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Methods

Indicators for the medicinal and aromatic potential of endemic plants in the Peloponnese (Greece)

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Abstract

The interest in new natural products and herbal raw materials increases in a variety of scientific and industrial fields, but many plant taxa of restricted distribution tend to be overlooked as potential assets. Their large number precludes their study and valorisation. Therefore, there is a dire need to develop tools for assessing the plant taxa potential as ecosystem service providers, to prioritise the research efforts and to enhance conservation priorities. With the aim of identifying taxa of interest as potential medicinal and aromatic plants (MAP), amongst the taxa of a given flora, we developed a set of indicators. These indicators are based on the available scientific literature and are formulated even for taxa of restricted distribution, based on their closely-related species in terms of phylogeny, taxonomy (same species or same genus within the flora) or in use as approved herbal medicine or edible crops. The developed indicators are herein applied to the endemic flora of the Peloponnese, a floristic region of Greece with high total - and endemic - species diversity. Even though only 12.5% of the endemic taxa have previously been documented as MAP, the use of indicators suggests 58.3% of the flora as

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of non-null MAP potential (Indicator I_1), while 74.1% of the taxa obtained a non-null value of Study Interest Index (Indicator I_2). The results suggest 25 taxa as of high MAP potential, whereas 24 taxa are emphasised as of high-priority for further studies. This is, to our knowledge, the first attempt to establish a systematic literature-based method to assess potentially significant edible, medicinal and/or aromatic taxa.

Keywords

medicinal plants, aromatic plants, MAP, ecosystem services, plant conservation, endemic, Flora of Greece

Introduction

Medicinal and aromatic plants have always been used for human needs, such as food, taste enhancement, food preservation, human or veterinary medicine, cosmetics and cultural uses (Giannenas et al. 2020). In the modern era, when society is facing the limits of synthetic drugs and aromas, nature-inspired solutions, based on plant ecosystem services and secondary metabolites, are pursued in many fields, either through scientific discoveries and/or through the valorisation of traditional knowledge (Aslam et al. 2016, Jamshidi-Kia et al. 2017). This interest cannot limit itself to a short selection of already acknowledged taxa: the study of Medicinal and Aromatic Plants (MAP) should consider the diversity of the World flora, in the context of increasing extinction risks (Brower 2008). Undocumented taxa are not necessarily deprived of properties of interest (Cheminal et al. 2020, Cheminal et al. 2022). The task of general MAP evaluation cannot be led simultaneously on all fronts. It requires the establishment of prioritisation rules, through which many promising taxa, their properties or distribution areas will not be ignored.

Relevant evaluation processes have been undertaken with different methods and purposes, to assess the benefits of plants that could be Ecosystem Services Providers (ESP). For instance, two recent studies have developed sets of parameters to define the alimentary or the medicinal and cosmetic potential of Neglected and Underutilised Plant species (NUP) from Crete, Tunisia and Morocco (Libiad et al. 2021, Bourgou et al. 2021). The indicators were developed with expert judgement and gathered in a spider chart with discreet values for use categories regarding their alimentary potential (e.g. wild edible greens, bee attraction, spice uses etc.) or their medicinal and cosmetic potential (e.g. ethnobotanical, phytochemical benefits etc). The same type of process has been applied to evaluate the ornamental benefits of Crete, Tunisia and Moroccan coast's floras, with 12 attributes related to cultivation suitability, ecological requirements and aesthetic characteristics, ranked, based on expert opinion (Krigas et al. 2021).

The calculation of an indicator to predict the specific properties of medicinal taxa has already been attempted by research teams (Liu et al. 2016), aiming to select taxa with high neuroprotective potential using an algorithm. In this case, the assessment was based on measurements (antioxidant capacity, inhibition of glycation, Aβ fibrillation,

AChE activity and neuroinflammation, plus in vivo tests) for a group of traditionally consumed taxa, focusing only on one medical application. Other indicators have been developed:

1. in Argentina for the evaluation of the harvesting pressure on medicinal plants, based mainly on their distribution, harvesting modes and uses (Martínez et al. 2006);
2. in India to measure their economic values in relation with their exploitation or consideration by different stakeholders (Suneetha and Chandrakanth 2006);
3. in Mexico and Tanzania for the homogeneity of traditional knowledge on medicinal plants as natural cures for specific categories of diseases (Heinrich et al. 1998, Schlage et al. 2000). These are a few examples amongst many of the conceptions of mathematical indicators to harness plants' potential and characteristics.

When it comes to the selection of promising taxa for research, scientists mostly base their choices on:

1. expert advice or knowledge;
2. specific genera known for their benefits or already studied locally;
3. high number of use reports in ethnobotanical studies;
4. observation of a plant's ecology (e.g. are herbivores consuming or rejecting the plant?, does it survive to extreme conditions? etc.).

Ningthoujam et al. (2018) compiled experimental or mathematical methods to predict plant medicinal properties and to find new pharmaceutical material. Amongst the most relevant to the present study, Rønsted et al. 2012) studied the patterns of metabolites' evolution, linking phylogeny and biosynthetic pathways, thus allowing a prediction of plants' compositions and properties. Computational tools, such as QSAR (Quantitative Structure-Activity Relationship) can also be used to link the structure of a molecule to its potential biological activity (Dhiman and Agarwal 2016, Bouarab-Chibane et al. 2019, Rajathei 2025). Gilca and Barbulescu 2015) correlated the taste of the plant and its ethnopharmacological use, according to Ayurveda traditions.

The present study aims to establish a taxonomic ranking, emphasising the evaluation of medicinal and aromatic potential, based on literature-derived data. A limited number of factors are here considered to play a role in the possession of medicinal or aromatic properties:

- The traditional uses of the taxon itself and/or the biological properties documented by studies;
- The chemical composition of the taxon itself;
- The properties and compositions of other taxa that could be considered as its "relatives", based on the taxonomic (belonging to the same genus or species) and the phylogenic relationships.

Should one taxon prove to be of interest, additional factors must be considered before it can be considered for further studies, for example, current extent of documentation, empirical uses etc. The extinction status of the taxon is also an important factor in its prioritisation for experiments: in the present article, a high IUCN status is considered as an argument to prioritise taxa that should be studied before their population size reaches a critical state.

