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National Park and UNESCO Global Geopark of Chelmos-Vouraikos (Greece): Floristic Diversity, Ecosystem Services and Management Implications

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Abstract: This study highlights the importance of including detailed (local-scale) biodiversity and ecosystem services data for land-use management and promotion of protected areas using the National Park and UNESCO Global Geopark of Chelmos-Vouraikos (Greece) as a case study. Along with the conducted field surveys and literature review for the National Park's flora documentation, ecosystem type mapping and assessment of ecosystem services have been performed, following National and European Union (EU) guidelines for the Mapping and Assessment of Ecosystems and their Services (MAES) implementation across EU Member States. Main results include floristic diversity indicators, ecosystem type mapping and assessment, and ecosystem services identification and assessment of their actual and potential supply. By this, a scientifically informed baseline dataset was developed to support management and policy needs towards a holistic National Park management and a sustainable spatial planning for protected areas. Additionally, local scale ecosystem type and ecosystem services data have been produced as input for the MAES implementation in Greece and the EU.

Keywords: Greek flora; MAES; LIFE-IP 4 NATURA; land use policy; protected area; spatial planning; sustainable development

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1. Introduction

National parks are well-established schemes for biodiversity, landscape, and cultural heritage protection [1]. Dating back to the establishment of the Yellowstone Park (USA) in 1872 that triggered worldwide interest in protected area designation for nature conservation, numerous efforts have been made globally to include areas of importance under a protection scheme (see [2]). According to the International Union for Conservation of Nature (IUCN) and its World Commission on Protected Areas (WCPA), more than 102,000 sites worldwide are declared as protected areas, including more than 3800 national parks [2]. However, national parks have been established to protect different aspects of biodiversity and their conservation and management targets, and the subsequent actions to reach them are especially variable. As a result, significant differences are found among countries mainly in their functional operations and their legislative frameworks, usually due to different political, economic, and social systems [1] as well as to different approaches regarding the conservation objectives (e.g., wilderness areas, sociocultural importance, inclusion of archaeological sites, etc.).

In the European Union (EU), the European Environment Agency (EEA) defines national parks as areas of outstanding natural beauty, designated for flora, fauna, and scenery

conservation as well as for recreation purposes when and where this does not conflict with the park's conservation objectives; other activities are all controlled within the parks' limits [3]. At least the core areas for conservation efforts of EU National Parks are also included in the Natura 2000 ecological network, while most of the national parks are members of the EUROPARC Federation network that aims to achieve conservation goals through international cooperation and as well as via communicating each protected areas needs to policy makers [4]. Moreover, several national parks in the EU are also designated as UNESCO Global Geoparks since they include landscapes of international geological significance and geodiversity [5,6]. Furthermore, they provide a major effort to protect endangered and threatened species, which are considered as essential providers of ecosystem services [7]. However, this constitutional protected area/National Park target implies that detailed scientific data of biodiversity are needed for a comprehensive assessment of the effectiveness and the proper management of the national parks [8].

Greece, one of the most biodiverse countries in the EU, belonging to the Mediterranean biodiversity hotspot [9], has declared 17 areas as national parks (according to the classifications provided in the Law 1650/1986 [10]), for the protection of wild flora and fauna, natural ecosystems, as well as for their cultural elements. However, extensive studies and reference catalogues of the national parks' flora and fauna and their attributes are missing, and thus degrading the potential for visitors and scientists to explore the parks at their best and biasing land-use management practices and decision making.

Using the Chelmos-Vouraikos National Park and UNESCO Global Geopark of Chelmos-Vouraikos (CVNP) as a case-study, which is rendered as a floristic diversity and endemism hotspot for Greece [11], this study aims to provide a baseline integrated assessment based on detailed floristic data to support decision making on conservation management and spatial planning efforts for the CVNP area. Simultaneously, and as too little is known about the state of the natural environment and the contribution it makes to human wellbeing (i.e., ecosystem capacity to provide services that societies depend on), this study aims to support national and EU actions for Mapping and Assessment of Ecosystems and their Services (MAES) [12], based on the National and EU Biodiversity strategy and the EU Green Deal relevant goals [12,13]. More precisely, the study goals are: (a) to provide detailed information on CVNP flora attributes (chorology, lifeform, and habitats/ecosystem types) and by this assess CVNP importance; (b) to identify plant species richness and endemism hotspots within the CVNP; (c) to identify and spatially designate ecosystem types' diversity at local scale; (d) to connect floristic diversity attributes and importance with ecosystem condition and relevant ecosystem services; (e) to provide input for the national set of MAES indicators of Greece, with emphasis on national park conditions (local scale assessment) under the LIFE-IP 4 NATURA project; and (f) to provide input for conservation strategies and policy decisions for national park integrated management at local, regional, and international levels.

2. Materials and Methods

The study's general methodological concept is based on the relation among the detailed knowledge of biodiversity attributes in terms of plant species and ecosystem types and their correspondence to the national efforts for the MAES implementation in Greece [14–17]. It is in line with the requirements of indicator development under the National Set of MAES Indicators in Greece [17], corresponding to a local-scale assessment for the CVNP flora and ecosystem types and provides spatially informed data via thematic mapping to support decision and policy making. More precisely, the current study deals with: (a) the floristic diversity indicator (IB2) and its subcategory of endemic diversity (see also [18,19]); (b) the ecosystem types' diversity and extent, a proposed indicator as a subcategory of total biodiversity indicator (IB5); (c) ecosystem condition; and (d) current and potential ecosystem services supply.

2.1. Study Area

The study area (CVNP) is located in northern Peloponnisos and is designated as the Protected Area of "Chelmos-Vouraikos National Park" and "UNESCO Global Geopark" covering an area of about 655 km^2 (Figure 1). Mt. Chelmos is the main mountain massif of the area and one of the greatest in the Peloponnisos, with five main peaks above 2000 m (highest at 2355 m). Major rivers of the area, i.e., Aroanios, Krathis, and Vouraikos, accompanied by numerous streams, provide a multifarious and complex relief. The protected area of Chelmos-Vouraikos National Park is classified as a "National Park" taking into consideration (a) the "IUCN Guidelines for Applying Protected Area Management Categories" and (b) the legal framework for conservation management of the Chelmos-Vouraikos National Park pertaining to four Natura 2000 sites (IUCN Management Category II) [7].

