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Review

Assessing the Ecosystem Services Potential of Endemic Floras: A Systematic Review on the Greek Endemics of Peloponnese

Alexian Cheminal [1], Ioannis P. Kokkoris [1], Anastasios Zotos [2], Arne Strid [3] and Panayotis Dimopoulos [1,*]

[1] Laboratory of Botany, Department of Biology, University of Patras, 26504 Patras, Greece; alexian.cheminal@upatras.gr (A.C.); ipkokkoris@upatras.gr (I.P.K.)
[2] Department of Biosystems & Agricultural Engineering, University of Patras, Nea Ktiria, 30200 Mesolonghi, Greece; azotos@upatras.gr
[3] 4 Bakkevej 6, DK-5853 Ørbæk, Denmark; arne.strid@youmail.dk
* Correspondence: pdimopoulos@upatras.gr; Tel.: +30-261-099-6777

Abstract: As the interest in new, natural, sustainable products arises in many fields, wild plants are reconsidered as providers of traditional or innovative applications. The notion of ecosystem services (ES) provides a frame to evaluate their benefits, but is still scarcely applied to endemic floras. The present study reviews the available literature on the ES provided by the 494 taxa endemic to Greece that are present in Peloponnese. Six main categories are isolated: medical, aromatic, folk medicine, antimicrobial, environmental and craftsmanship interests. The literature documents such ES for 24.7% of the endemic taxa, with Lamiaceae, Asteraceae and Boraginaceae as the families with the highest numbers of documented taxa. Spatial hotspots with a high density in taxa providing ES are mapped, while gaps of knowledge on the ES of endemic taxa are highlighted. For the first time, to our knowledge, taxonomic and phylogenetic bounds between taxa are exploited as a base to explore potential properties for endemic taxa. The basis for the development of predictive tools utilizing literature review datasets is set. Final outcomes also provide robust scientific evidence to support decision and policy making for the sustainable use and management of rural areas. The development of cultivation areas for threatened taxa of interest is suggested as a potent conservation measure, by selecting fields according to habitat suitability models.

Keywords: biodiversity management; Greek flora; knowledge gaps; MAIA H2020 project; MAES implementation; decision making; sustainable rural management; medicinal plants; aromatic plants

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1. Introduction

Facing an increasing pressure on fossil resources and a multiplication of biological, ecological and social issues (e.g., microbial resistance, long term health effects, pollution, work conditions, etc.), Western societies progressively consider natural resources as a solution for their ever-growing needs in energy, food, materials and drugs [1–3]. Previously left aside to the benefit of synthetic substances, plant products are now envisaged as the answers to the current demand in a local, environmental-friendly production [4,5]. As the World Health Organization itself recognizes the value of traditional and complementary medicines, phytotherapy, homeopathy, aromatherapy and naturopathy appear to be considered more often as alternatives to conventional medicine, and ethnobotany and ethnopharmacology emerge in biological sciences to re-discover ancient practices and to protect their endangered wisdom [6–10].

Greece has a role to play in this mutation of medicine. Rich in its millennial history, the country has left a significant print on medicine, with, for instance, herbalists such as Theophrastus and Dioscorides, who gathered a significant anthology of the medicinal plants' uses of their era [11,12]. Its natural richness is also a major asset of this Mediterranean country: covering about 7000 plant species, including more than 1400 endemic taxa [13–15], Greece is one of the most important plant diversity hotspots in Europe [16].

This multiplicity contributes to the bound between its history and its landscapes, as it provides, now as before, a wide array of ecosystem services [17].

Ecosystem services (ES) could be defined as 'the aspects of ecosystems utilized (actively or passively) to induce human well-being', linked to the basic ecology of the ecosystem (e.g., soil depollution, host for other species, flooding containment, etc.) or to the uses humankind make of it (e.g., food, wood, cultural or spirituals involvements, etc.) [18]. This notion underlines the strong bond between biodiversity and human activities and needs, acknowledging the value of taxa that will allow the subsistence and development of our species. It becomes a tool to argue with stakeholders on the necessity of environmental policies to preserve this bond [19,20]. With its outstanding biodiversity, Greece is considered one of the regions where medicinal and aromatic plants-major ES providers-constitute an important natural resource [21].

Greek and worldwide research teams have acknowledged this pit of diversity by leading numerous investigations on ecological, taxonomical, genetical or botanical aspects on the countries' flora [14,22,23]. The studies on the endemic species of Greece are nonetheless still punctual and uncomplete, particularly regarding the ES these taxa could provide [24]. In the context of the Mapping and Assessment of Ecosystems and their Services (MAES) [25] implementation in Greece, and in the frame of the currently in progress Flora of Greece Web project, the goals of the present study are to analyze the knowledge already acquired on ES offered by the endemic flora of Greece and to expose its potential for further ES, with a local focus on the floristic region of Peloponnese (SW Greece). More precisely, this work builds on the capacity developed via the MAIA H2020 project [26] and aims to:

(a) present a review of the studies focusing on ES provided by endemic taxa of Peloponnese and on the chemical composition of their essential oils,
(b) describe the distribution pattern of this endemic flora in Peloponnese,
(c) extract a list of relative non-endemic taxa based on taxonomic and phylogenetic studies and summarize their properties and chemical compositions,
(d) conclude on the actual and potential ES of the endemic plants present in Peloponnese,
(e) pinpoint data gaps and suggest leads for further studies,
(f) provide scientific evidence for sustainable management and integration of the results in sustainable agricultural and conservation practice.

We also discuss the construction of ES potentials' indexes which would combine the data on the endemics and their relatives to eventually evaluate numerically the probability of new properties for endemic taxa.

Finally, all outcomes provide input for a baseline delineation under the goals of MAIA H2020 project, for ES accounting in the region of Peloponnese.

2. Materials and Methods

2.1. Endemic Taxa

The list and presence data (georeferenced point data) of endemic taxa used for this review are extracted from the Flora Hellenica Database (Strid, ~1.2 M occurrences; ongoing). The endemic taxa taken into consideration are the taxa endemic to Greece (South-Eastern Europe) that can be found in the floristic region of Peloponnese (Figure 1). Some recent, doubtful or debated taxa have not been included in the present study and are listed as Table S1 (Supplementary Materials). Please note that in this review, the word 'taxon' will be used for defining either or both a species (e.g., *Anthemis cretica*) or a subspecies (e.g., *Anthemis cretica* subsp. *panachaica*). Nomenclature and endemism status follow Dimopoulos et al. [14,15].

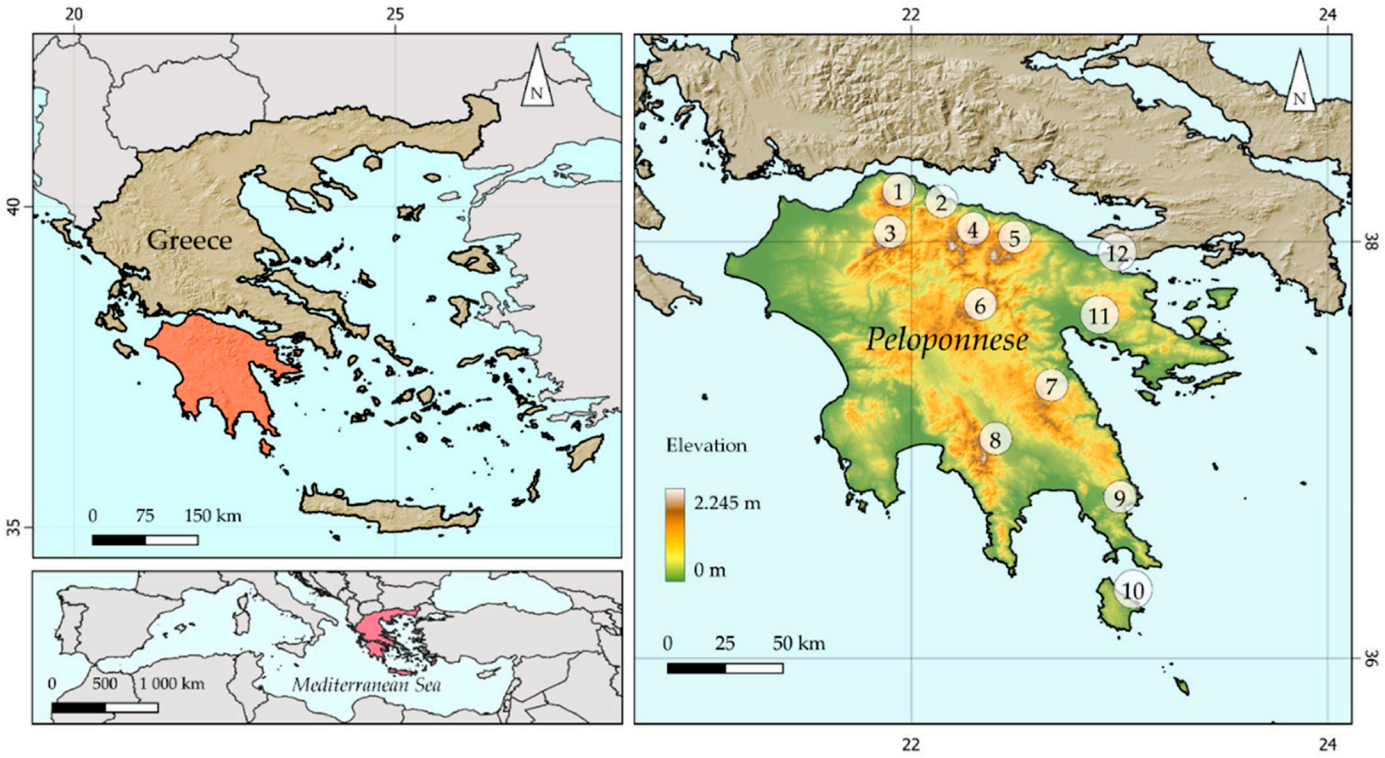

Figure 1. Representation of the study area, the region of Peloponnese (Greece), depicting main mountain massifs and areas of interest, i.e., (1) Mt. Panachaiko, (2) Mt. Klokos, (3) Mt. Erimanthos, (4) Mt. Chelmos (5) Mt. Killini, (6) Mt. Menalo, (7) Mt. Parnonas, (8) Mt. Taygetos, (9) area of Monemvasia, (10) Isl. Kithira, (11) area of Nafplio, (12) area of Korinthos.

2.2. Non-Endemic Taxa and Taxonomic Relatives

In order to extend the research field and improve the dataset, a review has also been conducted on non-endemic taxa which are closely related to endemic taxa on a taxonomic matter. Thus, for the plant species that are endemic to Greece at a subspecies level (e.g., *Amelanchier parviflora* subsp. *chelmea*), the review has also integrated eponymous non-endemic taxa at the subspecies level (e.g., *Amelanchier parviflora* subsp. *dentata* and subsp. *parviflora*), as well as at the species level (e.g., *Amelanchier parviflora* sp.). In order to find the related subspecies, GBIF website has been used, using the Peloponnese endemic taxa species' names as keywords.