In this article, we will present a new methodology using the example of the endemic flora of Peloponnese (south Greece):

1. we first explain the raw content of the dataset, its acquisition and categorisation: the dataset includes the ecosystem services provision of both MAP (medicinal, aromatic, edible uses) and non-MAP uses (environmental benefit, industrial application) by each endemic taxon, as well as their chemical composition, extinction risk status and literature sources;
2. we detail the dataset variables that are required to summarise the available data;
3. we formulate the indicators using these variables;
4. we validate the set of indicators by a test on a panel of Greek endemic taxa by comparison with expert knowledge;
5. we apply these indicators to the Greek endemic flora of Peloponnese.

The limits and application of such a method are eventually discussed, as well as the interest of its automation.

Material and methods

A formal methodology is developed that is systematically applied to the taxa of a selected flora, using only literature. It is based on a set of four indicators, described hereafter (Fig. 1). Amongst these four indicators, the two main indicators (i.e. I_1 and I_2) provide an insight into the MAP potential and the general interest for further study of the taxa into which they are applied, while two secondary indicators (i.e. I_{LIT} and I_{CHEM}) reveal the extent of knowledge available and the potential for pharmaceutical compound provision of these taxa.

Glossary and acronyms

In this article, the word '**taxon**' is used to define either a species, for example, *Anthemis cretica* (L.) or a subspecies, for example, *Anthemis cretica* subsp. *panachaica* (Halácsy) Oberpr. & Greuter.

To clarify the various categorisations included in the methodology, three specific terms will be used only for the following purposes: (a) "**types**" refer to the "types of taxa" (see Structure of the dataset: description of the rows); (b) "**categories**" refer to "categories of properties" (see Categories of properties); (c) "**groups**" refer to groups of plant-based chemical compounds (see Groups of components).

The abbreviations of **MAP** (Medicinal and/or Aromatic Plants) and **ESP** (Ecosystem Services Provider) are used regularly throughout the article.

The abbreviation **RNT** (Related Taxa Network) is introduced in the present article. It corresponds to all taxa that are 'close' to a selected taxon in terms of phylogeny and taxonomy. Amongst these related taxa, four types will be distinguished, including Species-Level relatives (**SL**) and Genus-Level relatives (**GL**) (see Structure of the dataset: description of the rows).

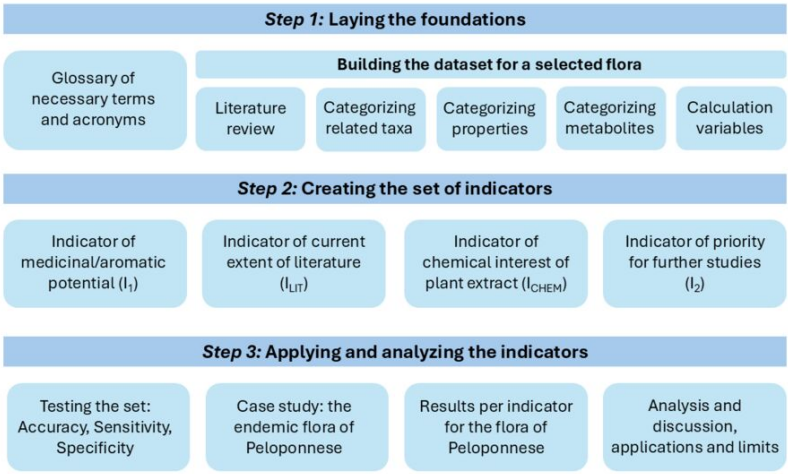

Figure 1.

Graphic table of the developed evaluation strategy.

Building the dataset, with the example of the case study on Peloponnese endemic taxa

Literature review

The data gathered on the existence of taxonomically and phylogenetically related taxa, as well as on the properties or chemical compositions of both endemic and non-endemic taxa, is extracted from Cheminal et al. (2022). All information regarding properties, composition, relationships between taxa, traditional uses and IUCN status is extracted from Cheminal et al. (2022) and IUCN (2022),and no additional field investigation was led in the framework of this study. This previous work consisted of an extensive literature review of the available knowledge on Greek endemic taxa present in Peloponnese. On search engines (Google Scholar, Scopus, Science Direct), each taxon was investigated with keywords as ["*name of the species*" + "x"], with "x" being alternatively "medicinal", "medical", "aromatic", "properties", "uses", "activity", "phylogeny", "components" or null.

Additional data were acquired on Herbal Medicinal Products, taxa that had not been integrated in Cheminal et al. (2022). The data related to their properties have been extracted from the European Medicines Agency, European Pharmacopoeia and the World Health Organisation (World Health Organization 1999, World Health Organization 2002, World Health Organization 2007, World Health Organization 2009, EMA 2022, EDQM 2023). The properties of the taxa mentioned by the European Medicines Agency or by the World Health Organisation were extracted from their description sheets on each platform. To define the exact properties of the taxa approved by the European Pharmacopoeia (EDQM 2023), a literature review was conducted on these taxa using Google Scholar with the keywords [“*name of the species*” + “overview”]. Only the results of the first page, if relevant, were considered. These results were complemented by the research of the keywords [“*name of the species*” + “medicinal”] or [“*name of the species*”] when there was still data deficiency.

All relevant information was gathered and analysed on spreadsheets for the calculation of indicators. The following subsections will describe the content of the main spreadsheet, forming the core of the database.

Structure of the dataset: description of the rows

One row of the dataset corresponds to one taxon. Five types of taxa are to be taken into account for this article.

The first type of plant taxa focuses on species and subspecies to which the set of indicators will be applied. In the present case study, the selected flora consists of the Greek endemic taxa found in Peloponnese. The list of 494 endemic taxa in the flora of Peloponnese (Greece), used for the present study, is extracted from the Flora of Greece Project’s Database (June 2024 version). Nomenclature and endemism status follow Dimopoulos et al. (2024). The existence of synonyms and/or related subspecies were controlled (POWO 2025, GBIF 2025) and taken into account during the review process.