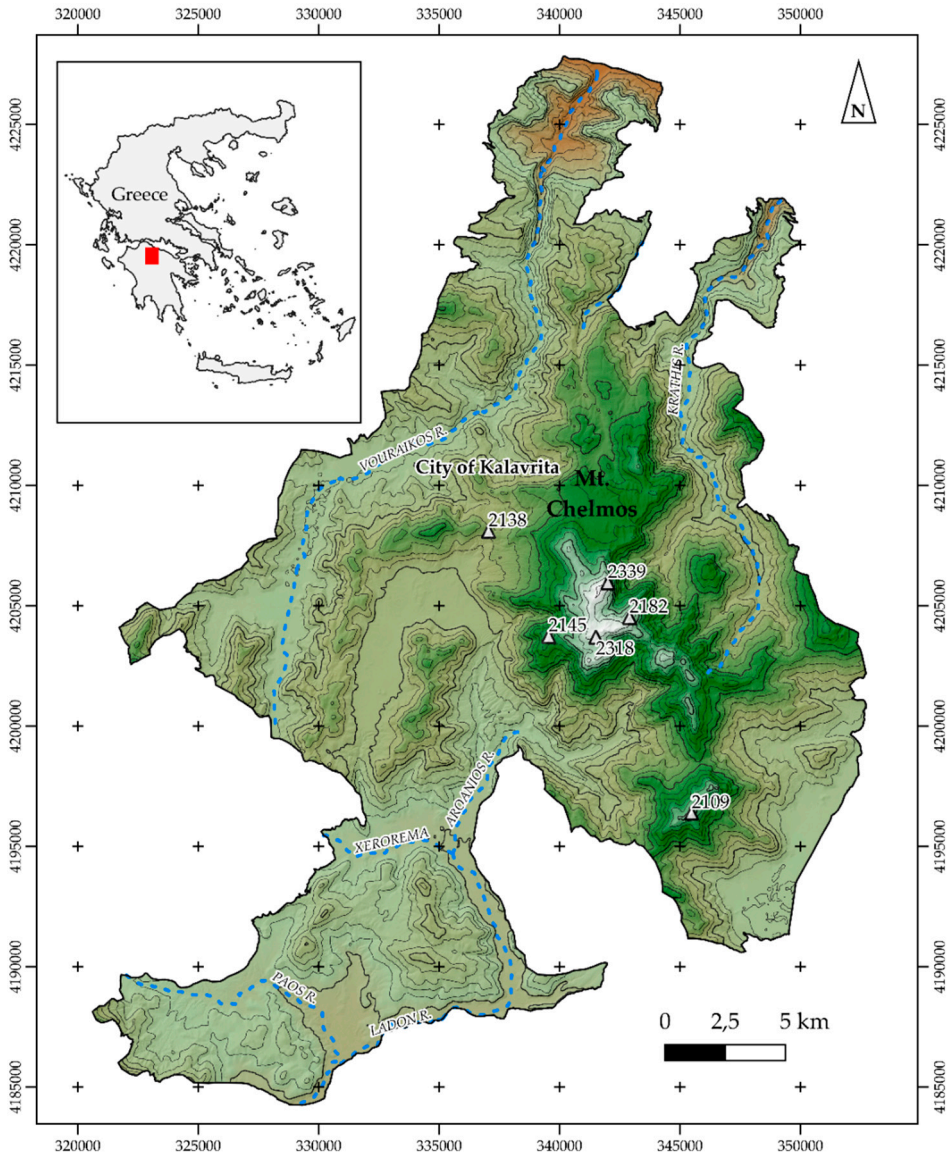

Figure 1. Map of the study area depicting the largest city of the area (Kalavrita), major rivers, and mountain peaks above 2000 m. Contours correspond to 100 m intervals; contours with thicker lines correspond to 500 m intervals.

2.2. Floristic Diversity

Floristic data were derived from the recent review work (including accessible specimens and new additions) by Tsakiri et al. [20] that included several collection and field

observation trips throughout the area of CVNP, from June 2012 until June 2017, to acquire a comprehensive knowledge of the national parks' native flora and its spatial distribution. The nomenclature, authors' citation, endemism, and range-restricted status and chorological categories followed Dimopoulos et al. [21,22]. For the habitat analysis of the vascular flora of CVNP, seven groups (categories) of habitats were distinguished, according to Dimopoulos et al. [21]. Life forms followed [22–24]. Family delimitation followed APG IV [25]. The status of the alien taxa occurring in the study area followed Dimopoulos et al. [26]; however, alien taxa are not included in the analysis since their recordings are considered scattered and non-exhaustive and may lead to important bias. Protection status under the Presidential Decree 67/81 and inclusion in IUCN extinction risk categories were obtained from the continuously updated "Flora of Greece Web" online database [23]. All taxa were checked for their inclusion in the Annex II of Dir. 92/43/EE, the CITES and Bern Convention Annexes [27–29]. Data regarding taxa's altitudinal distribution were derived from the field surveys with the support of the CVNP Management Body and from literature resources (i.e., [30–35]). To examine the altitudinal distribution of the endemic taxa and thus create a subcategory of the endemic diversity indicator, the elevational range of the study area (20–2355 m) was divided into five altitudinal intervals (one per 500 m); thus, the endemic species richness was calculated within each 500 m interval. For taxa with apparent gaps in their known elevational distribution, we used interpolation under the assumption that each species is distributed continuously between its recorded upper and lower limits. Thematic maps of biodiversity hotspots, i.e., for the total species richness and endemic diversity, were drafted using the QGIS platform [36].

2.3. Mapping and Assessment of Ecosystems and Their Services in CVNP

Ecosystem types were delineated and mapped at the MAES level 3 for Greece, following Kokkoris et al. [17] and Verde et al. [37] using: (a) the available data of habitat types for the Special Areas for Conservation (SACs) of the Natura 2000 Network [38]; (b) vegetation mapping data from the Special Environmental Study of the CVNP [39]; (c) photo interpretation of areas' satellite imagery [40,41]; and (d) field sampling data derived from the MAES_GR online platform [42]. The diversity of ecosystem types is also calculated on the basis of different ecosystem types (MAES level 3) present at each 1 × 1 km EEA reference grid cell [43], for the CVNP area; centroids of these cells including the diversity information (i.e., number of different ecosystem types per cell) are exported and used to create the relevant heatmap. All GIS-related procedures, thematic mapping (1:20000 scale), and representation were conducted using the QGIS platform [36].

Ecosystem condition assessment follows Maes et al. [13] and Kokkoris et al. [17] and was conducted through 228 field survey plots using the relevant MAES_GR online platform [42] for the different MAES level 3 ecosystem types.

Field-based identification and assessment of ecosystem services provided by the national park's ecosystem types (MAES level 2) follow Kokkoris et al. [17] and are classified using the Common International Classification of Ecosystem Services (CICES) [44,45] at the section and class level. Field assessment was held by using the MAES_GR online platform [42].

3. Results

3.1. Floristic Diversity Indicators

3.1.1. Species Richness Indicators

The total species richness indicator for the CVNP comprises the native vascular flora of the CVNP that includes 1467 taxa (Table S1 of the Supplement), belonging to 549 genera and 116 families (species richness indicators for the CVNP at the genus and family level) (Table S2 of the Supplement). Eleven alien taxa were recorded, but have not been included in the floristic analysis. The richest families of the CVNP's native flora are *Asteraceae, Fabaceae*, *Poaceae*, and *Caryophyllaceae*, including more than the one third of the CVNP total native flora (~33.95%). The most taxa-rich genera are *Trifolium*, *Silene*,

and *Allium* (Table S2 of the Supplement). Regarding life-form species richness (Table S3 of the Supplement), hemicryptophytes (~41.24%) predominate, followed by therophytes, geophytes, phanerophytes, chamaephytes, and finally, aquatics. According to the general distribution of the taxa, the native plants of the study area belong to 19 main chorological categories arranged under four wider chorological groups (Table S3 of the Supplement). The Mediterranean chorological group predominates (42.13%). Both within this group and among all the chorological categories, the Mediterranean element is dominant (21.47%). The European–SW Asia element follows with 15.61% and Greek endemic taxa with 12.07%. The other chorological categories are represented with lower percentages.

3.1.2. Spatial Distribution of Total Species Richness

The spatial distribution of the floristic records revealed that the main diversity hotspots occur at the high altitude areas of Mt. Chelmos, as well as at the middle part of the Vouraikos river gorge; secondary hotspots are scattered in the CVNP area (Figure 2).