2.3. Non-Endemic Taxa and Phylogenetic Relatives

With the same goal of a more complete dataset, the review has gathered scientific articles presenting phylogenetic trees which include Peloponnese endemic taxa (e.g., *Tulipa orphanidea*). If the endemic subspecies itself was not to be found in any phylogeny analysis, the review has taken into account the phylogeny of the inclusive species itself (e.g., as *Inula verbascifolia* subsp. *methanea* and subsp. *parnassica* were not investigated, the genetic classification of *Inula verbascifolia* sp. has been taken into account). The collection of the relevant phylogenetic analysis has been made on the platform Google Scholar, using the key words ["name of the taxon" + "Phylogeny"].

Out of these phylogenetic trees, the names of closely related taxa have been extracted. 'Closely related' can generally be defined as: taxon that is either present on the same, previous or next branch on the tree compared to the endemic taxa taken into account.

2.4. Review Process

For each taxon belonging to the three aforementioned categories, a literature review has been conducted in order to gather data on: (a) its medicinal properties, (b) its aromatic uses, (c) the chemical composition of its essential oils, and (d) all additional ecosystem services.

The literature has been extracted from the results given by the platform Google Scholar using different combinations of keywords:

- ["Medical" + "name of the taxon"],
- ["Medicinal" + "name of the taxon"],
- ["Aromatic" + "name of the taxon"],
- ["Properties" + "name of the taxon"],
- ["Uses" + "name of the taxon"],
- ["Activity" + "name of the taxon"],
- ["name of the taxon"].

To evaluate the efficiency of each combination, the number of results on Google Scholar with the use of each key word has been recorded for each taxon.

When the data seemed insufficient or an article on the platform was not accessible, the key word ["name of the taxon"] was used on Scopus and Science Direct. All information about the properties of the studied taxa have been extracted from literature, including the traditional uses in medicine for which no local users or experts have been interviewed at this stage.

Data on the risk status of all endemic taxa follow the Flora of Greece Web project [27], and are double-checked through the IUCN Red List website [28]. When Flora of Greece Web and IUCN status diverged, the following choices were made: *Allium frigidum* (Alliaceae) and *Aquilegia ottonis* subsp. *taygetea* (Ranunculaceae) are considered for this study as 'Data Deficient' rather than 'Non Evaluated' and, in order to include the species as potentially analyzed for ecosystem services, *Isoetes heldreichii* (Isoetaceae) is considered as 'Critically Endangered' rather than 'Extinct'.

Every document thought to be relevant (scientific article, book, thesis, etc.) has been recorded on Zotero software, in order to build a detailed bibliography [29].

2.5. Definitions for the Ecosystem Services

The results on the ES of the studied taxa have been split into six categories of properties, described as follows. These categories have been defined based on the list of their individual properties unveiled by the review process. They follow and implement the categories developed by Cheminal et al. [24].

The criterion 'Aromatic' is validated for the taxa that are documented or mentioned as:

- An ingredient for the preparation of local to common dishes (eaten raw or cooked, spice, food preservative);
- An ingredient for the preparation of local to common beverages (tea, milk preparations);
- Material for the preparation of perfumes or cosmetics;
- A plant with an acknowledged powerful scent that could be used for floristic, food or cosmetic applications.

The criterion 'Medical' is validated for the taxa that are documented or mentioned as:

- Possessing medicinal or medical properties with scientific proofs (i.e., antioxidant, anti-acetylcholinesterase, skin protection, anti-inflammatory, antinociceptive, etc.);
- Already exploited as plant material for pharmaceutical productions (i.e., drugs, homeopathy);
- Used for veterinary purposes that could potentially be widened into human care (i.e., anti-parasite, wound healing, etc.).

The criterion 'Traditional medicine' is validated for the taxa that are documented or mentioned as:

- Used in traditional medicine on a local to wide scale (i.e., against sore throat, epilepsy, stomach aches, as hepatoprotective, antispasmodic, to cure wounds, to regulate diabetes, anti-malarial etc.);
- Used for para-medical applications (i.e., aphrodisiac, hypnotic, psychedelic, etc.).

The criterion 'Antimicrobial' is validated for the taxa that are documented or mentioned as:

- Efficient treatments against viruses, fungi, bacteria, yeasts, parasites, worms. This excludes insecticidal, molluscicidal and nematocidal applications as well as uses for plant diseases that are integrated to the following category.

The criterion 'Environment benefits' is validated for the taxa that are documented or mentioned as:

- Having applications in the knowledge or mastering of landscapes (i.e., ornamental, habitat indicator, habitat restoration, resistance to extreme soil conditions, etc.);
- Beneficial for non-human species (i.e., veterinary uses, host-plant for insects, bee attractant, etc.);
- Beneficial for agricultural productions or necessary to reduce diseases' propagations by vectors (i.e., herbicidal, plant protection, cover crop, fodder, fertilizer, rodenticide, insecticide, etc.);
- A direct use of nature by humans for traditional or cultural purposes (i.e., religious, cultural);
- A tool for nature protection awareness (i.e., use in botanical gardens, touristic trails, presence on historical sites).

The criterion 'Industry and Craft uses' is validated for the taxa that are documented or mentioned as:

- Exploited for industrial applications (i.e., reducing agent, solvent, glue, etc.);
- Used for traditional applications linked to craftsmanship (i.e., tincture, wood uses for furniture, instrument, fuel, etc.);
- Exploited in non-traditional food processes (i.e., ice-cream production).

The exhaustive list of properties referenced for each category during the review process is to be found as Table S2 (Supplementary Materials).

Each taxon, endemic or non-endemic, can be noted as possessing for sure (x), potentially possessing (M), or proved not to possess or proved to have a toxic effect (No), for both, one or none of these properties. During the review process, the traditional medicinal properties have been noted with a (T) to differentiate them from modern medical applications. If, on a peculiar property, both traditional and modern uses were mentioned, only (x) was written. In the same way, and for all data agglomeration processes (i.e., gathering all articles to conclude on a taxon's property, gathering several relatives to evaluate an endemic taxon's potential properties, etc.), the following priority order has been followed: x > T > M > No.

Some non-endemic taxa proved to be highly studied by the scientific community (e.g., *Ruta chalepensis*, *Crocus sativus*, *Sideritis scardica*, *Lonicera caerulea*, etc.). As a comprehensive review of all the relevant literature would have been too demanding, these species will be given a special comment in the common analysis of endemic and non-endemic taxa.

2.6. Data Analysis

The results were listed and detailed in a catalog of properties and components for each endemic and non-endemic taxon. On spreadsheets were then summarized: (a) the properties of each documented taxon, (b) the detected chemical components, (c) the literature and review details. Relevant spreadsheet files were subsequently built, in order to facilitate the link between properties, functional traits and spatial data. The raw data analysis has been conducted in terms of general statistics and chart representation. From the whole dataset have particularly been extracted total taxa counts and numbers of taxa for each property category.

Datasets on the properties of non-endemic taxa related to endemic taxa (by taxonomy or phylogeny) are used as suggestions for additional properties for endemic taxa. With this goal in mind, the following assumption has been integrated: taxa that are closely related on taxonomy or genetic basis present a higher probability to share common properties. To allow a cross-analysis of the data, the endemics, their respective relatives (according to taxonomy and/or phylogeny), the properties of the endemics and those of their relatives have been listed and compared. The comparison aimed to transfer the relatives' properties, previously unproved for the endemic species, as potential properties for them.

For instance, *Anchusella variegata* (endemic Boraginaceae) has been mentioned as of 'Environmental interest' as part of the Botanical Garden of Kroussia. However, its phylogenetic relative *Lycopsis arvensis* has been documented for the categories 'Aromatic', 'Medical', 'Traditional medicine' and 'Industrial and craftsmanship'. For the extended dataset, *Anchusella variegata* will then be considered as potentially interesting for the following categories: 'Aromatic', 'Medical', 'Traditional medicine', 'Environmental interest' and 'Industrial and craftsmanship'.

The full review process is summarized in the flowchart of Figure 2.

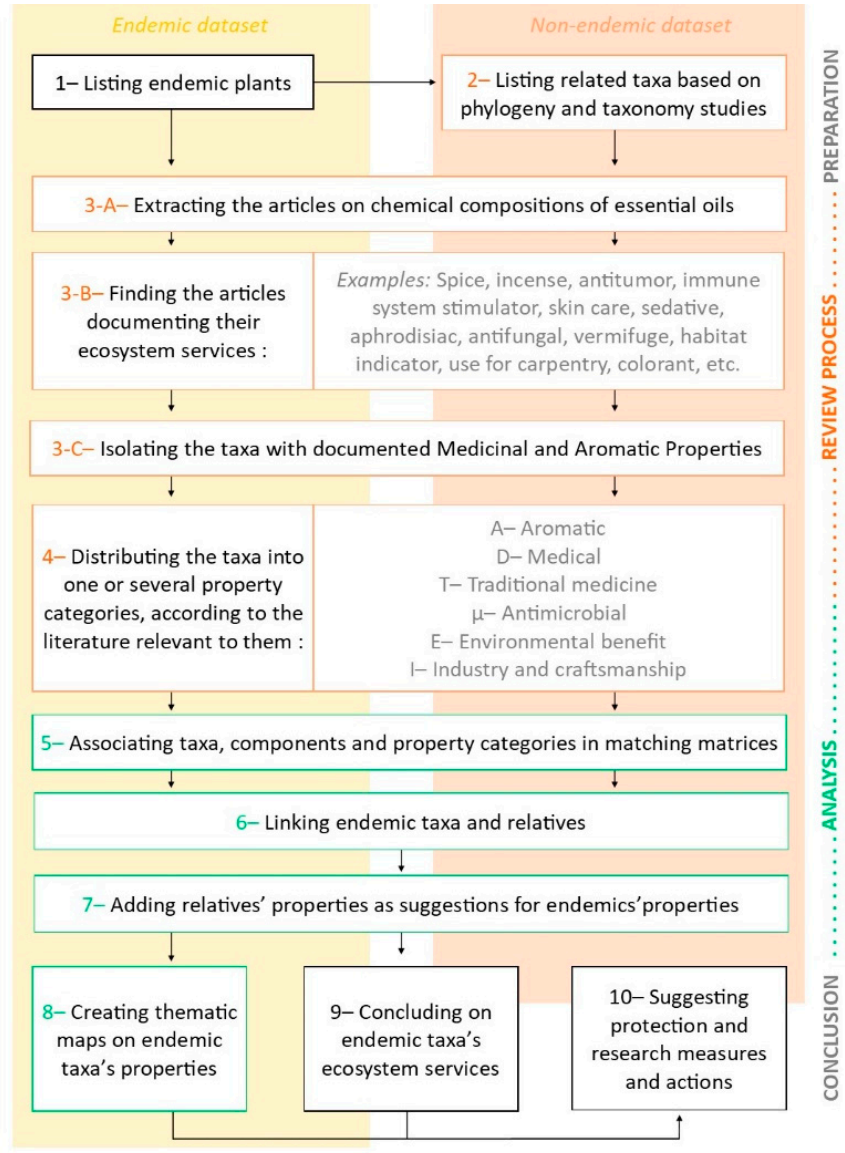

Figure 2. Methodological flowchart of the study.