In addition to this selected flora, four types of ‘related’ taxa are defined, according to their relationship with one or several taxa of the selected flora, as follows:

- ‘**Phylogeny relatives**’: taxa close to the studied taxon in a phylogenetic tree, i.e. separated by one to two nodes on the tree (moderate to strong correlation between the taxa, mostly bootstrap values of 70 and above for Maximum Likelihood method-based trees). Phylogenetic trees were sought in literature, using the keywords ["*name of the taxon*"+"phylogeny"].
- ‘**Species-level relatives’ (SL relatives)** : subspecies sharing the same species name (e.g., *Hieracium pannosum* subsp. *epiglossophyllum* (Arv.-Touv.) Greuter, *Hieracium pannosum* subsp. *euboeum* (Halácsy) Zahn etc.), including the base species itself if documented (e.g. *Hieracium pannosum* Boiss. sp.). This type of taxonomic relatives includes taxa from the selected flora as well as taxa not included in it.

- '**Genus-level relatives' (GL relatives)** : taxa of a selected flora sharing the same genus (e.g. amongst the endemic species of Peloponnese, *Crepis incana* Sibth. & Sm. and *Crepis heldreichiana* (Kuntze) Greuter are defined as GL relatives). This type of taxonomic relatives only includes taxa from the selected flora.
- '**Outstanding relatives**': taxa acknowledged for their outstanding benefits for pharmaceutical or food uses: (a) taxa approved for the production of herbal medicinal products [European Medicines Agency (EMA 2022), the European Directorate for the Quality of Medicines and Health Care in the European Pharmacopoeia (EDQM 2023) and the World Health Organisation (World Health Organisation 1999; 2002; 2007; 2009)] that belong to the same genus with the studied taxon ; (b) taxa of common use in alimentation and genetically and/or taxonomically related to the studied taxon (i.e. the studied taxon is considered as a Crop Wild Relative and is documented as such in literature) .

The indicators developed in the present study assume that a specific taxon is more likely to
present a property/ingredient if a closely-related taxon already possesses this property/ ingredient. This concept relies on the existence of common biosynthetic routes amongst closely-related taxa, leading to similar patterns of properties/components, even though inter-specific, intra-specific or intra-individual variations remain (Barra 2009, Rønsted et al. 2012, Teixeira da Silva et al. 2017, Ningthoujam et al. 2018). We define the concept of **Related Taxa Network (RTN)**, as the matrix of taxa that includes the studied taxon and all its close "relatives" (i.e. phylogeny, SL, GL, 'outstanding'). As they are considered closely related, they are expected to share common properties and each taxon of the RTN can 'suggest' properties for its relatives.

A single taxon only has one own RTN, that gathers all its types of relatives (phylogeny, SL, GL, 'outstanding'). An RTN is specific to a single taxon, as it relies on the literature (phylogeny, taxonomy) that namely refers to the taxon. For instance, if taxon A is documented as related to B, A will be in the RTN of B and B in the RTN of A. However, B may be documented by another reference as related to taxon C: A and C are in B's RTN, whereas C is not mandatorily in A's RTN (Fig. 2).

Many taxa will be documented by two or more articles for their properties and secondary metabolites. Therefore, each row will **summarise** the knowledge encountered for a single taxon during the literature review and stipulate in the adequate column the relevant references (e.g. if article n°1 documents the taxon as antibacterial and article n°2 mentions it as aromatic, the row dedicated to the taxon will note it as both antibacterial and aromatic, with articles 1 and 2 listed as references).

For the case study of Greek endemic taxa present in Peloponnese, in addition to the 494 endemic taxa, the dataset was enriched with **113 non-endemic taxonomic relatives (species-level relatives), 171 phylogeny relatives** (this includes 42 endemic taxa genetically related to other endemic taxa, 10 non-endemic taxa both SL and phylogeny relatives, 119 non-endemic taxa only phylogeny relatives) and **59 'outstanding' relatives**

(this includes 57 herbal medicinal products and three crop plants, *Crocus sativus* L. belonging to both).

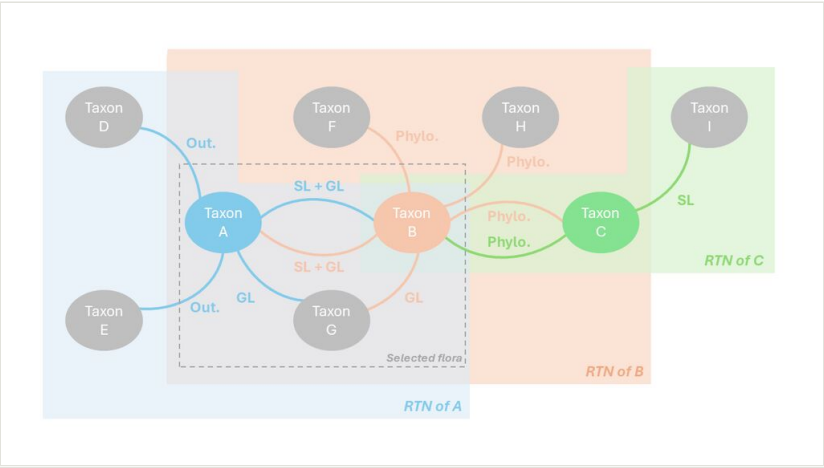

Figure 2.

Schematisation of three RTN s for three taxa A, B and C , including all types of relatives (phylogeny, SL, GL, 'outstanding') . If we study the selected flora, we will need to focus on the RTNs of A, B and G. The RTN of C is here given as an example for the independence of each RTN.

Structure of the dataset: description of the columns

Taxonomy

Four columns of the dataset are dedicated to the description of the taxon to which each row refers. These four columns consist of the 'Family', 'Genus', 'Species', 'Subspecies' of the taxon.

Categories of properties

As a basis for the analysis of properties for the plant taxa studied, the definition of categories clustering various related properties allows a simpler and more flexible process than if each property were considered individually. Up to now, Cheminal et al. (2020) and Cheminal et al. (2022) ranked **92** different properties in the following six categories: (a) Aromatic, (b) Medicinal, (c) Traditional medicine, (d) Antimicrobial, (e) Environmental benefits and (f) Industrial applications. Since we focus on the food uses and on the medicinal and aromatic properties of plants herein, another classification was necessary.

From various classifications suggested in literature, the more detailed categories are centred on medical applications (Schulz et al. 2001, Heinrich et al. 2017, Petrakou et al. 2020). For the present study, we adopted the Economic Botany Data Standards (Kew Royal Botanic Gardens 1995) since they better suit the dual purpose of estimating

whether they can be used as food and/or medicines, nutritional supplements and cosmetics. More specifically, four fields from these standards were exploited (reference codes in parentheses): food (0100), food additives (0200), vertebrate poisons (0900) and medicines (1100). These fields and their detailed categories are presented in Table 1. The correspondence between the 92 properties encountered by Cheminal et al. (2020, 2022) and the 25 selected property categories is included in Appendix A. These **25 categories of properties** form the 25 columns of the database dedicated to the ecosystem services supply by the taxa.