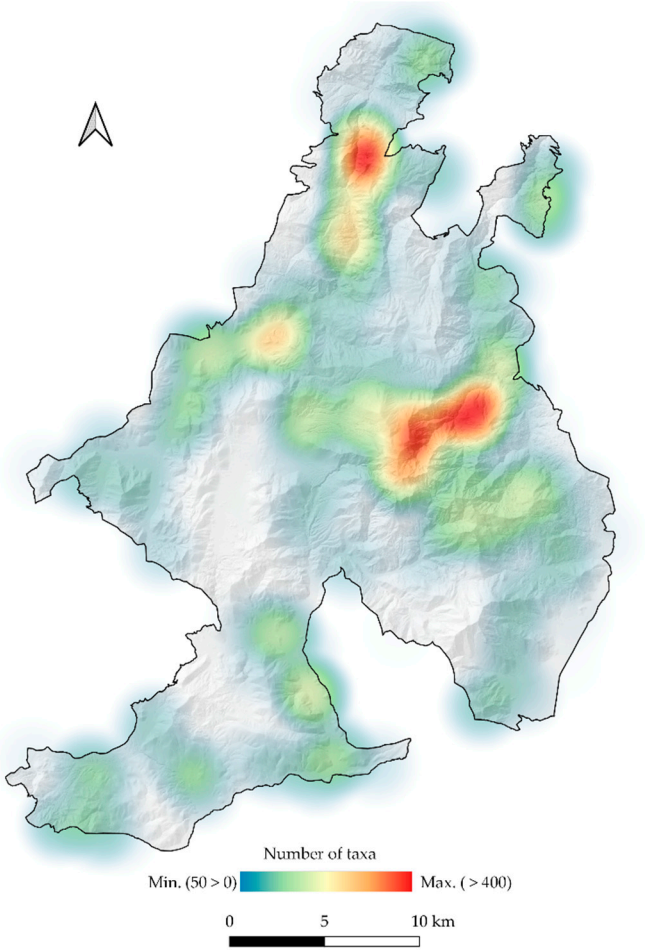

Figure 2. Floristic diversity hotspots in the CVNP area.

3.1.3. Endemic Diversity and Spatial Distribution

The vascular flora of the area consists of 177 Greek endemic taxa (12.07% of the native flora). The endemic species belong to 40 families and 101 genera. The most taxon-rich family of the endemic flora is Asteraceae (28 taxa) followed by *Caryophyllaceae* (20 taxa), *Lamiaceae* (13 taxa), *Apiaceae* (11 taxa), and *Brassicaceae* (11 taxa). The richest genera in endemic taxa are *Hieracium* (9 taxa), *Alkanna*, and *Verbascum* (with 5 taxa, respectively), followed by *Allium*, *Asperula*, *Campanula*, *Centaurea*, *Dianthus*, *Erysimum*, *Galium*, *Silene*, *Veronica*, and *Viola* (with 4 taxa, respectively). Among the endemic taxa, hemicryptophytes

are dominant (111 taxa, 62.71%) followed by chamaephytes (12.99%), geophytes (12.43%), therophytes, and finally, phanerophytes. Among the 177 Greek endemic taxa, 41 (~23.16%) taxa are endemic to the Peloponnisos.

The importance of endemism in the study area is pointed out by the presence of five local endemic taxa; one of these, *Silene conglomeratica* Melzh, is a local endemic of the Vouraikos river gorge, while *Alchemilla aroanica* (Buser) Rothm., *Lonicera alpigena* subsp. *hellenica* (Boiss.) Kit Tan & Ziel., *Polygala subuniflora* Boiss. & Heldr., and *Valeriana crinii* Boiss. subsp. *crinii* are local endemic taxa of Mt. Chelmos.

The spatial distribution of the endemic taxa revealed that their highest concentration is located at the main peaks of Mt. Chelmos; secondary endemic diversity hotspots are also present mainly at the NE areas of Mt. Chelmos, as well as along the Vouraikos river gorge (Figure 3).

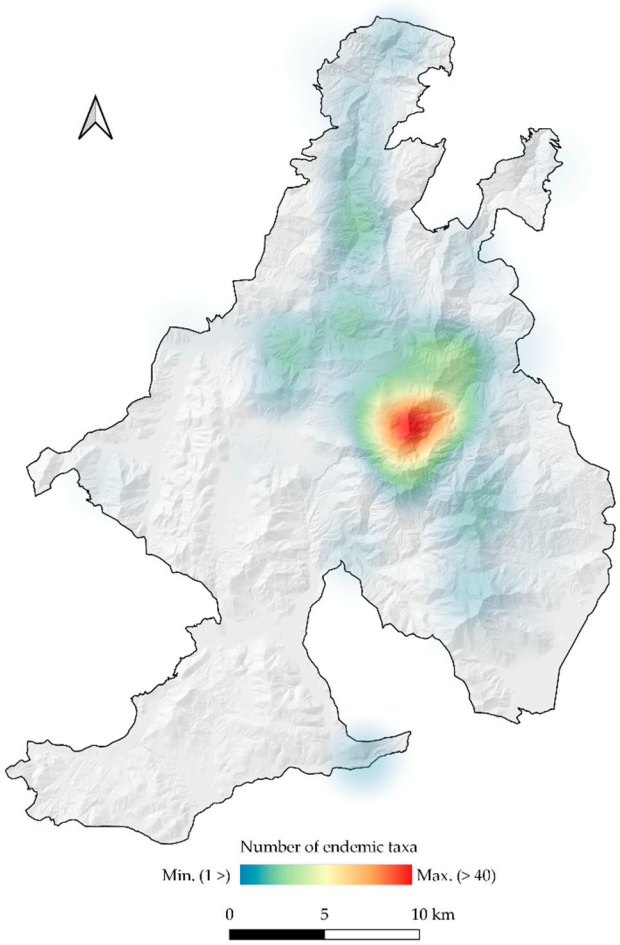

Figure 3. Endemic diversity hotspots in the CVNP area.

3.1.4. Altitudinal Diversity of Greek Endemic Taxa

Endemic species richness is highest at middle to high altitudes, with the maximum number of endemic taxa occurring in the upper forest zone, between 1500–2000 m. Moreover, a large number of endemic taxa occur between 1000–1500 m, while a reduced number is observed in the lower and the highest intervals (Figure 4).