3. Results

3.1. Review Characteristics

3.1.1. Endemic Taxa Review

The review gathered a total of 222 different documents dealing with ES, genetics and status of endemic plants of Peloponnese, giving place to 329 quotations (one quotation being one article mentioning one or several properties for one taxon: one article can be quoted several times for different taxa).

Focusing on the country of origin of the articles, among the 222 articles, 178 are related to one-country articles, whereas 44 are linked to documents edited in common by scientists from several countries (from two to six countries). Most of the articles related to the endemic flora of Peloponnese are issued by Greek researchers: 97 one-country articles (43.7% of the 222 articles) and 20 in collaboration (9.00%). However, 36 different countries have taken part in the construction of the existing knowledge, the main ones being the USA (15 one-country articles), Turkey (13 one-country articles) and Germany (10 articles in collaboration).

During the review process, each taxon has been searched on the Google Scholar platform using similar keyword combinations. The search performed using only the name of the species gives an overview of the amount of data and interest brought to knowledge on each taxon. The richest endemic taxa in terms of search results are as follows: *Abies cephalonica* (Pinaceae, 2670 results), *Crocus cartwrightianus* (Iridaceae, 376), *Marrubium velutinum* and its subspecies *velutinum* (Lamiaceae, 296), *Centaurea raphanina* (Asteraceae, 254), *Stachys candida* (Lamiaceae, 234) and *Dianthus fruticosus* (Caryophyllaceae, 218). The 100 taxa with the most results on Google Scholar are distributed in 26 families, with the main ones being: Lamiaceae (19 taxa on the podium), Asteraceae (18) and Caryophyllaceae (8).

After the review, despite the different keywords, seven taxa do not have any article or search results mentioning their names: six *Hieracum* species (Asteraceae) and one *Iris* (Iridaceae). In addition, 21 taxa are only related to a single document including one Alliaceae, ten Asteraceae (including five *Hieracum*), two Boraginaceae, two Caryophyllaceae, one Fabaceae, one Hyacinthaceae, one Hypericaceae, one Liliaceae, one Resedaceae, one Valerianaceae.

While 122 taxa are documented for at least one ES (see IV-B), 372 Greek endemic taxa from Peloponnese remain undocumented for their properties, apart from 74 taxa that are only documented for their status or genetics and 11 for which information on the chemical composition can be found. 287 taxa are thus considered as having no relevant data on the context of this study.

For the 17 proved or alleged aromatic taxa, 12 (70.6%) are documented by a single article whereas three taxa are documented by two studies and two taxa by three studies. The main documented taxa are *Centaurea raphanina* subsp. *mixta* (Asteraceae) and *Crocus cartwrightianus* (Iridaceae) with three articles respectively. A total of 23 articles are consigned for this category, written either by one country (15 articles) or by collaborations of several countries (eight articles). The most productive countries are Greece (seven one-country articles and four in collaboration), Portugal (4 articles in collaboration) and Turkey (three one-country and one collaboration article, respectively).

As far as the 35 'medical' taxa are concerned, 25 of them (71.4%) are only documented by a unique study, three (8.57%) by two articles, and only seven (20.0%) by more than two articles. The main documented taxa are *Onobrychis ebenoides* (Fabaceae, five articles) and *Sideritis clandestina* subsp. *peloponnesiaca* (Lamiaceae, four articles). This category is covered by 52 articles: 38 solos and 14 collaborations. Most of the studies come from Greece (29 one-country articles and 10 collaborations).

Only ten articles argue on the traditional medical uses of ten endemic taxa: six solos and four collaborations. Fifteen countries took part in these researches, especially with three articles from Turkey (two one-country articles and one collaboration) and two from the USA (one solo and one collaboration).

Antimicrobial properties are discussed for 37 taxa by 33 articles, 23 solos and ten collaborations. 33 of these taxa (89.2%) are only documented by one article, and only four taxa benefit from two to four studies (10.8%). The most studied endemic taxa are *Centaurea raphanina* subsp. *mixta* (Asteraceae, four articles) and *Origanum scabrum* (Lamiaceae, three articles). Greece (17 solos and 10 collaborations) and Serbia (one solo and five collaborations) are the main participating countries.

Fifty-four studies are related to the environmental benefits of 83 endemic taxa, 49 solos and five collaborations. Among these 83 taxa, 68 benefit of a single article (81.9%), 13 of two articles (15.6%) and two of three to four articles (2.41%). *Achillea taygetea* (Asteraceae, four articles) and *Tulipa orphanidea* (Liliaceae, three articles) are the most documented taxa, while Greece (24 solos and one collaboration), Turkey (four solos) and the USA (four solos) are the most productive countries in terms of documentation.

In addition to the properties categories, 20 articles are providing documentation on the genetic material of the endemic species and 22 studies quote a risk status for a taxon.

3.1.2. Non-Endemic Taxa Review

The extended review significantly increased the number of relevant scientific articles. The articles related to taxonomy or phylogeny related non-endemic taxa are published by research teams from 83 different countries from all continents (except Antarctica).

The study of the documented properties for the taxa linked by taxonomy yielded 383 articles (428 quotations) from 76 countries. The taxonomy-related species are documented by 318 articles edited by a research team based in one country, originating from 50 different countries with a strong participation of Turkey (124 articles) and Italy (24 articles); as well as by 65 articles written by teams from several countries in collaboration, with the main participants being Turkey (18), Italy (14) and Greece (10).

For the non-endemic taxa related by taxonomy, 103 (32.7%) are documented for one of the six types of properties and six are only studied for their genetics. The number of articles per taxon ranges from one (36 taxa) to twenty-three (one taxon). However, 22 taxa are studied by more than five articles, while 87 (79%) are documented by one to five publications. Two hundred and twelve (212) taxa (67.3%) are not documented for their properties.

All taxa linked by phylogeny were studied by 551 articles (593 quotations) from 79 origins. This also includes some endemic or taxonomy-related taxa which have been documented as phylogenetically bound to other endemic taxa. 460 articles present a single country of origin, with as the most frequent ones among the 60 countries concerned being: Turkey (71), Iran (48), Greece (33), Spain (27) and Italy (22). Ninety-one (91) articles are built by collaborations between 60 different countries, especially Italy (16), Serbia (16), Greece (15), Turkey (14) and the USA (11).

Focusing on all taxa related by phylogeny (including the endemic and taxonomic-relatives being part of phylogenetic trees), 131 have already been proved to possess properties (40.3%), and details on the genetic material is all that can be found for nine other taxa. The taxa with properties present one (52 taxa) to twenty-one (one taxon) articles. There are 27 taxa documented by more than five publications (19.1%) whereas 114 (80.9%) are subject to one to five articles. 194 taxa (59.7%) are not documented for any property.

The non-endemic additional data for the two categories both taken into account provide 867 articles (952 quotations). Eventually, the full non-endemic and endemic taxa review covers 985 articles (1137 quotations) providing substantial information on the properties of one to several taxa. If the additional articles dealing with genetics and endangered status are also considered, the review extends to 1073 articles (1281 quotations). In total, with supplementary articles on the spatial distribution, conservation measures and phylogenetic studies, 1479 articles have been browsed in the frame of this review.

The taxa with the lowest number of search results are the same seven endemic species with no reference (see IV-A-1), plus 40 taxa with a single relevant article (20 endemic

taxa, 14 taxonomic relatives, 6 phylogenetic relatives), with the genus *Hieracium* covering seventeen of these taxa.

Among the non-endemic related taxa proved to possess medicinal or aromatic properties, ten of them presented too high a quantity of scientific documentation to be fully covered during the review (see Table 1 below).

Table 1. List of the non-endemic species for which abundant documentation has been recorded, with mention of the number of articles available on Google Scholar when typing the name of the taxon enclosed in quotation marks (e.g., "*Achillea*" + "*millefolium*").

Species	N° of Articles	Species	N° of Articles
Achillea millefolium (Asteraceae)	48,700	*Lamium album* (Lamiaceae)	9120
Lonicera caerulea (Caprifoliaceae)	5550	*Lamium* amplexicaule (Lamiaceae)	10,200
Silene vulgaris (Caryophyllaceae)	15,900	*Satureja cuneifolia* (Lamiaceae)	1420
Crocus sativus (Iridaceae)	29,600	*Ruta chalepensis* (Rutaceae)	4850
Ballota nigra (Lamiaceae)	6480	*Sideritis scardica* (Lamiaceae)	1080

3.2. Endemic Flora Statistics

The flora of Peloponnese comprises 494 endemic taxa (species and subspecies levels), integrated in 171 genera and 49 families (Table 2 here, plus Table S3 in Supplementary Materials). The main families are Asteraceae (87 taxa), Caryophyllaceae (59) and Lamiaceae (45), with three of them representing 38.7% of the endemic taxa of Peloponnese. The genera containing the more endemic taxa are *Silene* (21 taxa), *Hieracium* (20), *Campanula* (17), *Centaurea* (17), and *Limonium* (15). Some taxa are restricted endemics to the region of Peloponnese, as their only records are limited to this area: ca. 195 taxa.

Table 2. Number of endemic taxa of Peloponnese with or without documented ecosystem services.

	Total Number of Peloponnese Endemics	N° of Pe. Endemics with Documented Properties		N° of Pe. Endemics without Documented Properties	
		Number of Taxa	% of Total	Number of Taxa	% of Total
N° of endemic taxa (subspecies or species)	494	122	24.7	372	75.3
N° of genera with endemic taxa	171	81	47.4	90	52.6
N° of families with endemic taxa	49	33	67.3	16	32.7

On the other hand, 16 families and 100 genera possess a single endemic taxon in Peloponnese. Among these, seven genera are monospecific in Greece, with their only Greek species being endemic to Peloponnese: *Heptaptera colladonioides* and *Thamnosciadium junceum* (Apiaceae), *Phitosia crocifolia* (Asteraceae), *Gymnospermium peloponesiacum* (Berberidaceae), *Ridera graeca* (Boraginaceae), *Halacsyella parnassica* (Campanulaceae) and *Halimium voldii* (Cistaceae).