Table 1.

Categories of properties used for the compilation of the indicators, based on the Economic Botany Data Standards.

Note: The categories 1102 and 1108 are excluded from the indicators' compilation, as not relevant to the prediction of accurate medicinal/aromatic/food properties (Kew Royal Botanic Gardens 1995).

European code	Category	Code in index formulation
1100 - Medicines		
1101	Unspecified medicinal disorders	1
1102	Abnormalities	/
1103	Blood system disorders	2
1104	Circulatory system disorders	3
1105	Digestive system disorders	4
1106	Endocrine system disorders	5
1107	Genitourinary system disorders	6
1108	Ill-defined symptoms	/
1109	Immune system disorders	7
1110	Infections/Infestation	8
1111	Inflammation	9
1112	Injuries	10
1113	Mental disorders	11
1114	Metabolic system disorders	12
1115	Muscular-skeletal system disorder	13
1116	Neoplasms (tumours)	14
1117	Nervous system disorders	15
1118	Nutritional disorders	16
1119	Pain	17
1120	Poisonings	18
1121	Pregnancy/Birth/Puerperium disorders	19
1122	Respiratory system disorders	20
1123	Sensory system disorders	21
1124	Skin/Subcutaneous cellular tissue disorders	22
0100 - Food		
0101	Unspecified parts	23
0200 – Food additives		
0201	Unspecified parts	24
0900 – Vertebrate poisons		
0906	Mammals	25

On each row, a column is ticked when the taxon was proved to contain this category of properties. According to the literature source and the robustness of its information, a taxon is recorded as:

- experimentally proved to possess a property (**X**);
- used as folk medicine for an application, based on ethnobotanical studies or expert knowledge (**T**);
- not used for food or health applications in general, due to experimentally or empirically documented low benefits or toxicity (i.e. mutagenicity or DNA damage, risk to fertility, general toxicity) (**No**);
- "promising" plant material for a property (**M**), based on:
    - its chemical ingredients, for example, *Alkanna sfikasiana* Kit Tan, Vold & Strid, which may present antioxidant and enzyme inhibition properties as it contains disodium rabdosin (Tufa et al. 2019);
    - its documentation as Crop Wild Relative, belonging to the same genus with a species cultivated for food use, for example, *Cicer graecum* Orph. ex Boiss. is a wild relative of the cultivated *Cicer arietinum* L. (Stathi et al. 2020);
    - incidental proof, for example, *Teucrium halacsyanum* Heldr. is listed as aromatic and/or medicinal plant in the collections of the Kroussia Balkan Botanic Garden (Maloupa et al. 2005), even though no direct scientific proof of its properties has been found in literature;
    - "doubtful" recording due to the taxonomic misidentification of a taxon, for example, the Peloponnesian endemic *Lamium garganicum* L. subsp. *pictum* is mentioned as traditionally used for food and medicine in Iran (Ghalkhani et al. 2021).

Once the review process was complete, all data were summarised by property category and by taxon. To balance the various cases described above, the following priorities are defined for the process of summarisation: **X > T > M > No > Absence of result**. For instance, if an article suggests a taxon as an antioxidant based on its ingredients (M), whereas a second article experimentally proves its scavenging properties (X), the taxon will be considered a proven antioxidant (X). We note here our attention on the proven toxicity which should not be overridden by assumed medicinal impacts.

Groups of secondary metabolites

The chemical composition of plant extracts is considered predictive of their biological activities (Maisuthisakul et al. 2008, Ningthoujam et al. 2018) and, therefore, of their potential as medicinal or aromatic plants (MAP). To integrate this element into the set of indicators, the metabolites with the highest pharmacological interest within the plant extracts must be categorised. Eighteen groups of secondary metabolites of pharmacological interest suggested in literature (Kabera et al. 2014, Patel and Patel 2016, Antolak and Kregiel 2017, Plants for A Future 2023) and enriched with additional groups according to pharmacognosy standard publications (Bruneton 1995, Dewick

2002), are summarised in Table 2. These **18 groups of compounds** form the 18 columns dedicated to secondary metabolites in the dataset.

Table 2.

Groups of plant extracts' components of pharmacological interest, with examples of molecules and rich plant sources.

Number	Groups of components of pharmacological interest	Examples of molecules of these groups found in plants	Examples of occurrences in plant species
1	Alkaloids	Morphine Hyoscyamine	*Papaver somniferum* L. *Atropa bella-donna* L.
2	Anthocyanins & Proanthocyanidins	Cyanidin glycosides	*Rubus fruticosus* L.
3	Anthraquinones	Cascaroside	*Frangula purshiana* (DC.) A.Gray ex J.G.Cooper
4	Cardiac glycosides	Digoxin	*Digitalis purpurea* L.
5	Carotenoids & Apocarotenoids	Zeaxanthin, crocins	*Crocus sativus* L.
6	Coumarins	Coumarin	*Melilotus officinalis* (L.) Lam.
7	Diterpenes & other triterpenes (excluding steroids)	Siderol	*Sideritis raeseri* Boiss. & Heldr.
8	Flavonoids	Genistein	*Glycine max* (L.) Merr.
9	Iridoids	Nepetalactones	*Nepeta cataria* L.
10	Lignans	Pinoresinol	*Sesamum indicum* L.
11	Monoterpenes	1,8-Cineole	*Salvia fruticosa* Mill.
12	Naphthoquinones	Alkannin	*Alkanna tinctoria* Tausch
13	Saponin glycosides (steroidal and triterpenoid)	Diosgenin	*Trigonella foenum-graecum* L.
14	Sesquiterpenes	β-Caryophyllene	*Syzygium aromaticum* (L.) Merr. & L.M.Perry
15	Simple amino acid derivatives (cyanogenic glycosides, organosulphur compounds, glucosinolates)	Amygdalin Alliin Sinigrin	*Prunus amygdalus* Batsch *Allium sativum* L. *Brassica nigra* (L.) W.D.J.Koch
16	Simple phenolics (phenolic acids and their esters, glycosides, gallotannins)	Chlorogenic acid	*Sideritis raeseri* Boiss. & Heldr.
17	Steroids (phytosterols and others)	β-sitosterol	*Urtica dioica* L.
18	Stilbenes	Resveratrol	*Vitis vinifera* L.