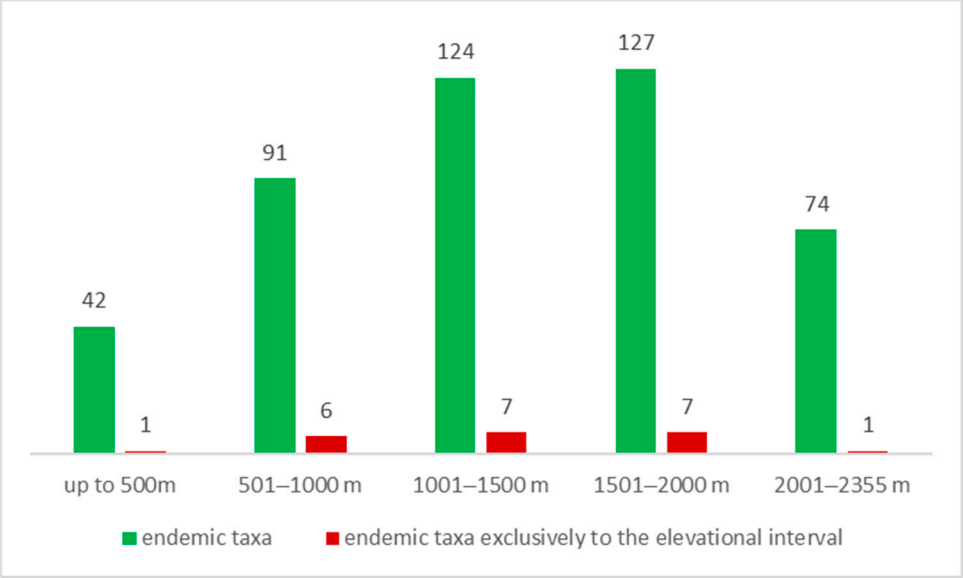

Figure 4. Altitudinal distribution of CVNP's Greek endemic taxa into five 500 m elevational intervals.

It is worth mentioning that: (a) *Centaurea raphanina* Sm. subsp. *mixta* (DC.) Runemark. *Cirsium hypopsilum* Boiss. & Heldr. and *Veronica glauca* subsp. *peloponnesiaca* (Boiss. & Orph.) Maire & Petitm are Greek endemic taxa occurring in a wide altitudinal range; (b) seven taxa occur only at the elevation interval from 1501 to 2000 m (e.g., *Alchemilla aroanica* (Buser) Rothm., *Corydalis blanda* subsp. *oxelmannii* Lidén, *Lonicera alpigena* subsp. *hellenica* (Boiss.) Kit Tan & Ziel.); (c) seven taxa occur only at the elevation interval from 1001 to 1500 m (e.g., *Alkanna calliensis* Boiss., *Centaurea athoa* subsp. *chelmea* Kit Tan, Zarkos, V. Christodoulou & G. Vold, *Hieracium sermenikense* Freyn & Sint.); (d) six taxa occur only at the elevation interval 501–1000 m, including the local endemic *Silene conglomeratica* Melzh (Figure 5); and finally, (e) *Teucrium halacsyanum* Heldr.is the only Greek endemic restricted to the elevation interval up to 500 m.

Figure 5. Silene conglomeratica Melzh., a local endemic taxon of the Vouraikos river gorge.

3.1.5. Distribution of the CVNP's Greek Endemics in the Floristic Regions of Greece

The distribution analysis among the floristic regions of Greece revealed that 71.75% of the 177 Greek endemic taxa of the study area are common with Sterea Ellas (127 taxa) (Table 1). West Aegean Islands follow with 28.81% (51 common endemic taxa) and South Pindos with 25.99% (46 taxa). The weakest relationship is between the study area and North Aegean Islands (2.5%; 4 taxa). A total of 38 Greek endemic taxa (18.9%) occur only in

Peloponnisos and Sterea Ellas. Three taxa occur only in Peloponnisos and Kriti-Karpathos. Two taxa occur only in Peloponnisos and the Ionian Islands.

Table 1. Distribution of Greek endemic taxa of CVNP in floristic regions of Greece.

Floristic Regions	Number of Endemic Taxa Per Floristic Region	Common Taxa only among Peloponnisos and Other Floristic Regions
East Aegean Islands (**EAe**)	11	
East Central (EC)	31	
Ionian Islands (IoI)	26	2
Kiklades (Kik)	13	
Kriti and Karpathos (KK)	15	3
North Aegean Islands (NAe)	6	
North Central (NC)	29	
Northern Pindos (NPi)	31	2
North East (NE)	16	
Peloponnisos (Pe)	177	177
Southern Pindos (SPi)	46	
Sterea Ellas (StE)	127	38
West Aegean Islands (WAe)	51	1

3.1.6. Distribution of CVNP Native Flora and Endemics among Habitats and Ecosystem Types

For the habitat analysis of the vascular flora of CVNP, seven groups (categories) of habitats were distinguished, according to Dimopoulos et al. [22] (Table 2). The analysis of the habitat preference corresponds to species presence in one or more habitat categories. From the total 1467 plant taxa, the analysis revealed that the temperate and sub-Mediterranean grasslands comprise the most species rich habitat with 31.77%, followed by agricultural and ruderal habitats, as well as woodlands and scrubs (Table 2). Regarding the MAES level 2 ecosystem types preference, heathlands and shrubs and grasslands host most taxa of the total flora, followed by cropland and woodland and forest MAES ecosystem types.

Focusing on Greek endemic taxa, the analysis revealed that plants of high mountain vegetation prevail, followed by temperate and sub-Mediterranean grasslands (Table 2). Regarding the habitat preferences of the Peloponnesian endemics, taxa which are found on habitats of cliffs, rocks, walls, ravines, and boulders prevail, followed by taxa of high mountain vegetation. Other habitat categories are represented in minor proportions. The local endemic *Alchemilla aroanica* occurs in aquatic habitats and rocky places.

Regarding the MAES level 2 ecosystem types, heathlands and shrubs and grasslands host most taxa of the total flora, followed by cropland MAES ecosystem type. For the Greek endemic flora and the Peloponnesian endemics, heathland and shrubs and grasslands prevail followed by the sparsely vegetated land (MAES typology).

The analysis of taxa exclusively present at each habitat category (Table 3) revealed that among 1467 taxa, 783 taxa (53.37%) are exclusively present at one habitat category. The plants of agricultural and ruderal habitats prevail with 14.31%, followed by plants of woodlands and scrubs, 10.57%, and high mountain vegetation, 6.82%. A total of 6.75% is found exclusively in temperate and sub-Mediterranean grasslands, 6.20% in xeric Mediterranean phrygana and grasslands, 5.66% in freshwater habitats, and 3.07% is found exclusively on cliffs, rocks, walls, ravines, and boulders.

Table 2. Distribution of CVNP's total Greek endemic and Peloponnesian endemic plant taxa into habitat categories [22]. Left column includes the correspondence to the MAES level 2 ecosystem types [13].

MAES Level 2	Habitat Categories following Dimopoulos et al. [22]	Habitat Abbreviation	Total Taxa (% of 1467 Taxa)	Greek Endemic Taxa (% of 177 Greek Endemics)	Peloponnesian Endemic Taxa (% of 41 Peloponnesian Endemics)
Rivers and lakes	Freshwater habitats	A	159 taxa (10.84%)	1 taxon (0.56%)	1 taxon (2.44%)
Sparsely vegetated land	Cliffs, rocks, walls, ravines, boulders	C	146 taxa (9.95%)	46 taxa (25.99%)	15 taxa (36.59%)
Grasslands	Temperate and sub-Mediterranean grasslands	G	466 taxa (31.77%)	58 taxa (32.77%)	11 taxa (26.83%)
Heathland and shrub/Grasslands	High mountain vegetation	H	326 taxa (22.22%)	75 taxa (42.37%)	14 taxa (34.15%)
Heathland and shrub/Grasslands	Xeric Mediterranean Phrygana and grasslands	P	351 taxa (23.93%)	36 taxa (20.34%)	3 taxa (7.32%)
Cropland	Agricultural and ruderal habitats	R	448 taxa (30.54%)	15 taxa (8.47%)	0 taxa (0.00%)
Woodland and forests	Woodlands and scrub	W	356 taxa (24.27%)	28 taxa (15.82%)	6 taxa (14.63%)

Table 3. Distribution of CVNP's total Greek endemic and Peloponnesian endemic plant taxa exclusively present at each habitat category [22]. Left column includes the correspondence to the MAES level 2 ecosystem types.

