + | II | 1 | . | . | . | . |
| **Veronica beccabunga** | . | . | . | . | . | . | . | . | + | . | II | . | . | . | . |
| **Lythrum salicaria** | . | . | . | . | . | . | . | . | . | . | + | II | . | . | . |
| **Alisma lanceolatum** | . | . | . | . | . | r | . | 1 | V | . | . | . | r | . | . |
| **Galium elongatum** | . | . | . | . | . | I | 1 | . | r | III | . | . | . | . | . |

**Characteristics of Molinio-Arrhenatheretalia**

| **Stachys palustris** | 2m | . | . | . | . | . | I | . | . | + | . | II | . | . | . |
| **Carex otrubae** | r | . | . | . | . | . | r | II | 3 | III | . | . | . | . | . |
| **Rumex conglomeratus** | 1 | . | . | . | . | . | 1 | II | . | + | III | . | . | . | . |
| **Rorippa sylvestris** | . | + | . | . | . | . | 1 | II | 1 | III | . | . | . | . | . |
| **Poa trivialis** | . | + | . | . | . | + | II | r | III | . | . | . | . | . | . |
| **Galium debile** | . | . | . | 2m | . | 1 | . | . | . | . | . | . | . | . | . |
| **Verbena officinalis** | . | . | . | . | r | . | 1 | . | . | . | . | . | . | . | . |
| **Oenanthe fistulosa** | . | . | . | . | . | . | 1 | . | 1 | III | . | . | . | . | . |
| **Carex hirta** | . | . | . | . | . | . | . | . | + | . | III | . | . | . | . |
| **Juncus inflexus** | . | . | . | . | . | . | + | III | . | . | . | . | . | . | . |
| **Scirpoideae holoschoenii** | . | . | . | . | . | . | . | . | + | II | . | . | . | . | . |

**Companions**

| **Lemna trisula** | 2a | . | . | . | . | . | I | . | . | . | . | . | . | . | . |
| **Riccia fluitans** | 1 | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . |

Other species: *Hydrocharis morsus-ranae* + in 1; *Cirsium vulgare* r, *Vinca major*, *Nuphar lutea* + in 6; *Ranunculus marginatus* + in 7; *Lemna minor* 2m in 15.

Localities: datum ETRS89 (see Figure 1). 1: 20.852225, 39.69; 2: 20.873713, 39.684704; 3: 20.873619, 39.684519; 4: 20.8729, 39.673724; 5: 20.884722, 39.680556; 6: 20.889651, 39.6796; 7: 20.773428, 39.75021; 8: 20.90491, 39.643612; 9: 20.879148, 39.649393; 10: 20.904767; 39.643529; 11: 20.926709, 39.664354; 12: 20.859281, 39.688189; 13: 20.878988, 39.64172; 14: 20.872096, 39.648062; 15: 20.859618, 39.593523.
The *Bolboschoenus*-dominated vegetation, mainly reported from coastal regions of Europe, also occurs in a variety of inland freshwater and saline habitats (Hroudová et al., 2009). Although *Bolboschoenus maritimus* communities are rather frequent in coastal saline ecosystems of Greece (Wolff, 1968; Gradstein & Smittenberg, 1977; Babalonas, 1979; Georgiadis et al., 1990; Karagianni et al., 2008; Sarika, 2012), up to date few records from inland freshwater wetlands exist (Zotos, 2006; Dimopoulos et al., 2005; Pirini et al., 2011).

Almost monospecific *Alisma lanceolatum* stands were found in the south-central region of Ioannina basin, in a seasonally flooded depression. Hrivnák et al. (2015) report that communities dominated by *Alisma lanceolatum* are relatively poorly documented in Central Europe and that their appearance is directly correlated to the water level fluctuation during a given year, an opinion which is also adopted here. *Alisma lanceolatum* is frequently reported from Greece however, data concerning vegetation units dominated by this species are not available up to date. The community found in Ioannina basin is floristically impoverished (Table 8, rel. 5–6), but the presence of *Butomus umbellatus* and *Eleocharis palustris* strengthens the conviction that the investigated stands are correlated to the *Eleocharito palustris-Sagittarion sagittifoliae* alliance (Hroudová et al., 2009). Additionally, our field observations agree with the statements of Hrivnák et al. (2015) regarding habitat preference and frequency of occurrence of the association *Eleocharito palustris-Alismatetum lanceolati*, which has not been reported from Greece up to present. However, Hrivnák et al. (2015) cite that it can be expected in regions with intensively drought summer because the development of “strong wetland competitors” is discouraged under these circumstances.