The conservation status of the endemic taxa has also been investigated. During the review, several articles brought details on the status of 26 species of interest. The addition of these studies to the Flora of Greece and IUCN website data reveals that 416 taxa have not been evaluated yet and eight of them lack data to allow a precise definition of the risk status: 85.7% of these rare taxa do not possess a conservation status (Figure 3).

Among the 70 taxa with a status, the 'Least Concern' label only covers seven species (10.0%), while the dominant category is 'Vulnerable' (29 taxa, 41.4%). The main threat levels concern 48.6% of the taxa with status, with a significant proportion of taxa with high risks: 'Near Threatened' (14 taxa, 20.0%), 'Endangered' (15 taxa, 21.4%), 'Critically Endangered' (five taxa, 7.14%). It is to note that articles mentioned the species *Isoetes heldreichii* and

Polygala subuniflora as potentially extinct, whereas the IUCN data consider them 'Critically Endangered' and 'Not Evaluated' respectively.

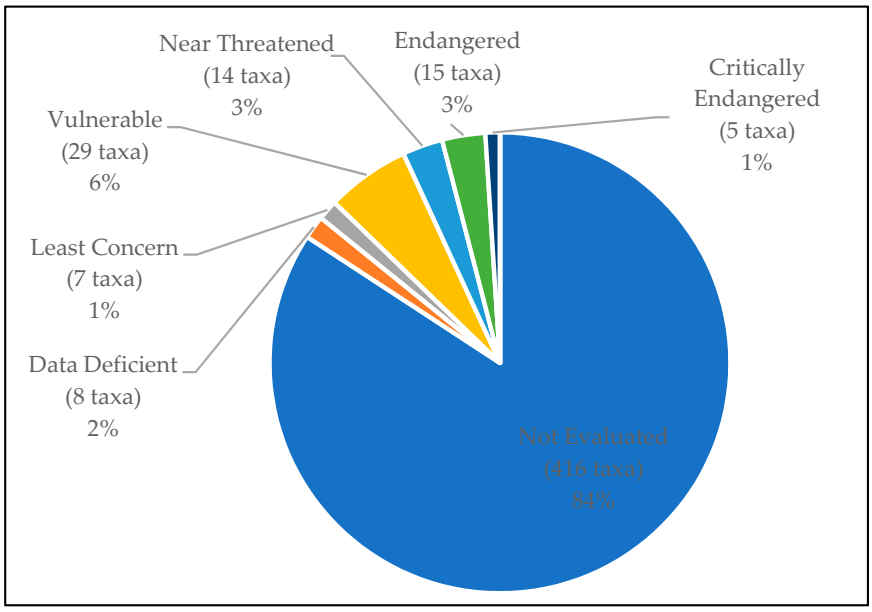

Figure 3. Conservation status of the endemic taxa of Peloponnese, with the number of taxa for each status and the percentage of endemic flora they represent (according to Flora of Greece Web and IUCN databases).

3.3. Habitats and Distribution of Endemic Flora

According to the data collected in the checklist Vascular Plants of Greece [14,15], each endemic taxon has been associated to one or several habitats, with 170 taxa out of 494 recorded to more than one habitat (Figure 4). It is to mention that the sum of the presented percentages exceeds 100%, as some taxa may be found on various habitat types.

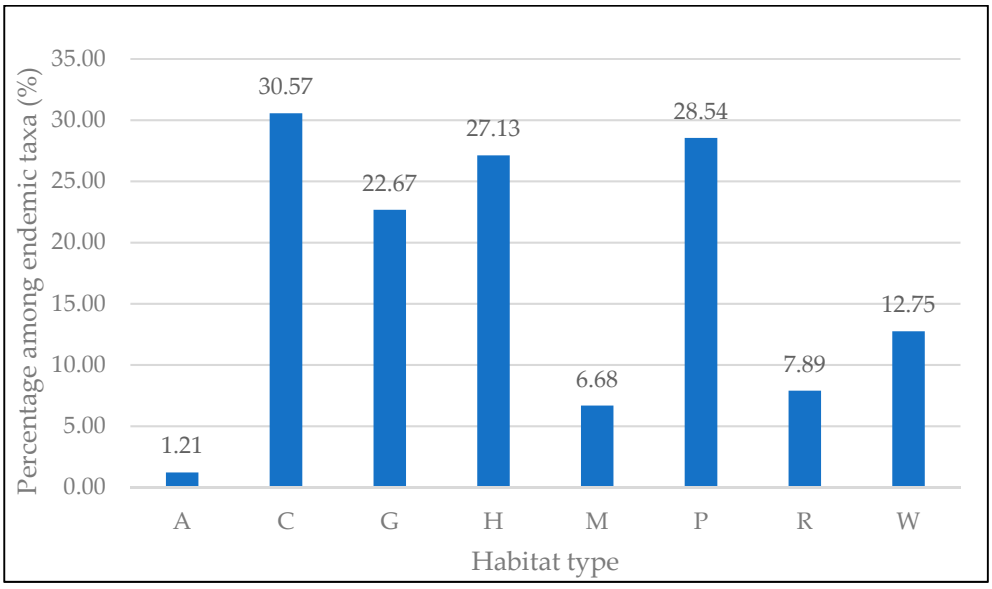

Figure 4. Habitats of the endemic taxa of Peloponnese. Habitat types: A (Freshwater habitats), C (Cliffs and ravines), G (Grasslands), H (High-mountain), M (Coastal), P (Phrygana), R (Ruderal), W (Woodlands and scrubs).

Most of the endemic taxa of Peloponnese are present on cliffs (30.57%) and high-mountain habitats (27.13%). They are also largely found in phrygana (28.54%) or grasslands (22.67%). Unlike these rates, these taxa are rarely found in woods (12.75%), ruderal (7.89%), coastal (6.68%) or aquatic (1.21%) habitats.

Most of the taxa are to be found on a unique type of habitat (324 taxa, 65.6%). However, some of the Peloponnese endemics can grow in two (159 taxa, 32.2%), three (7 taxa, 1.42%) or four (4 taxa, 0.81%) habitat types.

Their concentration on mountainous areas is well illustrated on the distribution map of the endemic taxa of Peloponnese, where hotspots can be found for the main summits of the region, and under the protection regime of the Natura 2000 Network (Figure 5).

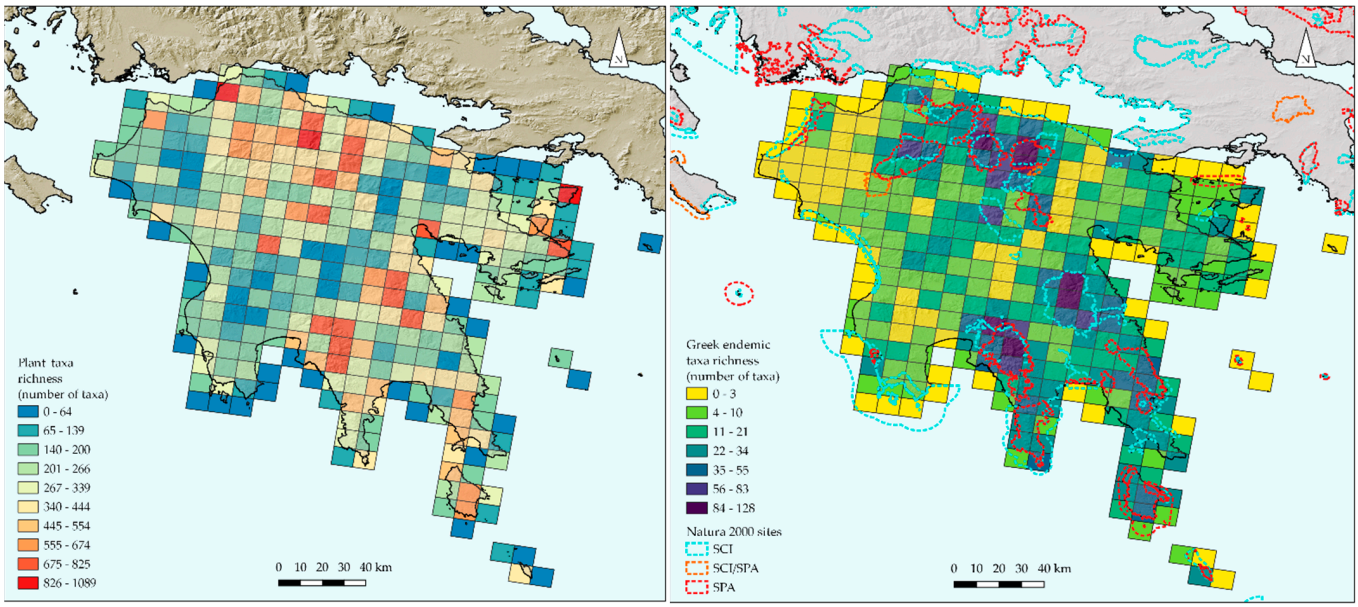

Figure 5. Distribution of the general flora of Greece in Peloponnese, in terms of taxa richness per area (**left**); Distribution of the endemic taxa of Greece in Peloponnese in terms of taxa richness per area, compared to the Natura 2000 network sites (**right**).

3.4. Endemic Flora Properties and Chemical Compositions

3.4.1. General Results on Ecosystem Services

According to the literature review, 122 taxa are checked for at least one of the 6 categories of ecosystem services (24.7% of the endemic flora). This represents 81 genera (47.4% of the endemic genus diversity) with the main ones as follows: *Crocus* (six taxa), *Alkanna*, *Centaurea*, *Limonium* and *Stachys* (four). The 122 taxa belong to 33 families (67.3% of the endemic family diversity), with the main families being: Lamiaceae (20 taxa), Asteraceae (14) and Boraginaceae (nine taxa) (Table 2).

Focusing only on the medicinal and aromatic properties, 63 taxa (12.8%) appear to have previously been studied or documented for aromatic, medical, traditional uses or/and antimicrobial properties. These taxa belong to 22 different families, which represent 44.9% of the Peloponnese endemic family diversity.

More precisely, among the 122 endemic taxa that appear to be ecosystem services providers (ESP) for one or several ES, the most quoted category is related to environmental properties: 83 taxa are checked for these criteria, representing 16.8% of the endemic flora of Peloponnese. The next two main categories are antimicrobial properties, with 37 taxa (7.49%), and medical applications (35 taxa, 7.09%), followed by aromatic (17 taxa, 3.44%) and traditional medicine uses (10 taxa, 2.02%) (Table 3). The industrial and craftsmanship uses have not been mentioned as ecosystem services for the endemic plants.

Table 3. Summary of the ecosystem services provided by the endemic taxa of Peloponnese.