MAES Level 2	Habitat Categories following Dimopoulos et al. [22]	Habitat Abbreviation	Total Taxa (% of 1467 Taxa)	Greek Endemic Taxa (% of 177 Greek Endemics)	Peloponnesian Endemic Taxa (% of 41 Peloponnesian Endemics)
Rivers and lakes	Freshwater habitats	A	83 taxa (5.66%)	0 taxa (0.00%)	0 taxa (0.00%)
Sparsely vegetated land	Cliffs, rocks, walls, ravines, and boulders	C	45 taxa (3.07%)	19 taxa (10.73%)	11 taxa (26.83%)
Grasslands	Temperate and sub-Mediterranean Grasslands	G	99 taxa (6.75%)	22 taxa (12.43%)	6 taxa (14.63%)
Heathland and shrub/Grasslands	High mountain Vegetation	H	100 taxa (6.82%)	34 taxa (19.21%)	11 taxa (26.83%)
Heathland and shrub/Grasslands	Xeric Mediterranean Phrygana and grasslands	P	91 taxa (6.20%)	10 taxa (5.65%)	2 taxa (4.88%)
Cropland	Agricultural and ruderal habitats	R	210 taxa (14.31%)	5 taxa (2.82%)	0 taxa (0.00%)
Woodland and forests	Woodlands and scrub	W	155 taxa (10.57%)	9 taxa (5.08%)	3 taxa (7.32%)

Especially for endemic taxa, 99 taxa (53.93%) are exclusively present at one habitat category. As for the analysis of endemic plant taxa with multiple habitats, the predominant habitat category is the high mountain vegetation with 19.21%, followed by temperate and

sub-Mediterranean grasslands (12.43%) and cliffs, rocks, walls, and ravines with 10.73%. A total of 5.65% exclusively occurs in xeric Mediterranean phrygana and grasslands, a total of 5.08% exclusively occurs in woodlands and scrubs, and 2.82% occurs in agricultural and ruderal habitats. Finally, none of the taxa exclusively occurs in freshwater habitats. Regarding the habitat preference of Peloponnesian endemics, 33 taxa (80.49%) are exclusively present at one habitat category. An equal percentage of taxa (26.83%) occurs both on cliffs, rocks, walls, ravines, boulders, and in high mountain vegetation, and the other habitat categories are presented in lower proportions. Finally, no Peloponnesian endemic taxa exclusively occur in freshwater habitats and also in agricultural and ruderal habitats

Among the local endemics, *Silene conglomeratica* and *Valeriana crinii* subsp. *crinii* are found exclusively in habitats associated with cliffs, while *Polygala subuniflora* occurs exclusively in rocky substrates in high mountain vegetation and *Lonicera alpigena* subsp. *hellenica* is found only in rocky substrates of habitats with woodlands and scrubs.

Regarding the MAES level 2 ecosystem types of taxa exclusively present at each habitat category, they coincide with the analysis of taxa with multiple habitats. More specifically, heathland and shrubs and grasslands exclusively host most taxa of the total flora (19.77%), followed by Cropland MAES ecosystem type with 14.31%. For the Greek endemic flora and the Peloponnesian endemics, heathland and shrubs and grasslands prevail as exclusive habitats with percentages 37.29% and 46.34%, respectively, followed by sparsely vegetated land MAES ecosystem type with percentages 10.73% and 26.83%, respectively.

3.1.7. Range Restricted Taxa

CVNP hosts 196 range-restricted taxa, which constitute the 13.10% of the total native flora (1467 taxa) of the study area. Among them, a total of 159 range-restricted taxa (81.12%) are Greek endemic and constitute the 89.83% of the total Greek endemic flora of the study area, including 40 Peloponnesian endemic taxa. A total of 34 range-restricted taxa (17.35%) are Balkan elements (including 33 Balkan taxa and one Balkan–Anatolian taxon) and three range-restricted taxa are East Mediterranean elements. The rank of habitat preference of range-restricted taxa coincides with the rank of endemic taxa. More precisely, high mountain vegetation and temperate and sub-Mediterranean grasslands prevail, with 30.85% and 23.39% respectively, followed by habitats of cliffs, rocks, walls, ravines, and boulders with 17.97%, xeric Mediterranean phrygana and grasslands with 11.53%, woodlands and scrubs with 9.49%, agricultural and ruderal habitats with 6.44%, and finally, only 0.34% of range-restricted taxa occurs in freshwater habitats.

3.1.8. Protection Status and Extinction Risk Status

Totally, 147 taxa of the native flora are classified under protection status or/and are included in threat categories (Table 4). More precisely, 129 taxa are protected by the Greek Presidential Decree 67/1981 [46], and among them 49 taxa are Greek endemics. Forty one (41) taxa are included in the CITES Convention [28] and among them, five taxa are Greek endemic, including the Peloponnesian endemic *Epipactis halacsyi* Robatsch. Furthermore, the Peloponnesian endemic *Globularia stygia* Boiss. and the Balkan *Viola delphinantha* Boiss. are included in the Annex II of Dir. 92/43/EE [27]. Furthermore, the Greek endemic *Campanula asperuloides* (Boiss. & Orph.) Engl. and *Erodium chrysanthum* L'Hér. as well as the Balkan *Fritillaria graeca* Boiss. & Spruner and *Pinguicula crystallina* subsp. *hirtiflora* (Ten.) Strid are protected by Bern Convention [29]. Regarding the total flora, 17 taxa have been classified under an IUCN's threat category [47] including 12 Greek endemic taxa. The Greek endemics *Cicer graecum* Boiss. Orph. ex Boiss. and *Draba laconica* Stevanović & Kit Tan, as well as the Mediterranean *Phelipanche gussoneana* (Lojac.) Domina, Raab-Straube, and Rätzel & Ulrich have been classified as endangered. Six Greek endemic taxa, which are *Anacamptis boryi* (Rchb. f.) R.M. Bateman & al., *Beta nana* Boiss. & Heldr., *Campanula aizoides* Greuter, *Campanula asperuloides* (Boiss. & Orph.) Engl., *Cruciata taurica* subsp. *euboea* (Ehrend.) Ehrend., *Globularia stygia* Boiss., as well as Leucojum aestivum L. have been classified as vulnerable. The Greek endemic taxa *Colchicum peloponnesiacum* Rech.

f. & P.H. Davis, *Gymnospermium peloponnesiacum* (Phitos) Strid, *Teucrium aroanium* Boiss., *Thymus hartvigii* R. Morales subsp. *hartvigii*, the Mediterranean *Juniperus turbinata* Guss. and *Vicia laeta* Ces., as well as the Balkan *Viola delphinantha* Boiss. have been classified as near threatened.

Table 4. Protection Status and threat categories of CVNP's vascular plants.