| Juncus inflexus-Juncus effusus comm. (rel. 1–4), Eleocharito palustris-Alismatetum lanceolati (rel. 5–6). |
| Altitude (m asl) | 495 | 463 | 463 | 460 | 482 | 482 |
| Plot size (m²) | 16 | 16 | 16 | 16 | 16 | 16 |
| Total cover (%) | 100 | 100 | 80 | 50 | 85 | 90 |
| Group (Figure 2) | 4 | 4 | 4 | 4 | 6 | 6 |
| Species N. | 4 | 9 | 8 | 6 | 5 | 4 |
| Relevé N. | 1 | 2 | 3 | 4 | 5 | 6 |

Characteristics of *Molinio-Arrhenatheretea*

*Pulicaria dysenterica*

- 2a

*Teucrium scordium* subsp. *scordoides*

- +

*Rumex conglomeratus*

- + 1 +

*Potentilla reptans*

- + 1 + IV

*Carex hirta*

- 2m r III

*Carex otrubae*

- + II

*Agrostis stolonifera*

- 2a II

Characteristics of *Phragmito-Magnocaricetea*

*Menhia aquatica*

- 2b + III

*Lycopus europaeus*

- 2b II

*Iris pseudacorus*

- + II

*Lythrum salicaria*

- 3 II

* Cyperus longus*

- 3 II

* Calystegia sepium*

- 2a II

*Butomus umbellatus*

- + + V

*Eleocharis palustris*

- + + V

Companions

* Cirrhium ceticum*

- r III

*Cynodon dactylon*

- 3 + III

* Xanthium strumarium*

- r V

*Equisetum arvense* 2b, *Festuca arundinacea*, *Hypericum* sp. + in 1; *Rumex pulcher* 1 in 4.

Localities: datum ETRS89 (see Figure 1). 1: 20.946547, 39.613976; 2: 20.927308, 39.664128; 3: 20.879094, 39.641077; 4: 20.879094, 39.641077; 5: 20.871453, 39.556554; 6: 20.851863, 39.690026.

**Molinio-Arrhenatheretea**

Habitat type of national interest: 72B0 “Rush meadows”

Rush meadow vegetation dominated by *Juncus inflexus* and *Juncus effusus* develops sporadically behind the reed bed zone of Lake Pamvotis on soils waterlogged.
for less than half of the year. Penas et al. (2017) mention that *Juncus inflexus*, *Juncus effusus* and *Mentha aquatica* are among the characteristic species of the *Mentho longifoliae-Juncion inflexi* alliance assigned to the order *Filipendulo ulmariae-Lotetalia uliginosi*. Several types of wet grasslands occur within the Natura 2000 network of Greece (Kakouros et al., 2013). Among them, the rush meadows are considered as a habitat type of national interest (habitat type 72B0). We think that the *Juncus inflexus-Juncus effusus* community, which is reported here for the first time from Epirus (Table 8, rel. 1–4), belongs to this habitat type. Wet meadow communities reported from Greece (e.g. Karagianni et al., 2008; Grigoriadis et al., 2009) are often assigned to the habitat type 6420 (“Mediterranean tall humid grasslands of the *Molinio-Holoschoenion*”) of Annex I of the EU Habitats Directive. However, in our case, such a correlation could not be justified as both the floristic composition of the investigated relevés and the local environmental conditions (freshwater-fed meadows) do not refer to the *Molinio-Holoschoenion*. On the contrary, most of the species evaluated as diagnostic of *Juncus inflexus-Juncus effusus* community within the framework of the present study are included among the indicator species of the EUNIS habitat type R36, [E34b] “moist or wet mesotrophic to eutrophic pasture”, with which the alliance *Mentho longifoliae-Juncion inflexi* is associated.

**Habitat types: classification system and pressures affecting the conservation status**

Both the EUNIS indicator species found in the study area and the crosswalk between the recognized alliances of the EuroVegChecklist and the EUNIS habitat types allowed the interpretation and classification of the habitat types. Twelve alliances were assigned to eleven of the EUNIS habitat types, eight of which are related to habitats of Annex I (Habitats Directive 92/43/EEC) and three to habitats of national (Greece) interest (Table 1).