	Aromatic	Medical	Traditional Medicine	Antimicrobial	Environment Benefit
Taxa with proved properties	13	28	8	31	71
Taxa with suspected properties	4	3	2	0	11
Taxa with a property proved to be absent	0	4	0	6	1
Total number of taxa with documentation for this category of properties	17	35	10	37	83
Total number of taxa with documentation for this category of properties in %	3.44	7.09	2.02	7.49	16.80
N° of genera concerned	14	27	9	30	56
N° of families concerned	8	12	7	14	26

In addition, scientific articles have studied the genetics (number of chromosomes, use for genetic analysis) of 100 taxa (20.24%), and a prognostic on the threat level of the species has been provided for 26 taxa (5.97%).

Nevertheless, among the 494 endemic taxa of Peloponnese, 372 taxa, 90 genera and 16 families remain unstudied for their ecosystem services. Seventy-four (74) taxa are only studied for their genetics or mentioned as endangered, 11 are analyzed only for the chemical composition of their essential oils, and 287 are not studied at all (58.1%).

3.4.2. Aromatic

Among the 17 taxa documented or quoted as aromatic, five are part of the Lamiaceae family, three are Asteraceae, three are Brassicaceae, and the six remaining taxa belong to Fabaceae (two), Chenopodiaceae (one), Hyacinthaceae (one), Iridaceae (one) and Liliaceae (one). At the genus level, the endemic *Brassica*, *Centaurea* and *Sideritis* (two taxa each) are the most represented.

In order to document the aromatic properties, any use as food ingredients (15 taxa), beverages (six), food preservative (two) or perfume (one) were thought as validation (Table 4). The species closely related to cultivated edible plants are also taken into account in the 'Food use' (*Brassica cretica* subsp. *cretica* and *laconica*, *Beta nana*, *Crocus cartwrightianus*).

Table 4. Aromatic properties documented for the endemic taxa of Peloponnese (x: taxa with proved properties, M: taxa with suggested properties).

	N° of Pe. Endemic Taxa Concerned		
Properties	**x**	**M**	**Total**
Food use (spice/food/aromatic)	10	5	15
Food use (beverage)	6	0	6
Food preservative	1	1	2
Perfume/Fragrance/Incense	0	1	1

3.4.3. Medical

Twenty-seven (27) genera contain the 35 endemic taxa of medical interest. The genera with the most of these taxa are *Centaurea* and *Stachys* (three taxa each), *Crocus*, *Nepeta*, *Marrubium* and *Sideritis* (two taxa each). The families documented for 'Medical' plants are 12, with the main ones being: Lamiaceae (11 taxa), Asteraceae (six) and Fabaceae (four).

Among the families containing endemic taxa, two have all their endemic taxa documented as far as their medical interest is concerned: Paeoniaceae and Pinaceae, having one taxa endemic to Greece each. However, 38 families are not documented at all, as Rubiaceae (which contains 23 endemic taxa), Campanulaceae (18) or Plumbaginaceae (15). The same can be stated at the genera level: 27 genera have at least one study describing

one medicinal property for each of their species (e.g., *Abies*, *Beta*, *Crataegus, Geranium, Melilotus,* etc.), whereas 145 genera have no endemic species investigated for medicinal purposes: *Hieracum* (16 endemic taxa), *Limonium* (15), *Asperula* (14), *Dianthus* (nine), etc.

From the list of potential properties for the 'Medical' category, only 17 different applications have been medically proven or suggested for the endemic taxa of Peloponnese (Table 5). The main properties are: anticancer and/or cytotoxic (20 taxa in total), antioxidant (19 taxa affected) and estrogenic (6 taxa concerned).

Table 5. Medical properties documented for the endemic taxa of Peloponnese (x: taxa with proved properties, M: taxa with suggested properties, No: taxa documented on the absence of a property).

	N° of Pe. Endemic Taxa Concerned			
Properties	**x**	**M**	**No**	**Total**
Antioxidant/Radical scavenging	17	1	1	19
Anti-tumor/Anticancer	12	0	1	13
Cytotoxic	8	1	1	10
Estrogenic/Vs Endometriosis	4	0	2	6
Anti-inflammatory	5	0	0	5
Health, fertility or DNA risk	1	1	1	3
Enzyme inhibition	2	1	0	3
Anti-acetylcholinesterase/Anticholinesterase/ Antibutyrilcholinesterease	2	0	0	2
Antileukemic	1	1	0	2
Antianxiety/Antidepressive/Anxiolytic	2	0	0	2
Skin care	1	1	0	2
Bone protection	2	0	0	2
Antinociceptive/Pain relief/Analgesic	1	0	0	1
Anti-malaria	1	0	0	1
Immunostimulant/regulator, Homeopathy	1	0	0	1
Relaxant/Sedative/Anesthetizing	1	0	0	1
Hepatoprotection	0	0	1	1

3.4.4. Traditional Medicine

Ten (10) endemic taxa are part of folk medicine practices. The plants used are either Lamiaceae (four taxa), Alliaceae, Dipsacaceae, Fabaceae, Hyacinthaceae, Iridaceae or Scrophulariaceae (one taxon each). The only genus with more than one representative used in traditional medicine is *Teucrium*, with *Teucrium flavum* subsp. *hellenicum* and *Teucrium halacsyanum*. A total of nine genera are examined by this category.

Fifteen (15) types of properties have been mentioned for traditional applications. Most often, the targeted benefit is not stipulated (three taxa), however hemorrhoids, gastrointestinal, cough issues and astringent uses are the most often quoted uses (two taxa each) (Table 6).

Table 6. Traditional medicine properties documented for the endemic taxa of Peloponnese. (x: taxa with proved properties, M: taxa with suggested properties).

	N° of Pe. Endemic Taxa Concerned		
Properties	**x**	**M**	**Total**
Anti-inflammatory	1	0	1
Cicatrizant	1	0	1
Relaxant/Sedative	1	0	1
Tonic	1	0	1
Carminative	1	0	1
Skin care	1	0	1
Vs Eczema	1	0	1
Anti-hemorrhoids	2	0	2

Table 6. *Cont.*

	N° of Pe. Endemic Taxa Concerned		
Properties	**x**	**M**	**Total**
Gastrointestinal protection	2	0	2
Digestive	1	0	1
Anti-asthmatic	1	0	1
Expectorant/Antitussive	2	0	2
Vs Respiratory illnesses	1	0	1
Astringent	2	0	2
Other traditional uses	1	2	3

3.4.5. Antimicrobial

The 37 endemic taxa documented as antimicrobial belong to 30 different genera, the most represented ones being *Marrubium* and *Stachys* (three taxa each), *Centaurea*, *Erysimum* and *Nepeta* (two taxa each). The main families among the 14 represented ones are: Lamiaceae (13 taxa), Asteraceae (six), Boraginaceae and Brassicaceae (three each).

Antibacterial applications are the most studied benefits for the Peloponnesian endemics, with 28 taxa proved to be efficient (5.7% of the endemic flora). Potential uses as antifungals (19 taxa) and antivirals (nine taxa) have also been mentioned, however mostly on the absence of effect (six taxa) of the former (Delitheos et al. published in 1997 a study investigating potential antiviral applications for a wide array of Greek taxa [30]) (Table 7).

Table 7. Antimicrobial properties documented for the endemic taxa of Peloponnese. (x: taxa with proved properties, M: taxa with suggested properties, No: taxa documented on the absence of a property).

	N° of Pe. Endemic Taxa Concerned			
Properties	**x**	**M**	**No**	**Total**
Antiviral	3	0	6	9
Antifungal	18	0	1	19
Antibacterial/Antiseptic/Desinfectant	28	0	0	28
Anti-yeast	1	0	0	1
Anti-parasitic	1	0	0	1

3.4.6. Environmental Benefit

The environmental benefit or appeal is the most represented ecosystem services' type in terms of number of documented taxa: 83 taxa are quoted for one or several properties which represent 56 genera and 26 families. The main genera are *Crocus* (six taxa), *Limonium* (four), *Achillea*, *Campanula* and *Alkanna* (three each). The most represented families for this category are: Lamiaceae (ten), Apiaceae and Asteraceae (eight each).

The environmental benefit of the endemic taxa is distributed into 9 different properties. The most popular one is the ornamental interest, mentioned or suggested for 41 taxa (8.30% of the endemic flora). The two following properties in number are related to a potential educational and conservation interest: the presence of the species on a historical site (castle, archeological site) for 16 taxa, and the cultivation of the species in a botanical garden for 14 taxa. Two important applications are related to the use of the plant for the management of insects (11 taxa) or habitats (soil restoration, adaptation to extreme conditions; 10 taxa) (Table 8).

Table 8. Environment benefits documented for the endemic taxa of Peloponnese. (x: taxa with proved properties, M: taxa with suggested properties, No: taxa documented on the absence of a property).

	N° of Pe. Endemic Taxa Concerned			
Properties	**x**	**M**	**No**	**Total**
Insect repellent, insecticide or molluscicide	10	1	0	11
Bee-attractant, melliferous	2	0	0	2
Host plant (for insects of interest)	3	1	0	4
Ornamental	33	7	1	41
Historical site flora	16	0	0	16
Herbicidal, cover crop, or plant protection/stimulation	3	0	0	3
Plant for restoration, depollution, extreme soil conditions	10	0	0	10
Habitat indicator, keystone species	0	1	0	1
Educational value (botanical gardens or touristic trails)	14	0	0	14

3.4.7. Spatial Distribution of Ecosystem Services

According to the results of the review regarding the ecosystem services of the endemic taxa in Peloponnese and to the distribution of their collection sites, a series of map linking spatial data and ecosystem services has been drafted in terms of hotspot representation (Figure 6). This hotspot analysis highlights: (a) taxa with identified aromatic properties are concentrated mainly at Mt. Taygetos and Mt. Menalon, and secondary at Mt. Killini, Mt. Erimanthos, and Mt. Panachaikon (Figure 6a); (b) taxa with identified medicinal properties are concentrated at Mt. Chelmos, Mt. Killini, Mt. Menalon, Mt. Parnonas, Mt Taygetos and at the area of Monemvasia; (c) taxa with identified traditional use(s) are concentrated mainly at Mt. Chelmos and Mt. Killini and secondary at Mt. Menalon, Mt. Parnonas and Mt. Taygetos; (d) taxa with identified antimicrobial properties are concentrated mainly at Mt. Chelmos and Mt. Killini and secondary at Mt. Menalon and Mt. Taygetos; (e) finally, taxa with identified environmental properties are concentrated mainly at Mt. Chelmos, Mt. Parnon and Mt. Taygetos and secondary at Mt. Killini, Mt. Menalon and Mt. Erimanthos.