Protection and Threat Categories	Greek Endemic Taxa	Total Taxa
Protection status		
CITES	5	41
Bern Convention	2	4
Hellenic Official Government Gazette	49	129
Council Directive 92/43/EEC	1	3
Threat categories		
Endangered	2	3
Vulnerable	6	7

3.2. Mapping and Assessment of Ecosystems and Their Services in CVNP

The mapping procedure identified 18 different ecosystem types at the MAES level 3 [17,37] corresponding to eight MAES level 2 ecosystem types (Figure 6 and Table 5). Woodland and forest dominate, covering 53.55% of the CVNP area; temperate mountainous coniferous forests prevail, followed by Mediterranean sclerophyllous forests. Cropland covers more than a quarter of the CVNP area (29.28%), corresponding to permanent crops (26.17%) and arable land (3.11%). All other ecosystem types follow with lower cover.

Table 5. Ecosystem types area cover and their percentage with respect to CVNP area.

MAES Level 2 Ecosystem Type	MAES Level 3 Ecosystem Type	Area (km^2)	% of CVNP Total Area
Urban	Dense to medium urban fabric (I.M.D. 30–100%)	1.58	0.24%
	Low density urban fabric (I.M.D. 0–30%)	3.56	0.54%
Cropland	Arable land	20.39	3.11%
	Permanent crops	171.43	26.17%
Grassland	Natural grasslands prevailingly without woody species scrubs (W.C.D. < 30%)	0.04	0.01%
Woodland and forest	Mediterranean deciduous forests	15.07	2.30%
	Floodplain forests (riparian forest/fluvial forest)	4.76	0.73%
	Temperate mountainous coniferous forests	189.12	28.87%
	Mediterranean coniferous forests	24.77	3.78%
	Mediterranean sclerophyllous forests	110.19	16.82%
	Mixed forest	6.67	1.02%
	Afforestation	0.19	0.03%
Heathland and shrub	Moors and heathland	42.42	6.48%
	Sclerophyllous vegetation	57.12	8.72%
Sparsely vegetated land	Sparsely vegetated areas	5.47	0.83%
	Bare rocks, burnt areas, mines, dumps, and land without current use	0.31	0.05%
Wetland	Inland freshwater and saline marshes	1.28	0.20%
Rivers and lakes	Rivers and lakes	0.14	0.02%
	Railroad	0.07	0.01%
	Road	0.52	0.08%
	Total	655.09	100.00%

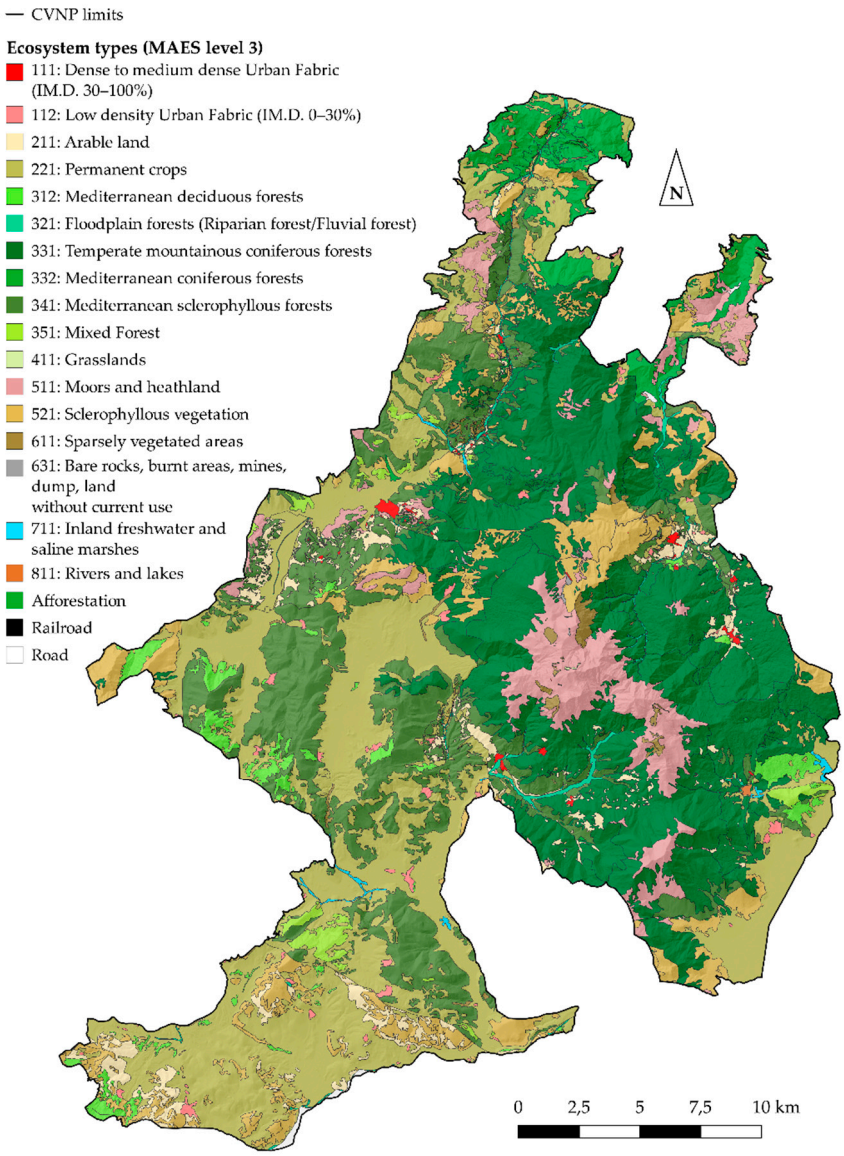

Figure 6. Ecosystem types (MAES level 3 [17,37] map of the CVNP.

The distribution of different MAES level 3 ecosystem types revealed that diversity hotspots are present at the surrounding area of Kalavrita city and along the Vouraikos river gorge (mainly at its southern parts); secondary hotspots are found scattered throughout the area (Figure 7).

Field surveys for ecosystem condition assessment revealed that CVNP ecosystem types are generally in above moderate condition (Table 6), i.e., 40% are in excellent condition, 37% are in good condition, 20% are in moderate condition, and 11% are in bad condition. None of the ecosystem types were assessed as being in poor condition. Low percentages represent ecosystem types in bad condition, i.e., 3% of the Mediterranean sclerophyllous forests, 1% of temperate mountainous coniferous forests, 1% of floodplain forests (riparian forest/fluvial forest), 5% of sclerophyllous vegetation and 10% of Moors and heathland. It also highlighted that all plots of Mines, dump, land without current use is in moderate ecosystem condition, while 50% of Inland freshwater marshes are in moderate condition.

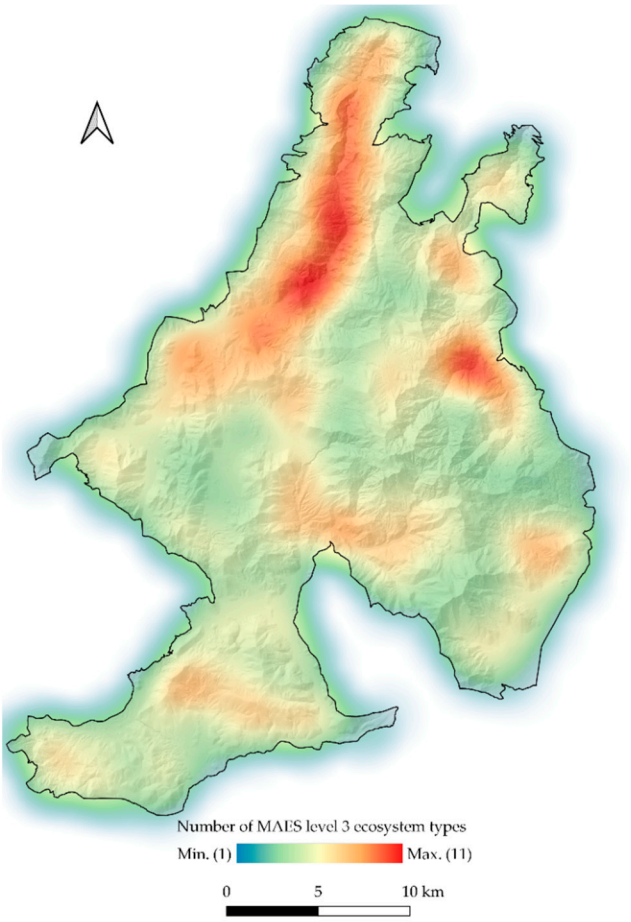

Figure 7. MAES level 3 ecosystem type diversity hotspots in the CVNP area.