Following the distribution categories, responsibility criteria and threats of the Natura 2000 habitats of Greece proposed by Dimopoulos et al. (2006), six of the recorded habitat types (4090, 5210, 8210, 934A, 92A0, 92C0) are of high and two (72A0, 8140) of medium monitoring importance. Only one habitat type (3150) has a scattered distribution in Greece, while the rest are widespread or abundant. The conservation status assessment of the habitat types revealed that three (4090, 8210, 91M0) of the recorded habitat types are in favourable (FV) conservation status, seven (8140, 934A, 92A0, 92C0, 3150, 72A0, 72B0) are in unfavourable-inadequate (U1) conservation status, and only one (5210) is in unfavourable-bad (U2) conservation status (Figure 3). The main pressures and threats affecting the conservation status of the identified habitats are discussed below:

1. **Pressures and threats affecting the habitats with favourable (FV) conservation status**

Partial habitat loss is the most common threat both for the chasmophytic vegetation (8210) and the deciduous oak forests (91M0). Gerasimidis et al. (2009) note that human inhabitation and pastoral activities were the most crucial interferences which caused the substitution of deciduous oak forests that once thrived in low and middle elevations of the study area by shrublands. The oro-mediterranean heaths with gorse (4090) are most threatened through the lack of interventions such as grazing, fire, and logging, disturbances, which according to Janssen et al. (2016), favour the dominance of this habitat type against forest ones.

2. **Pressures and threats affecting the habitats with unfavourable-inadequate (U1) conservation status**

Intense grazing, land-use change, habitat fragmentation, water regime alterations, urbanization and eutrophication were assessed as the most frequent pres-
sures that threaten the respective habitats. For the montane limestone scree vegetation (8140) and the Quercus coccifera woods (934A) grazing, land-use change and habitat fragmentation seem to be of utmost importance.

Drainage practices (water drilling, streamflow regulation, etc.) highly disturb and degrade the oriental plane woods (92C0) and the willow low open galleries (92A0). Infection by the invasive fungal species Ceratocystis platanii, usually leads to the death of the infected plane trees (Ocasio-Morales et al., 2007). Several long-lasting anthropogenic interferences (Sarika-Hatzinikolaou, 1999; Stephanides & Papastergiadou, 2007) reduce dramatically the submerged macrophyte vegetation (3150) of the study area. According to Stephanides & Papastergiadou (2007), the direct restocking of Lake Pamvotis with benthivorous (Cyprinus carpio) and herbivorous (Ctenopharyngodon idella) carp, as well as the high eutrophication levels, were the most decisive factors for the massive reduction of submerged vegetation during the last thirty years. This view is also adopted here. The significant degradation observed in some of the investigated reed bed stands (72A0) can be mainly attributed to the eutrophication effects and, to a lesser extent, to various management practices applied for several purposes. Eutrophication damages reed beds (De Nie, 1987), and it is well documented that in Lake Pamvotis, nutrients are still sufficiently high to maintain eutrophic conditions (Alexakis et al., 2013). The rush meadows (72B0) that exist in few localities along the lake shores and in surrounding wet microenvironments are remnants of this formerly widespread vegetation type. Land-use changes and hydromorphologic alterations are crucial for the loss of waterlogged meadows in the Ioannina basin region (Alexakis et al., 2013).

3. Pressures and threats affecting the habitat with unfavourable-bad (U2) conservation status.

The arboreal matorral with Juniperus oxycedrus subsp. deltoides were assessed as U2, mainly due to grazing, land-use change, and habitat fragmentation. It is presumed that this vegetation type is in a state of recovery since vigorous regeneration is observed, as a result the decreasing grazing intensity. As stated before, these stands are often the result of degradation of broad-leaved evergreen or thermophilous deciduous forests, and we assume that due to the decrease of grazing pressure, the stands have gained in size and in the long term the return of thermophilous forests cannot be ruled out. It would be interesting to reassess this habitat type in a few years, having the current results as a reference.

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Supplementary Material

Table S1. Correspondence of the habitat types found in the study area with the MAES ecosystem categories and types.

Table S2. The names and the codes of the EUNIS and Natura 2000 Habitat types.