On each row, a column is ticked if the taxon was proved to contain this group of compounds. The concentration of these groups in the plant extracts was taken into account and the ingredients were considered as present in significant amounts (X) or as traces (t).

References related to the taxon

Two columns of the dataset are dedicated to the account of the literature documenting the taxon for: (a) properties (both MAP and non-MAP properties) and (b) secondary metabolites. All relevant references are listed in the corresponding boxes.

Taxa relationships

A column is used to indicate whether the taxon is part of the selected flora or if it corresponds to one or several of the ‘relatives’’ types.

Four columns are necessary to mention to which other taxa the row of interest relates, as phylogeny, SL, GL or outstanding relative. The accurate tracking of a taxon’s relatives is important for the calculation of the indicators and may require anterior work on specific spreadsheets to ensure the proper connections between taxa.

All columns of the raw dataset are summarised hereafter (Table 3). The variables mentioned in the columns K to AD and the indicators of columns AE to AH will be described in the following sections.

Table 3.

Structure of the dataset: content of the columns. Note: the columns are counted as on a spreadsheet, from A to Z and then AA to AZ, BA to BZ etc.

Column numbers	Content
A to E	Taxonomy: Full name, Family, Genus, Species, Subspecies
F	Type of taxon for the RTN: selected flora or relatives (P, SL, OUT)
G to J	Names of relatives per type of relatives in the taxon's RTN (for taxa of the selected flora only)
K to N	Total number of relatives per category
O to S	Number of property categories per taxon of the RTN (individual number per taxon of the selected flora OR sum for all taxa per type of relative)
T to W	Number of articles per taxon of the RTN (individual number per taxon of the selected flora OR sum for all taxa per type of relative)
X to AA	Number of groups of components per taxon of the RTN (individual number per taxon of the selected flora OR sum for all taxa per type of relative)
AB to AC	Comparison between empirical and experimental knowledge
AD	IUCN extinction assessment for taxa of the selected flora
AE to AH	Values of the indicators I_1, I_{LIT}, I_{CHEM} and I_2 per taxon of the selected flora
AI to BG	DATA : Property categories (medicinal, aromatic) (27 categories)
BH to BY	DATA : Component groups encountered for the taxon (18 groups)
BZ to CA	DATA : Literature references documenting components/properties to the taxon

Calculation of the dataset's variables

To build the indicators, variables and parameters must be defined and calculated to summarise the raw data of the dataset. All variables and parameters, their signification and source data are detailed in the following table (Table 4). **The set of indicators introduced here applies to individual taxa within a selected flora.** For the following explanations, the indicators will be applied to a taxon called **sp_1.**

Table 4.
Variables and parameters necessary to the formulation of the set of indicators.

Topic	*Variable/Parameter*	*Description*
Taxa of the RTN	sp_1	Taxon of interest
	Pv	Taxa phylogenetically related to sp1 (v varies from 1 to vmax, vmax being the number of phylogenetic relatives found during the review for sp1).
	SLx	Taxa taxonomically related to sp1 at the species level (x varies from 1 to xmax, xmax being the number of SL relatives found during the review for sp1).
	GLy	Taxa taxonomically related to sp1 at the genus level (y varies from 1 to ymax, ymax being the number of GL relatives found during the review for sp1).
	OUTz	Taxa related to sp1 as an 'outstanding' taxon of the genus (z varies from 1 to zmax, zmax being the number of 'outstanding' relatives found during the review for sp1).
Total number of relatives per category (N_{ALL})	$N_{ALL\ P}$	Total number of phylogeny relatives found for sp1 during the review.
	$N_{ALL\ SL}$	Total number of SL relatives found for sp1 during the review.
	$N_{ALL\ GL}$	Total number of GL relatives found for sp1 during the review.
	$N_{ALL\ OUT}$	Total number of 'outstanding' relatives found for sp1 during the review.
Number of property categories per taxon of the RTN (N_{Prop})	$N_{Prop\ sp1}$	Weighted number of properties documented for the taxon sp1 itself. (see the paragraph after the table).
	$N_{Prop\ Pv}$	Weighted number of property categories documented for a phylogeny related species Pv.
	$N_{Prop\ SLx}$	Weighted number of property categories documented for a species-level related species SLx.
	$N_{Prop\ GLy}$	Weighted number of property categories documented for a genus-level related species GLy.

Topic	*Variable/Parameter*	*Description*
	$N_{Prop\ OUTz}$	Weighted number of property categories documented for an 'outstanding' related species OUTz.
Number of articles per taxon of the RTN (D)	D_{sp1}	Number of articles documenting ecosystem services' provision for the taxon sp1 itself.
	D_{Pv}	Number of articles documenting ecosystem services' provision for a phylogeny related species.
	D_{SLx}	Number of articles documenting ecosystem services' provision for a species-level related species.
	D_{GLy}	Number of articles documenting ecosystem services' provision for a genus-level related species.
Number of groups of components per taxon of the RTN (C)	C_{sp1}	Number of groups of components documented for the taxon sp1 itself.
	C_{Pv}	Number of groups of components documented for a phylogeny related species.
	C_{SLx}	Number of groups of components documented for a species-level related species.
	C_{GLy}	Number of groups of components documented for a genus-level related species.
Indicators and related parameters (I)	I_1	MAP potential index value of sp1. (see Formulation of the MAP potential index I1).
	I_{1max}	Maximal MAP index value obtained by a taxon of the selected flora.
	I_{LIT}	Literature Volume index for sp1. (see Formulation of the Literature Volume Index ILIT).
	$I_{LIT\ max}$	Maximal Literature Volume index value obtained by a taxon of the selected flora.
	I_{CHEM}	Chemical Interest index of sp1. (see Formulation of the Chemical Interest Index ICHEM).
Comparison between empirical and experimental knowledge (Prop)	$Prop_{Tradi\ sp1}$	Number of properties (amongst the 92 initial properties and unweighted) that have only been mentioned for empirical/folk uses without complementary experience, for sp1. (Type of mentions: T).
	$Prop_{All\ sp1}$	Number of properties (amongst the 92 initial properties and unweighted) that emerge from empirical use and/or have been proved or induced by scientific experience, for sp1. (Types of mentions: x, M, No, T).