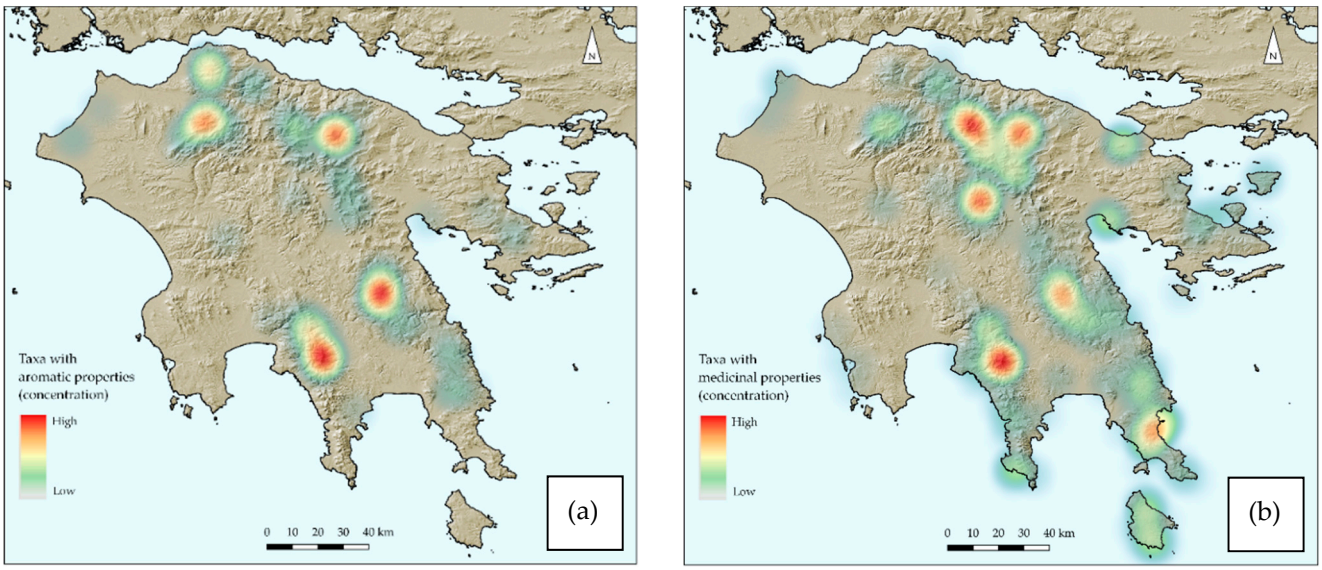

Figure 6. *Cont.*

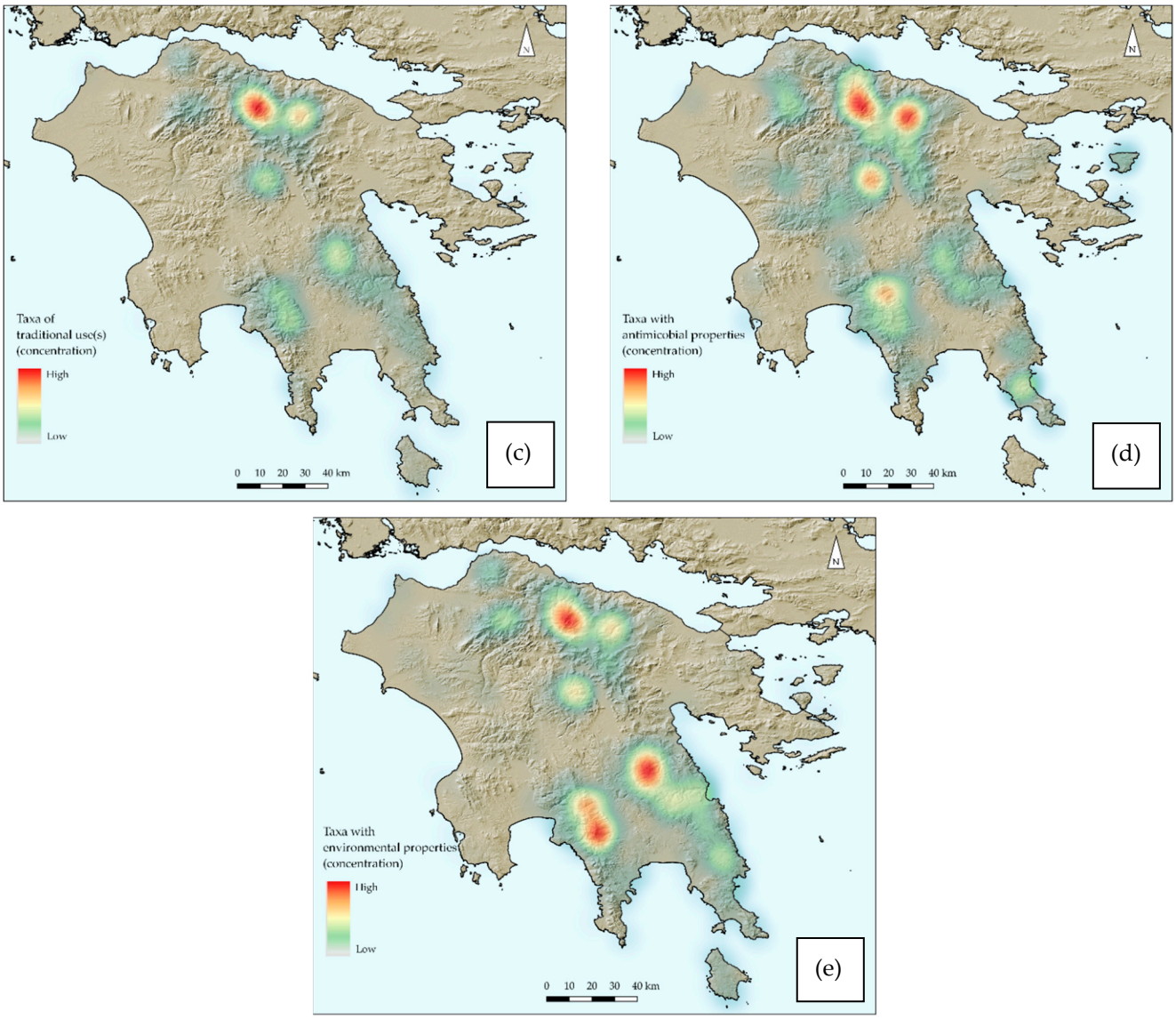

Figure 6. Distribution of the Greek endemic taxa in Peloponnese filtered by the ecosystem services they present: (**a**) Aromatic, (**b**) Medical, (**c**) Traditional medicine, (**d**) Antimicrobial and (**e**) Environmental benefits.

3.4.8. Essential Oils Main Components

Among the 494 Peloponnese endemic taxa, 75 of them (15.2%) have been analyzed for full or partial chemical composition analysis. A full chemical composition with percentages per component has been provided for 39 taxa (7.89%), whereas the 36 other taxa have been provided with insights on peculiar aspects of their essential oil composition (i.e., secondary metabolites, iridoids, flavonoids, fatty acids, carotenoids, punctual components of interest, etc.).

For the 39 taxa with fully analyzed compositions, one to six samples have been detailed. The vast majority of these samples belong to three families: Lamiaceae (44 samples for 17 taxa), Asteraceae (11 for eight taxa) and Apiaceae (10 for seven taxa); the other samples belong to 7 other families. The analysis of these samples shows a diversity of the 38 first components, with the main ones being: carvacrol (nine samples: Lamiaceae), thymol (seven samples: Lamiaceae), alpha-pinene (four samples: Apiaceae, Hypericaceae, Lamiaceae), germacrene D (four samples: Lamiaceae) and (E)-caryophyllene (four samples: Lamiaceae) (Table 9).

Table 9. List of the first components quoted in the composition of the essential oils of endemic plants of Peloponnese, with the number of samples that contained this first component.

Component	N° of Samples	Component	N° of Samples
Carvacrol	9	Beta-thujone	1
Thymol	7	Fragranyl acetate	1
alpha-pinene	4	Nopol	1
Germacrene D	4	Caryophyllene oxide	1
(E)-caryophyllene	4	Methyl chavicol	1
1,8-cineole	3	Geraniol	1
Nonanal	3	Linalool	1
gamma-terpinene	2	Methyl salicylate	1
trans-epoxypseudoisoeugenyl-2-methylbutyrate	2	Germacrone	1
Limonene	2	trans-phytol acetate	1
Camphor	2	Nepetalactone derivatives	1
cis-trans-nepetalactone	2	Spathulenol	1
p-cymene	2	Beta-copaene	1
Delta-cadinene	2	Beta-caryophyllene	1
Beta-elemene	2	Isoabienol	1
Sabinene	1	Alpha-cadinol	1
Germacrene B	1	Salicylaldehyde	1
Nonacosane	1	Ethyl palmitate	1
2-phenylphenol	1	Verbacoside-like compounds	1

Some taxa are to be remembered as presenting a high concentration in one component, and could be considered valuable sources of active compounds. Among them, *Thymus leucospermus* (Lamiaceae) is rich in carvacrol (93.4%) or thymol (92%), *Origanum scabrum* (Lamiaceae) in carvacrol (74.86%) and *Paeonia mascula* subsp. *hellenica* (Paeoniaceae) in salicylaldehyde (74.7%).

3.5. Non-Endemic Flora Additional Dataset

To evaluate the potential of endemic plants that have rarely been studied for their ES, the review extended onto non-endemic taxa, related to endemic taxa by taxonomy or phylogeny.

3.5.1. Taxonomy Relatives' Properties

On a taxonomic basis, 315 taxa non-endemic to Peloponnese have been documented as related subspecies or covering species for 120 endemic subspecies (see Table S4 as Supplementary Materials). These additional taxa are unequally shared among the different species: *Anthemis cretica* covers 20 subspecies including a single Peloponnese endemic, *Crocus biflorus* 19 subspecies for one endemic, and *Hieracium hypochoeroides* 18 subspecies for two endemics, whereas most of the other species present fewer subspecies. An irregular repartition of the taxonomic relatives is also observed at the family level: they belong to 22 families but mostly concentrate in Asteraceae (80 taxa), Lamiaceae (71), Fabaceae (47), Gentianaceae (41) and Caryophyllaceae (31). In spite of this lack of homogeneity, the taxonomic relatives suggest potential new applications to a significant number of endemic taxa: among the 120 endemic taxa for which non-endemic taxonomic relatives have been found, 88 taxa are taxonomically linked to relatives with ecosystem services.

One-hundred and seven (107) taxa out of the 315 non-endemics (34.0%) have been quoted as ecosystem services providers (ESP). Taking into account the articles assessing and suggesting the presence or absence of a property, the total numbers of taxa per type of properties are as follows: 40 aromatics, 50 medical taxa, 50 used in traditional medicine, 46 with antimicrobial applications, 60 with environmental interests and eight of use for industry or craftsmanship. The most quoted properties are antibacterial (49 taxa), antioxidant (37), food use as aliment or spice (30) and ornamental (26).