Table 6. Synoptic results for ecosystem condition assessment via field surveys using the MAES_GR online platform [42] at the CVNP.

MAES Ecosystem Types		Ecosystem Condition					Total Plots
MAES Level 2	**MAES Level 3**	**Bad**	**Poor**	**Moderate**	**Good**	**Excellent**	
Cropland	Permanent crops	-	-	4 (100%)	-	-	4
	Arable land	-	-	-	6 (100%)	-	6
Grassland	Natural grasslands prevailingly without woody species scrubs (W.C.D. < 30%)	-	-	1 (17%)	1 (17%)	4 (67%)	6
Woodland and forest	Mediterranean coniferous forests	-	-	14 (56%)	3 (12%)	8 (32%)	25
	Mediterranean sclerophyllous forests	2 (3%)	-	19 (24%)	32 (41%)	26 (33%)	79
	Mediterranean deciduous forests	-	-	-	4 (40%)	6 (60%)	10
	Temperate mountainous coniferous forests	1 (1%)	-	12 (16%)	38 (49%)	26 (34%)	77
	Floodplain forests (riparian forest/fluvial forest)	1 (1%)	-	16 (21%)	32 (42%)	27 (36%)	76
Heathland and shrub	Sclerophyllous vegetation	2 (5%)	-	12 (27%)	20 (45%)	10 (23%)	44
	Moors and heathland	5 (10%)	-	2 (4%)	13 (27%)	29 (59%)	49

Table 6. *Cont.*

MAES Ecosystem Types		Ecosystem Condition					Total Plots
MAES Level 2	**MAES Level 3**	**Bad**	**Poor**	**Moderate**	**Good**	**Excellent**	
Sparsely vegetated land	Sparsely vegetated land		-	3 (7%)	3 (7%)	36 (86%)	42
	Mines, dumps, and land without current use	-	-	2 (100%)	-	-	2
Wetlands	Inland freshwater marshes	-	-	1 (50%)	1 (50%)	-	2
Rivers and lakes	Rivers and lakes	-	-	-	2 (100%)	-	2
	Total	11 (3%)	-	86 (20%)	155 (37%)	172 (40%)	424

3.3. Ecosystems Services Actual and Potential Supply

In total, 53 different ES have been identified in the CVNP area via field surveys using the MAES_GR platform, i.e.: (a) 16 provisioning ES (11 biotic and 5 abiotic), (b) 22 regulating and maintenance ES (17 biotic and 5 abiotic), and (c) 15 cultural ES (11 biotic and 4 abiotic). The dominant ES recorded in the CVNP for each major ES category are:

- Provisioning: "Animals reared for nutritional purposes" (80 recordings), followed by "Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition" (46 recordings), "Fibres and other materials from wild plants for direct use or processing (excluding genetic materials)" (43 recordings), and "Ground water (and subsurface) used as a material (non-drinking purposes)" (27 recordings).
- Regulating and maintenance: "Pollination" (199 recordings), "Control of erosion rates" (156 recordings), "Hydrological cycle and water flow regulation (Including flood control, and coastal protection)" (115 recordings), "Seed dispersal" (109 recordings), and "Decomposition and fixing processes and their effect on soil quality" (97 recordings).
- Cultural: "Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge" (137 recordings), "Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions" (108 recordings), "Characteristics of living systems that enable aesthetic experiences" (96 recordings), and "Characteristics or features of living systems that have an existence value" (95 recordings).

A detailed presentation of the field survey results per ES class and per MAES level 2 ecosystem type is presented in Table S5 of the Supplementary Materials, while the actual and potential supply for the main ecosystem services categories, per MAES level 2 ecosystem types, is presented in Table 7.

Table 7. Actual (A) and potential (P) supply for the main ecosystem services categories, per MAES level 2 ecosystem types. Each record depicts: mean rating; median of rates; (reference number of protocols).

Ecosystem Types (MAES Level 2)	Number of Protocols	Ecosystem Services											
		Provisioning				Regulating and Maintenance				Cultural			
		Biotic		Abiotic		Biotic		Abiotic		Biotic		Abiotic	
		A	P	A	P	A	P	A	P	A	P	A	P
Cropland	11	3.50;4 (8)	4.00;4 (8)	-	-	2.09;2 (9)	2.36; (9)	-	-	1.71;1 (7)	2.14;2 (7)	3.00;3 (1)	3.00;3 (1)
Grassland	2	1.00;1 (1)	2.00;2 (1)	-	-	1.60;2 (2)	2.20;2 (2)	-	-	2.85;2 (1)	3.28;3 (1)	-	-
Woodland and forest	162	2.00;2 (93)	2.74;3 (93)	1.70;2 (27)	2.26;2 (27)	2.29;2 (161)	2.90;3 (161)	2.31;2 (49)	3.93;3 (49)	2.39;2 (140)	2.92;3 (140)	2.48;3 (32)	3.46;4 (32)

Table 7. *Cont.*

Ecosystem Types (MAES Level 2)	Number of Protocols	Ecosystem Services											
		Provisioning				Regulating and Maintenance				Cultural			
		Biotic		Abiotic		Biotic		Abiotic		Biotic		Abiotic	
		A	P	A	P	A	P	A	P	A	P	A	P
Heathland and shrub	39	1.93;2 (28)	2.82;3 (28)	-	-	2.16;2 (38)	2.88;3 (38)	1.60;2 (3)	4.20;4 (3)	2.34;2 (33)	2.97;3 (33)	2.33;2 (3)	4.00;4 (3)
Sparsely vegetated land	11	2.00;2 (1)	2.00;2 (1)	5.00;5 (2)	5.00;5 (2)	1.78;2 (7)	2.17;2 (7)	-	-	2.57;3 (9)	3.00;3 (9)	1.45;1 (7)	1.90;1 (7)
Wetlands	1	3.00;3 (1)	4.00;4 (1)	-	-	3.00;3 (1)	4.00;4 (1)	-	-	-	-	-	-
Rivers and lakes	2	1.00;1 (2)	2.00;2 (2)	2.00;2 (2)	3.00;3 (2)	1.60;2 (2)	2.60;3 (2)	2.00;2 (2)	3.00;3 (2)	3.00;3 (2)	3.60;4 (2)	2.00;2 (2)	2.00;2 (2)

4. Discussion

The present study deals with an extensive assessment of the floristic diversity of a National Park, i.e., CVNP with reference to ecosystem types, their condition, and their services. The results are used to provide scientifically informed data to propose specific ecosystem services indicators; thus, supporting national efforts for the MAES implementation in Greece and guiding land-use management and spatial planning in the protected area. Moreover, this floristic inventorying and spatial delineation of important areas for biodiversity (e.g., species richness hotspots, concentration, and extent of different ecosystem types) provide valuable baseline input for natural capital accounting in terms of extent, condition, and ecosystem services [17].