Topic	*Variable/Parameter*	*Description*
IUCN status of sp_1	St	Grade ranking from 0 to 1 attributed to the species sp1 according to its endangered status (Grading: NE/DD/LC = 0; NT = 0.25; VU = 0.5; EN = 0.75; CR/EW = 1; EX = 1 with a specific notification).

To evaluate the robustness of the property's documentation, the number of properties N_{Prop} is defined as follows:

$$N_{Prop} = N_{Prop(X)} + N_{Prop(T)} + 0.5 * N_{Prop(M)} - N_{Prop(No)}$$

N_{Prop} corresponds to the number of property categories listed for a taxon, modulated by the following labels according to how it is referenced in literature: experimentally proved property (X), traditional use (T), low benefits or toxic (No), promising plant material based on undirect proof (M) (see Categories of properties for more details). The weight of each label in the formula is chosen to include data based on simple suggestions, without under-estimation of empiric or formal proof; as well as to lower the grade of the taxa with moderate results. For instance, proof of mutagenicity or toxicity is included as 'No' in the count of properties as they jeopardise the use of the taxon as a safe herbal material.

The weights were chosen as follows: X*(1); T*(1); M*(0.5); No*(-1).

N_{Prop} is a weighted number of property categories (out of 25 categories) and it differs from $Prop_{All\ sp1}$ which is a non-weighted number of properties (out of 92 non-categorised properties) in which all properties (i.e. positive, negative etc.) count as one (i.e. X = T = No = M = 1).

Formulation of the set of indicators

Formulation of the MAP Potential Index (I_1)

The first indicator is the **medicinal and aromatic plants (MAP) potential index** (I_1). Its value
reflects the probability for a specific taxon to possess one or several medicinal and/or edible/aromatic properties, based on the existing documentation related to the specific taxon or its related species. For the definition of related species, all four types of "relatives"' proximity have been taken into account: (a) the **genetic** influence is integrated with the inclusion of phylogeny relatives; (b) the **taxonomic** influence with taxonomic relatives of the same species; (c) with relatives of the same genus within the selected flora and (d) with 'outstanding' taxa of the same genus approved as herbal medicinal products or edible crops.

The properties and uses of these "relatives" can lead to a higher probability for an insufficiently studied taxon to be a MAP. A plant taxon obtains an increasing value of

medicinal or aromatic properties potential (I_1), if it presents a wide array of proven properties for itself and/or for its relatives.

The mathematical formulation of the index is to be applied to a taxon of the flora called sp1. It is formulated as follows:

$$I_1 = \frac{N_{Prop.sp1} + (\sum_{v=vmax}^{1} N_{Prop.Pv}) + (\sum_{x=xmax}^{1} N_{Prop.SLx}) + (\sum_{y=ymax}^{1} N_{Prop.GLy}) + (\sum_{z=zmax}^{1} N_{Prop.OUTz})}{1 + N_{ALL.P} + N_{ALL.SL} + N_{ALL.GL} + N_{ALL.OUT}}$$

Mathematically, I_1 corresponds to the evaluation of the average number of property categories per taxon of the Related Taxa Network (RTN), based on the available literature for the considered taxon and its phylogeny, SL, GL and 'outstanding' relatives. The values of the index rank from **0 to 25** (according to the number of listed property categories).

Additional notes on the development of the indicator can be found as a methodological supplement in Appendix B.

Formulation of the Literature Volume Index (I_{LIT})

Some taxa of the selected flora can already be highly investigated for their properties and would thus be considered of lower priority for additional studies. Other taxa can be under-documented whereas their relatives have attracted a significant scientific interest with many articles proving various properties. In order to integrate the extent and diversity of the literature in the Study Interest Index, a sub-indicator is developed. The **Literature Volume Index** (I_{LIT}) summarises the literature available on the properties of the taxa of an RTN, allowing a comparison between a species of interest and its RTN, based on its documentation.

The mathematical formulation of the index is as follows:

$$I_{LIT} = \frac{D_{sp1} + (\sum_{v=vmax}^{1} D_{Pv}) + (\sum_{x=xmax}^{1} D_{SLx}) + (\sum_{y=ymax}^{1} D_{GLy})}{1 + N_{ALL.P} + N_{ALL.SL} + N_{ALL.GL}}$$

Mathematically, I_{LIT} corresponds to the average number of articles for a taxon of the Related Taxa Network (RTN) as an indicator of the available volume of literature on the RTN (to compare with the number of taxa in RTN). The included articles document all ecosystem services provision (medicinal, aromatic/edible but also environmental and industrial interests). The values of the index rank from **0 to $I_{LIT\ max}$**, the maximal Literature Volume index being obtained by a species of the considered flora.

Formulation of the Chemical Interest Index (I_{CHEM})

The pharmaceutical, cosmetic or nutritional applications of medicinal and aromatic plants are related to their contents in metabolites of interest. For a wider apprehension of the

MAP potential, chemical compositions are included in the Study Interest Index formula via a sub-indicator of Chemical Interest, according to the following considerations:

- Ingredients are considered by **groups** according to the groups presented in Table 2;
- The index ICHEM includes the compounds documented for the taxa of the **RTN** linked to the studied taxon: its phylogeny, SL and GL relatives;
- In the formula of this indicator, the ingredients are considered for their mere **presence** in the composition (measurable amounts or traces), without considering their exact concentration in the extract;
- The inclusion of the **ingredients** of taxa from the studied flora into the Study Interest Index permits to value taxa for which the extracts' composition is more documented than the properties;
- **Various sorts of plant extracts** are taken into account, to include as much documentation as possible (e.g. essential oils, whole plant extracts or extracts from specific plant parts, volatile components etc.).

The suggested formula for the **Chemical Interest Index I_{CHEM}** is as follows:

$$I_{CHEM} = \frac{C_{sp1} + (\sum_{v=vmax}^{1} C_{Pv}) + (\sum_{x=xmax}^{1} C_{SLx}) + (\sum_{y=ymax}^{1} C_{GLy})}{1 + N_{ALL.P} + N_{ALL.SL} + N_{ALL.GL}}$$

Mathematically, I_{CHEM} corresponds to the average number of groups of components present in the extracts of a taxon of the Related Taxa Network (RTN). The values of the index rank from **0 to 18**, according to the number of groups of components considered for this study.