3.5.2. Phylogeny Relatives' Properties

On a phylogenetic basis, 325 taxa have been mentioned as linked to endemic taxa (see Table S5 as Supplementary Materials). Among these are: (a) 42 endemic taxa proved to be genetically linked to another endemic taxon; (b) 26 non-endemic taxa proved to be linked both phylogenetically and taxonomically to some endemic taxa; (c) 257 non-endemic taxa only genetically linked to Peloponnese endemic taxa.

The main families represented in these three (a, b, c) classes are Caryophyllaceae (50 taxa), Asteraceae (44), Lamiaceae (27), Apiaceae (25) and Campanulaceae (20); while 15 families are deprived of phylogenetic studies including Peloponnese endemics.

These 325 taxa proved to be related to 161 endemic taxa. Here again, all endemic species are not exploited as material for phylogeny analysis, and the ones that do are not linked to the same number of taxa. The taxa with the highest number of related non-endemic species are *Bupleurum greuteri* (13), *Helianthemum hymettium* (9), *Nigella arvensis* subsp. *aristata* and *Nigella stricta* (8).

Among the 325 phylogenetically-related taxa, 155 (43.1%) are mentioned as ESP, including 29 endemic-to-endemic relatives, nine taxa linked by both taxonomy and phylogeny and 117 non-endemic taxa related only through phylogeny. They suggest new properties to 103 endemic taxa. In total (proved, suggested, absent or detrimental properties counted), the numbers of taxa per property type are the following: 50 aromatics, 70 taxa of medical interest, 74 included in folk medicine, 61 with antimicrobial effects, 80 of environmental interest, seven with industry or craft applications. The main applications to be noted are: antibacterial (55 taxa), antioxidant (54), food use as aliment or spice (36) and anticancer (33).

3.5.3. Taxonomy and Phylogeny Relatives' Main Components

In addition to the endemic taxa, the compositions of 20 taxonomic relatives and 17 phylogenetic relative taxa have been mentioned. This data can suggest potential components of interest for 27 endemic taxa to which they are related.

The 63 samples of non-endemic plants studied for their compositions belong to 15 different families, with the main represented being: Asteraceae (20 taxa), Apiaceae (seven taxa) and Veronicaceae (seven taxa). They present 40 different first components (Table 10). The most common ones are: 2-undecanone (five samples: three subspecies of *Ruta chalepensis*, Rutaceae) and (E)-beta-farnesene (four samples: Apiaceae). In the same way as for endemic species, some non-endemic relatives are noticeable for the concentration they present in peculiar components: *Silene saxifraga*'s fragrance (Caryophyllaceae) is rich in methylbenzoate (96.1%), one sample of *Anthemis cretica* subsp. *albida* (Asteraceae) contains 80.57% of camphor, three samples of *Geocaryum cynapioides* (Apiaceae) contain much (E)-beta-farnesene (57.7%, 66.6% and 73.3%).

Table 10. List of the first components quoted in the composition of the essential oils of non-endemic plants, with the number of samples that contained this first component.

Component	N° of Samples	Component	N° of Samples
2-undecanone	5	(E)-2-hexanal	1
(E)-beta-farnesene	4	Chlorogenic acid	1
1,8-cineole	3	6-methyl heptan-2-ol	1
Borneol	3	Decanal	1
Camphor	3	Linalool	1
Beta-pinene	3	Methylbenzoate (in the fragrance)	1
Palmitic acid	3	Longifolen aldehyde	1
Germacrene D	2	Tetradecene	1
Chamazulene	2	n-nonane	1
Hexadecanoic acid	2	Alpha-pinene	1

Table 10. *Cont.*

Component	N° of Samples	Component	N° of Samples
Caryophyllene oxide	2	(E)-β-ocimene	1
Hexahydrofarnesyl acetone	2	(−)-α-pinene	1
Trans-p-mentha-1(7),8-dien-2-ol	2	Safranal	1
Myristicin	1	E-Phytol	1
Gamma-terpinene	1	Bornyl acetate	1
Eucalyptol	1	Limonene	1
Spathulenol	1	Carvacrol methyl ether	1
Beta-caryophyllene	1	Beta-elemene OR carvacrol methyl ether OR beta-pinene	1
Nonacosane	1	2-nonanone	1
4-vinyl-guaiacol	1	Methyl eugenol	1

It is, nevertheless, important to keep in mind that due to the amount of data on some non-endemic taxa, a considerable number of composition-related articles have not been treated by the review and that more components and non-endemic taxa of chemical interest could emerge.

3.6. Cross Analysis between Endemic and Non-Endemic Datasets

In order to use the data on non-endemic species in the analysis of endemic species, a comparison of the properties of non-endemic taxa with the list of related endemic taxa has been conducted. As mentioned previously, 315 taxonomy-related taxa are linked to 165 endemic taxa while 325 phylogeny-related taxa are associated with 160 endemic taxa, for a total of 272 relatives both categories confounded. Peloponnese endemic taxa present up to 19 taxonomic relatives (with an average of 1.2 related taxa) and up to 13 phylogenetic relatives (average of 0.8 taxon).

However, all these relatives have not been documented as ESP. Eventually, 253 relative taxa with properties prove to be linked to 154 endemic taxa. Among these, 107 taxonomy relatives suggest potential properties for 88 endemic taxa, while 155 phylogenetic relatives with properties are linked to 103 endemic taxa. Among the phylogenetic relatives, 29 endemic taxa are counted, with properties for which a genetic link to another endemic taxa has been proven, nine (9) taxa linked both taxonomically and phylogenetically to a same or different taxa, and 117 non-endemic taxa linked only on phylogenetic basis.

Using only the available data on their own properties, 122 endemic taxa are highlighted as potential ESP (24.7% of the endemic flora). If the properties of their relatives are taken into account as suggestions of potential benefits for the endemic taxa, the list of endemic taxa with potential climbs up to 216 taxa (43.7%), supported by an increase in the number of potential taxa for each properties' category (Table 11).

Different profiles are present in the list of 216 endemic taxa of potential: 63 taxa are only documented for their own properties as no relatives come to extend their dataset, 60 taxa are mentioned for having potential properties thanks to the combination of their own and the relatives' datasets, 93 taxa are only suggested as potentially beneficial based on their relatives' dataset.

As the number of taxa with potential properties increases, the number of potential properties per taxon also rises (Table 12). The number of taxa presenting three or more properties goes from 13 (2.63% of the endemic flora) to 97 (19.6%), with noticeably six taxa that are newly suggested for the whole six categories of properties: *Anthemis cretica* subsp. *panachaica* (Asteraceae), *Lonicera alpigena* subsp. *hellenica* (Caprifoliaceae), *Centaurium erythraea* subsp. *limoniiforme* (Gentianaceae), *Abies cephalonica* (Pinaceae), *Nigella arvensis* subsp. *brevifolia* and subsp. *aristata* (Ranunculaceae). If the addition of the relatives' datasets provides an average of 0.76 new property per endemic taxon, five taxa are suggested for six new properties while having no original application.

Table 11. Comparison between the endemic taxa's own properties and their potential properties based on the related taxa dataset.

	Aromatic	Medical	Traditional Medicine	Antimicrobial	Environment Benefit	Industrial/Craft	Total
N° of endemic taxa with own properties	13	28	8	31	71	0	122
N° of endemic taxa with potential properties based on the comparison with their relatives	62	108	79	107	153	15	216
Factor of augmentation	×4.77	×3.86	×9.88	×3.45	×2.15	+15	×1.77

Note: The first line summarizes the number of endemic taxa documented for each category of properties, the second line counts the number of endemic taxa with ESP taxonomic or phylogenetic relatives and/or own properties. The factor of augmentation is the division of the values of the second line by the values of the first: it represents the increase in the number of taxa with potential properties allowed by the extension of the dataset. For the Industrial/Craft uses, the factor of augmentation is noted as the number of additional taxa, as no endemic taxa was documented for this category.

Table 12. Impact of the addition of the extended dataset (own properties + taxonomy relatives properties + phylogeny relatives properties) to the literature related to the ecosystem services provision of the endemic species of Peloponnese on the number of endemic taxa with suggested properties.

Total Number of Categories of Property per Taxon	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Number of concerned endemic taxa based on their own documentation	372	77	32	11	2	0	0
Number of concerned endemic taxa based on the extended dataset (own + taxonomy + phylogeny relatives)	278	76	43	37	24	30	6
Number of categories of properties added to each endemic taxon by the addition of the extended dataset	**+0**	**+1**	**+2**	**+3**	**+4**	**+5**	**+6**
Number of endemic taxa concerned by the addition of suggested categories of properties	356	36	34	28	20	15	5

Note: On the first line of the first table, a taxon counted in the '4' column is documented as presenting four out of the six categories of properties. On the second line of this table, a taxon counted in the '4' column is suggested as potentially pertinent for four categories thanks to its own properties or to the existence of gifted related species. On the second part of the table, a taxon counted in the '+4' column is suggested for four more categories than its initial own properties thanks to the consideration of gifted related species.

4. Discussion

4.1. A wide Diversity Accurate to Greek Flora

With 494 endemic taxa, Peloponnese presents the highest number of Greek endemic taxa for a region in Greece. On a previous edition of the Vascular Plants of Greece [14,15], as its list only counted 468 endemic taxa, Peloponnese had the most important proportion of endemic species and subspecies in terms of total number of taxa and the second most important endemism rate (percentage of endemic taxa within the flora of a region) after the Kiklades (Cyclades) (14.6% for Peloponnese against 17.6% for Kiklades).

The content of its diversity is in agreement with the endemic flora of Greece as presented by Dimopoulos et al.: the genera with the most endemic taxa are for both Greece and Peloponnese *Limonium* (79 taxa in Greece and 15 in Peloponnese), *Centaurea* (76 and 17), *Hieracium* (73 and 20), *Campanula* (60 and 17) and *Silene* (53 and 21).

The pattern concerning the habitats rich in endemic species is equally similar between Greece and Peloponnese scales. The most frequent habitats are, for both, either cliffs, high mountains or phrygana.

The diversity of the endemic flora is also figured by the diversity in the essential oil compositions of the tested taxa: from 73 samples of 39 endemic taxa provided with full analysis, 38 first components have been extracted. The main ones, as carvacrol and

thymol, have already been specified for their high medical interest, for applications such as antimicrobial, antioxidant or anticancer [31,32].

The significant number of countries (36 countries) involved in the investigation of the Greek endemic flora present in Peloponnese highlights the importance of its endemic species for genetic, phytochemical and taxonomical stakes.