4.1. CVNP Flora Assessment and Its Importance to Land Use Managment

The importance of CVNP is highlighted by its exceptionally high floristic diversity and uniqueness (i.e., the presence of the local endemic taxa *Silene conglomeratica*, *Alchemilla aroanica*, *Lonicera alpigena* subsp. *hellenica*, *Polygala subuniflora* and *Valeriana crinii* subsp. *crinii*). Results on CVNP native flora (1467 taxa), including 177 Greek endemics with 41 appearing only in Peloponnisos, and including 46.26% of the total Peloponnesian vascular flora (3171 taxa, according to Dimopoulos et al. [22]), renders the floristic diversity and the significance of CVNP's flora for a biodiversity conservation as an oriented land use management approach. It is notable that the study of a floristic composition of a habitat as a principle tool in biodiversity, as well as, attributes and characteristics such as chorology and lifeform, are required for establishing priorities for targeting conservation and management actions for species and ecosystems [48]. More particularly, the knowledge of the chorological spectrum provides information such as about cosmopolitan and alien elements, useful for control measures and management. For instance, it is not possible to design a robust management strategy without a thorough knowledge of the distribution of alien species within an area [49]. Moreover, life-form analysis is also useful in order to propose management practices that will improve the delivery of ecosystem services; e.g., the therophyte species portion is a parameter describing community structures to assess efficiently ecosystem services in grasslands [50]. Additionally, there are studies that confirm the association of lifeform with habitat disturbances [51,52], helping in assessing these disturbances.

Taking all the aforementioned into account and based on the results of the study, a holistic spatial planning and management scheme should be drafted based on fine-scale data, along with large-scale information in order to properly design spatially allocated development needs, human activities and nature conservation actions. For instance, the identified differences in altitudinal distribution of endemic species richness suggest different types of land use planning and/or assessment prior environmental legislation for development infrastructure or other human activities, considering that due to several

elevation ranges of plant taxa presence, they are affected by different threat factors and exposed at different risk of extinction [53].

Moreover, previous studies suggest the implementation of micro-reserves projects in specific sites [54] that simultaneously delineate exclusion zones for other development actions. Such sites and actions should be assessed in CVNP at the pinpointed hotspot areas, especially for endemic diversity. However, hotspots of total species richness are also crucial to be maintained since total species richness is a key indicator for ecosystem condition [17] and should be considered for monitoring purposes, especially where threatened endemics are present.

4.2. Mapping and Assessment of Ecosystems and Their Services in CVNP

Ecosystem type mapping in CVNP pinpoints the ecosystems' diversity and their spatial complexity within the area and revealed that human-induced land uses can coexist under a protected area scheme in CVNP. Simultaneously, the diversity of ecosystem types supports a relevant variety of ecosystem services in terms of actual and/or potential supply [14,15]. However, the capacity of ecosystems to provide services is directly related to their extent and ecosystem condition [12]; most of CVNP ecosystem types are assessed at above moderate condition; however, there are significant percentages of specific ecosystem types that are in moderate condition and cover important areas within the national park. For instance, 56% of Mediterranean coniferous forests, 27% of sclerophyllous vegetation, and 24% of Mediterranean sclerophyllous forests plots are assessed as in moderate condition. By this, the capacity of these ecosystems to provide services is limited and relevant conservation actions and/or measures should be considered. These results can be interpreted based on recent forest fires events in the area, and thus, suggest that fire prevention measures are needed for the CVNP protection with respect to these ecosystem types that are crucial for a variety of ecosystem services (e.g., regulation of mass flows, carbon storage, habitat for biodiversity and pollinators, aesthetic value, and outdoor recreation). Moreover, a grazing management plan is needed for the CVNP (since overgrazing is one of the main recorded pressures in the area [55]) that will assess all types of ecosystems with respect to their biomass production for grazing, simultaneously considering the amelioration need for all ecosystem types affected by grazing to achieve at least above moderate ecosystem condition. Especially in the above timberline ecosystem types (i.e., moors and heathland, grasslands, and sparsely vegetated areas) that constitute endemic species hotspots and/or cover a small portion of the total area (i.e., grasslands), specific, spatially designated actions and measures should be investigated and implemented to support conservation needs and sustainable development goals.

CVNP, hosting rare and endemic as well as medicinal and aromatic plants and their ecosystems, has an exceptional scientific interest, attracting throughout the ages, scientists from different scientific fields of plant science, such as plant taxonomy (e.g., [56]), vegetation science (e.g., [57,58]), plant genetics (e.g., [59,60]), and floristics and plant systematics (e.g., [61–67]).

Furthermore, the mountain region of CVNP attracts tourists from all over the world [68]. The uniqueness of the plant- and habitat-diversity of the area, including a high number of rare and endemic plant species and the presence of five local endemic plants, acts as a valuable asset for the promotion of the area's ecotourism, contributing toward attracting tourists. Considering that exploiting natural and ecological potentialities, such as the high plant diversity, in the form of ecotourism, give a comparative advantage and play a significant role in the development of ecotourism industry [69–71].

4.3. Contibution to National and EU Efforts for Sustainable Development Spatial Planning

The present study adds value to the ongoing national efforts of Ministry of Environment and Climate Change for drafting management plans and providing a zonation scheme for land uses and human activities that will alter the current management scheme and provide concrete guidelines for the CVNP role in the future (see Table S6 of the Supple-

mentary Materials). The inclusion of local scale, detailed biodiversity data for ecosystems and ES builds the baseline information that should be a prerequisite in these types of management and policy decisions and should guide national park spatial planning under the provisions of the EU Biodiversity Strategy and the EU Green Deal, using the best available and up-to-date data and tools.

5. Conclusions

The CVNP and UNESCO Global Geopark is not a homogeneous landscape. The geomorphology, the formation of different ecosystems, and the high altitudinal range have contributed to the creation of a variety of habitats in which the species have been adapted, and resulted, in some cases, to impressive specialization. Each rare, endemic, or threatened species is a unique element and ecosystem attribute with special needs and different requirements; however, a holistic aspect and management is needed, excluding fragmentary ineffective conservation management actions. Utilizing and combining available data and resources in an integrated way and at the same time enriching them with additional data regarding natural and cultural landscape and diversity, national parks and all other types of protected areas could be more effectively designed and managed. Moreover, governments, international development agencies, and local people could contribute to the sustainable welfare of national parks and protected areas by providing their professional support, nevertheless ensuring the full range of species, natural ecosystems, and ecosystem services as an integral part of the human habitat.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/land11010033/s1, Table S1: Floristic catalogue of National Park and UNESCO Global Geopark of Chelmos-Vouraikos; Table S2: The richest in taxa families and genera of the native vascular flora of CVNP; Table S3: Life-form categories and species richness of the CVNP native flora; Table S4: Species richness and distribution among chorological groups and categories of the CVNP vascular flora; Table S5: Ecosystem services dataset; Table S6: Correspondence of the present study with the National Set of MAES indicators in Greece, conservation strategies and policy decisions.

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