Formulation of the Study Interest Index (I_2)

A taxon of a selected flora can be considered as of high potential for medicinal and aromatic applications, but present no specific priority for science for various reasons (e.g. already documented, already used for pharmaceutical applications, many properties proved etc.). In addition to the MAP potential, the interest in leading further studies for a species should be appreciated, as it does not only rely on the factor of MAP interest. The final indicator would thus be a **Study Interest Index (I_2)**, which grades the scientific benefit of studying a specific taxon rather than another one. Its goal is to prioritise taxa not yet thoroughly studied, despite their potential. In the present indicator, a great scientific interest for a taxon lies in the six factors summarised in Table 5.

The mathematical formula of the indicator is as follows:

$$I_2 = \left(1 - \frac{N_{Prop.sp1}}{25}\right) * \left(\frac{I_1}{I_{1max}} + \frac{I_{LIT} - D_{sp1}}{I_{LITmax}} + \frac{I_{CHEM}}{18} + \frac{Prop_{Tradi.sp1}}{Prop_{ALL.sp1} + 1} + St\right)$$

Table 5.
Explanation of the main factors influencing the Study Interest Index I_2.

Topic	*Factor*	*Explanation*
Properties	MAP potential of the taxon sp_1	If the taxon is suspected to have medicinal and/or aromatic properties, it could be interesting to assess the presence of these properties.
	Own documentation of sp_1	If a taxon has already been documented for its own properties, it can be considered as of lower property for further studies.
	Proportion of empirical properties	If a taxon is mostly mentioned for traditional uses, without being scientifically tested for them, it would be of interest to assess experimentally its folk use.
Literature	Extent of documentation of the properties of the taxon sp_1	If the taxon is already studied and many properties are experimentally proven, adding new studies to its literature may not be a priority.
	Documentation of sp1's Related Taxa Network (RTN)	If its RTN (phylogeny, SL, GL relatives) is highly documented, whereas the taxon itself is not, the gap of knowledge needs to be filled.
Components	Components of interest of sp1 and its RTN	If the extracts of the taxon or its relatives are rich in components of medicinal or aromatic properties, the taxon is deemed of interest for further studies on extraction and pharmaceutical applications.
Extinction	Conservation status	Proving the existence of properties of interest for an endangered taxon would serve as an additional argument for conservation policies and actions. Altogether, the interest here rises with the increasing threat level.

Mathematically, I_2 corresponds to a grade evaluating the priority to study a taxon according to selected parameters of scientific interest. It ranks from a minimal negative grade of -**5** (not a priority) to **5** (high priority), if no bonus point is added.

Following the needs, when the indicator is used, some bonuses could be integrated, adding advantages to the total grade of a taxon provided by I_2. For instance, the interest to study sp_1 could be considered increased if sp_1 is the unique representative of its genus or family within the flora, if a taxon of sp_1's RTN is extensively documented for properties or known to produce high quantities of essential oils or if the whole genus/family of sp_1 is understudied for its properties and composition. No bonus point was included in the frame of the present case study, based on the high subjectivity of the importance of these factors. Additional notes on the development of the indicator can be found as a methodological supplement in Appendix B.

Testing the indicators I_1 and I_2

To assess the validity of the indicators, these were compared to expert knowledge. Only the indicators I_1 and I_2 have been tested in the present study, for the following reasons: (a) to focus on the main indicators of the set; (b) to reduce the amount of work for the expert; and especially (c) as the testing of I_{LIT} and I_{CHEM}, based on expert knowledge, required a deep insight on both botanical, chemical and pharmacological literature.

Of the endemic flora of Greece that cannot be found in Peloponnese, 100 taxa were selected on the basis of their value of I_1: 50 taxa were selected as potential MAP ('Yes', the taxon is of MAP interest if $I_1 > 0.9$) and 50 as unpromising MAP ('No' the taxon is not of MAP interest if $I_1 < 0.4$). It was also taken into account whether these taxa were of high interest for further studies ('Yes', there is an interest for further studies if $I_2 > 0.4$) or not ('No', there is no high study interest if $I_2 < 0.4$) (see Appendix C). The threshold values were selected to obtain an even number of taxa as 'Yes' and 'No' for each indicator.

This list of taxa (taxon, family, extinction status) was sent to Prof. Gregoris Iatrou (Emeritus Professor, Laboratory of Botany, University of Patras) as an expert on the flora of Greece and Peloponnese, on the Greek endemic taxa and on plant uses. He was asked to reply for each taxon to the following questions:

- Is this taxon highly probable to present medicinal/aromatic properties? (Yes, No, Maybe);
- Should this taxon be considered a priority for further studies (pharmaceutical, food/aromatic, chemical composition)? (Yes, No, Maybe).

His answers, based on expert knowledge, were compared to the results of the indicators to evaluate their accuracy, sensitivity and specificity (Shreffler and Huecker 2023). 'Maybe' results were set aside from the test, to focus on the results firmly validating or denying MAP or study interest.

Accuracy defines the proportion of truly positive and truly negative results amongst all valid results (i.e. the proportion of taxa that are obtaining the same result under the expert feedback and under the indicator calculation, amongst all taxa that were given a result by both the expert and the indicators).

Sensitivity is the proportion of truly positive results amongst the results of the indicators (i.e. the proportion of positive results that match both the expert and indicator's approvals).

Specificity describes the proportion of true negative results amongst the results of the indicators (i.e. the proportion of negative results that match both the expert and indicator's approvals).

These three parameters are calculated as explained in the following tables (Tables 6, 7).

Table 6.

Basic format of the result's crosstab *[1].

Indicator / Expert	YES	NO
YES	a	b
NO	c	d

Table 7.

Explanation and formulation of the accuracy parameters calculated in the test.

Parameter	Explanation	Formula
Accuracy	Proportion of accurate guesses (true negatives and true positives) amongst all valid results.	Accuracy = (a+d)/ (a+b+c+d)
Sensitivity	Proportion of true positives amongst the true positive and false negative results of the indicator.	Sensitivity = a/(a+c)
Specificity	Proportion of true negatives amongst the true negative and false positive results of the indicator.	Specificity = d/(b+d)

This testing method, including a single expert's feedback, was selected as a simple and time-efficient method to assess the efficiency of our approach against expert judgement. A single expert is involved as one of the rare specialists of both endemic plants of Peloponnese and medicinal/aromatic plant uses.