4.2. Gaps in the Knowledge of This Diversity

Despite its acknowledged scientific interest, the endemic flora of Peloponnese remains widely understudied for its ecosystem services. The average number of articles per taxon is 0.52 (including properties, status and genetic), whereas it reaches 1.37 for the full list of taxonomy relatives and 1.76 for the full list of phylogeny relatives. If the available data on some rare species reveals to be highly restricted (seven taxa with no search results on Google Scholar, 21 taxa with only one hit), the most striking figure relies on the 372 taxa that have not been studied for their ecosystem services yet, representing 75.3% of the endemic flora of the region. The lack of information also extends to the risk status which remains unevaluated or data deficient for 85.7% of this restricted flora.

In addition to this gap in terms of quantity of investigated endemics, an imbalance is visible on the repartition of the research effort among the different families. This effort is particularly concentrated on Lamiaceae and Asteraceae taxa; both these families representing 27.9% of the endemic taxa with documented ecosystem services and 64.1% of the taxa with full essential oil composition described. The interest in these two families is legitimated by traditional and medical uses as well as by their proportion among the endemic flora, the easy extraction of their essential oils and an abundant scientific background on the properties of their more common species. It should, however, not obstruct the high potential of rare taxa from other families. The discrepancy also shows in the variety of phylogenetic studies, as 15 families out of 49 (30.6%) are not provided with phylogenetic investigations, and are thus deprived of phylogenetic relatives in the context of this article (e.g., Alliaceae, Globulariaceae, Polygalaceae, Rutaceae, etc.).

The diversity of documented properties is another subject of imbalance, at the scale of a genus as well as at the scale of the whole endemic flora. The environmental benefits are the most frequently quoted properties for the endemic taxa (71 taxa). There is nonetheless a proportion of these benefits that relies on the observation of punctual and indirect assets for aesthetic and educational purposes, such as the display in a botanical garden (17 taxa) or presence on a historical site (16 taxa). For the medicinal properties, priority is given to antimicrobial or antioxidant applications which require well-defined and accessible in vitro protocols, leaving aside uses such as skin care or gastrointestinal treatments, for instance, which would require in vivo or at least more complicated experiments to set.

The small number of taxa investigated for their full essential oil composition confines the knowledge on the benefits of the essential oils, as the documented ones prove not only to contain molecules of interest, but also to develop them at high concentrations (*Thymus leucospermus* with carvacrol and thymol; *Paeonia mascula* subsp. *hellenica* with salicylaldehyde, a compound that once derived can have antibacterial, antitumor or fluorescence properties) [33,34].

As mentioned by Cheminal et al. [24], the reasons for these gaps of knowledge can be various, e.g.,

- Complicated access to the natural habitat of the species and localization of the growth spot,
- Limited plant material for small populations, which limits both the quantity of analysis and the potential ulterior applications,
- Limited productivity in essential oils for several families,
- Lack of relevance in the scientific context of one laboratory,
- Lack of time, workforce and funds,
- Lack of appeal for families with no well-acknowledged properties, etc.

4.3. Evaluating the Potential of Endemic Plants through Related Taxa

The review on the taxonomic or phylogenetic bounds between endemic and non-endemic taxa is used formally for the first time in the analysis of endemic flora's ecosystem services. It allowed to considerably widen the scope of the study. Associating these related taxa to their endemic cousins permitted to suggest additional properties for 88 endemics based on taxonomy and 103 endemics based on phylogeny, leading to a total of 154 taxa with completed properties potential. The number of potential applications improves in quality and in quantity, with the number of properties categories per taxon jumping from 0.37, without the addition of relatives' data, to 1.12 after, including some 65 uses that have not yet been studied for endemic taxa, such as treatment in case of mental disorders, fever or bladder issues. Some precaution needs to be taken for the 'Traditional medicine' and 'Environmental benefit' categories being tightly dependent to the spatially limited knowledge of local inhabitants or to punctual presence in gardens or historical sites, and thus being less 'extensible' properties from non-endemics to endemics.

Moreover, the addition of this dataset suggests other chemical composition patterns, with main components such as 2-undecanone or (E)-beta-farnesene, that have not been found among endemic taxa yet. These two components have been extracted from Rutaceae and Apiaceae taxa, whereas most of the endemic taxa analyzed belong to Lamiaceae and Asteraceae. A wider range of investigated families would then allow to discover more diverse chemicals of interest, in concentrations that may prove of use for their production.

Practically, if the investigation of related taxa can bring a denser and more diverse array of properties suggestions, it also shares the research effort with multiple research teams, study specialties and countries, evolving from 36 countries invested on the study of Greek endemics of Peloponnese to 83 countries mentioning their relatives. This helps to buffer the low amount of data targeting endemic species and to enlarge the evaluation of their potential.

Nevertheless, for chemicals as well as for properties, the extension of non-endemic datasets as relevant to endemic taxa only leads to the definition of characteristics that become more likely to be discovered in the concerned taxa. As chemicals and properties are not only dependent upon genetics and taxonomy but also on environmental conditions (i.e., climate, soil, light, disturbance, season, etc.), the purpose of this part of the article is not to conclude on the effective presence of properties in taxa, but to nominate some taxa as of priority for further studies. We therefore highlight the following taxa as the ones presenting either/both the higher number of relatives with properties, of suggested property categories or of total weight in terms of articles for their relatives: *Achillea taygetea* and *Anthemis cretica* subsp. *panachaica* (Asteraceae), *Rindera graeca* (Boraginaceae), *Lonicera alpigena* subsp. *hellenica* (Caprifoliaceae), *Centaurium erythraea* subsp. *limoniiforme* (Gentianaceae), *Crocus biflorus* subsp. *melantherus* (Iridaceae), *Ballota nigra* subsp. *anomala, Lamium garganicum* subsp. *pictum, Sideritis clandestina* and its two subspecies *clandestina* and *peloponnesiaca* (Lamiaceae), *Abies cephalonica* (Pinaceae), *Nigella arvensis* subsp. *brevifolia* and subsp. *aristata* (Ranunculaceae).

Noticeably, even with the addition of this dataset, the gaps of knowledge are still visible; especially concerning some families that have a contrast between a considerable number of endemic taxa but a low number of documented properties: Campanulaceae (18 endemic taxa, three documented for their own environmental properties, and three by extended properties), Plumbaginaceae (15 endemic taxa, four documented for their own environmental properties, and one by extended properties), Alliaceae (14 taxa, one with documented properties and one with supposed environmental interest), Poaceae (11 taxa, only one with extended properties) or Colchicaceae (six taxa, only one with own supposed ornamental interest). Nine families of smaller sizes are deprived of properties even with the extension: Aceraceae, Convolvulaceae, Fumariaceae, Isoetaceae, Linaceae, Orobanchaceae, Polygalaceae, Resedaceae, Saxifragaceae.

4.4. Stakes and Clues for the Protection of Important Flora

The vast majority of the Greek endemic plant taxa is considered under threat in general, while the mountain massifs of Peloponnese are rendered as threatened Greek endemic hotspots [35]. Based on the results of our study, the current extent of the Natura 2000 network seems to provide a concrete protection scheme for the Greek endemics of Peloponnese, safeguarding simultaneously the ES that they provide or could potentially provide. However, concrete measures and actions should be integrated for MAPs in the current protection scheme by the -under development- Special Environmental Studies for the Natura 2000 sites of Peloponnese, that propose protection zones within each Natura 2000 sites, where specific actions and projects will be allowed [36]. Moreover, identification, current assessment and thematic mapping of MAPs' and relevant ES' hotspots support the national efforts for the MAES implementation in Greece [17] and provide baseline data for relevant indicator development.

In order to provide a new tool for the protection of endemic flora, the present method adding non-endemic relatives to the endemic knowledge could be formalized into an indicator. With the goal of evaluating the ESP potential of under-documented taxa, this literature-based indicator could be an accessible and numbered argument in favor of the protection of ES-rich areas or of rare MAP taxa, reinforcing the current conservation processes.

4.5. Implications for Sustainable Rural Management

Based on the results of our study, the components, properties, and the unique genetic resources that render the profile of the endemic MAPs a valuable, natural resource for a variety of ES, points out their importance as a well-being element of the countryside. Already in the Peloponnese, endemic MAPs are under collection threat in the wild and relevant monitoring programs are ongoing by the Greek authorities (personal communication with the Management Unit of Chelmos-Vouraikos National Park and the protected areas of north Peloponnese). Moreover, their importance as valuable ES is recently rendered by the field-based assessment for local scale MAES implementation at the National Park of Chelmos-Vouraikos, by Tsakiri et al. [37]. By this, it is evident that MAPs are an integral part of rural practice, supporting traditional uses, local, agricultural income and needs [24,38]. However, the added value that can be provided by Greek and local (e.g., Peloponnesian) endemics should be taken into account in the agricultural practice and the national agricultural strategy, since the provisions of the European Green Deal [39] support biodiversity sustainable agricultural products and schemes. Practice can be developed by identifying suitable areas for endemic MAPs cultivation, using habitat suitability models (e.g., [40]) and suggest their being priority sites for MAP cultivations and/or for agro-tourism, thematic parks. By this, MAPs will be sustainably exploited as a unique and important part of the natural capital of Greece.

5. Conclusions

The flora of Peloponnese comprises 494 endemic taxa, belonging to 49 families. However, only 122 taxa (24.7%) have been documented as ecosystem services providers (ESP) with a total of 222 articles investigating their properties, mainly issued by Greek research teams (97 articles alone and 20 under international cooperation). The main categories of properties are linked to environmental benefits (83 taxa), antimicrobial uses (31) or medical applications (28). To widen the evaluation of the potential of endemic plants as ESP, the review gathered information on 315 non-endemic but taxonomically related taxa and 325 taxa related by phylogeny. Among them were 253 relatives with properties. They suggest potential properties to 154 endemic taxa, bringing the total number of endemic taxa with ESP potential to 216 (43.7% of the endemic flora). This article aims to demonstrate new methods for the consideration of endemic taxa: first by taking them into account as valuable ESP and not only as rare taxa; then by implementing their scarce evaluations as ESP by the addition of data on related species. This study is a first com-

prehensive review on the properties of endemic taxa of Peloponnese, meant as a basis for a wider study on the endemic species of Greece led by the University of Patras and on the development of ESP potential indexes. It also acts as a guide to the knowledge gaps that would require further research and as an argument for the protection of rare flora and the sustainable management of Greek natural capital, in favor of the socio-ecological wellbeing.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su14105926/s1, Table S1: List of potential Peloponnese endemic taxa not taken into account for this study; Table S2: List of the properties gathered in each ecosystem services category; Table S3: Endemic plants of Greece present in Peloponnese and their documented ecosystem services; Table S4: Non-endemic taxa linked to the endemic flora of Peloponnese by taxonomy and their provision of ecosystem services; Table S5: Taxa linked to the endemic flora of Peloponnese by phylogeny and their provision of ecosystem services; Table S6: Complete bibliography of the review sorted by genus or by authors name.

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