Results

Evaluation of the accuracy, sensitivity and specificity of the indicators

The MAP potential and the interest for further studies of 100 taxa, endemic to Greece, but absent from the Peloponnese, were evaluated, based on expert knowledge and based on the indicators I_1 and I_2. The results obtained are presented in Table 8.

Table 8.

Evaluation of the MAP potential and study interest for 100 Greek endemic taxa, by expert knowledge and by indicators.

	Indicators		Expert knowledge	
	MAP potential	Study Interest	MAP potential	Study Interest
Total YES	50	28	28	23
Total NO	50	72	16	18
Total MAYBE	/	/	56	58

The results by expert knowledge were set on a clear absence or presence of MAP potential for 44 taxa and of priority for study interest of 41 taxa. Excluding the taxa with

doubts (“Maybe”), the net results for each taxon, under expert knowledge and indicators, were compared to evaluate their homogeneity (Table 9).

Table 9.

Cross-tabulation opposing the experts answers (Yes/No, columns) to the indicators’ results (Yes/No, lines), on the evaluation of MAP potential and study interest. Note: The cell containing the value “4” (first table, second line, third column) expresses that four taxa out of 100 were evaluated as of no MAP interest by the expert (No, in column), but as of MAP interest by the indicator (Yes, in line). They are considered as ‘false positive’ results (see Table 7 in the section 'Testing the indicators I1 and I2').

MAP potential			Study interest		
Indicator / Expert	YES	NO	Indicator / Expert	YES	NO
YES	19	4	YES	13	2
NO	9	12	NO	10	16

These results were used for the calculation of accuracy, sensitivity and specificity of the two indicators (Table 10).

Table 10.

Calculation of the accuracy, sensitivity and specificity of the MAP potential index (I_1) and Study interest index (I_2).

	MAP potential	Study interest
Accuracy	70.45%	70.73%
Sensitivity	67.86%	56.52%
Specificity	75.00%	88.89%

Application of the indicators: endemic flora of Peloponnese

MAP Index (I_1)

The results of MAP index I_1 are summarised in Table 11.

A total of **139** taxa presents a value of MAP index greater or equal to 1 (28.1% of the flora), suggesting that they could present from one up to eleven properties if they proved faithful to their RTN’s properties. A total of **288** taxa out of 494 Peloponnese endemics (i.e. 58.3%) rank above zero for their I_1 value. The most represented families amongst these taxa are Asteraceae (67 taxa with $I_1 > 0$), Lamiaceae (41), Caryophyllaceae (26) and Boraginaceae (20).

Eight taxa obtain negative values of I_1 (three *Teucrium* L., three *Onopordum* L., *Malcolmia graeca* subsp. *graeca* and *Aristolochia microstoma* Boiss. & Spruner). Eventually, despite the investigation of potential related taxa, **198** endemic taxa obtain a null value of I_1

(40.1% of the flora): they are numerous in families Caryophyllaceae (33 taxa with $I_1 = 0$), Rubiaceae (21), Campanulaceae (18) and Asteraceae (17).

Table 11.

Main results of the MAP index I_1 applied to the endemic flora of Peloponnese.

I_1	Min. value	-1.00 /*25*	Max. value	10.83 /*25*
	Ten highest ranking taxa	- *Crataegus pycnoloba* Boiss. & Heldr. (Rosaceae, I_1 = 10.83), - *Pimpinella rigidula* (Boiss. & Orph.) H. Wolff (Apiaceae, I_1 = 10.50), - *Thymus laconicus* Jalas (Lamiaceae, I_1 = 8.14), - *Thymus leucospermus* Hartvig (Lamiaceae, I_1 = 8.14), - *Melilotus graecus* (Boiss. & Spruner) Lassen (Fabaceae, I_1 = 7.50), - *Origanum lirium* Heldr. ex Halácsy (Lamiaceae, I_1 = 7.50), - *Origanum scabrum* Boiss. & Heldr. (Lamiaceae, I_1 = 7.50), - *Achillea taygetea* Boiss. & Heldr. (Asteraceae, I_1 = 7.17), - *Paeonia mascula* subsp. *hellenica* Tzanoud. (Paeoniaceae, I_1 = 7.00), - *Potentilla arcadiensis* Iatroú (Rosaceae, I_1 = 7.00).		
	N° of taxa with $I_1 < 0$	8 /*494* (1.62%)		
	N° of taxa with $I_1 = 0$	198 /*494* (58.3%)		
	N° of taxa with $I_1 > 0$	288 /*494* (58.3%)		
	N° of taxa with $I_1 > 1$	139 /*494* (28.1%)		
	N° of taxa with $I_1 > 2$	105 /*494* (21.3%)		
	N° of taxa with $I_1 > 5$	25 /*494* (5.06%)		

The values are unequally shared amongst the families: 19 families contain taxa with both positive, null and/or negative taxa, 18 families grade all their taxa with $I_1 > 0$, while 11 families only present taxa with a null value of MAP index.

Literature Volume Index (I_{LIT})

The results of Literature Volume Index I_{LIT} are summarised in Table 12.

The values of the Literature Volume index reflect the extent of available documentation regarding the properties of the taxa of an RTN. They express the average number of articles available on the ecosystem services of a taxon of the RTN. A total of **370** taxa out of the 494 Peloponnese endemics (i.e. 74.9%) rank above zero for their I_{LIT} value. The most represented families amongst these taxa are Asteraceae (49 taxa with $I_{LIT} > 0$), Lamiaceae (45), Caryophyllaceae (42) and Rubiaceae (23).

Chemical Interest Index (I_{CHEM})

Before the application of the Chemical Interest Index, 71 endemic taxa (14.4% of the endemic flora) were documented as containing at least one component from the eighteen component groups (Table 2). The taxa ticking the most secondary metabolite groups are *Lamium garganicum* subsp. *pictum* (Lamiaceae, 7.5 groups), *Hypericum rumeliacum*

subsp. *apollinis* (Hypericaceae, 5.0 groups) and *Galium melanantherum* (Rubiaceae, 5.0 groups).

Table 12.

Main results of the Literature Volume Index I_{LIT} applied to the endemic flora of Peloponnese.

I_{LIT}	Min. value	0.00	Max. value	7.00
	Ten highest ranking taxa	- *Satureja hellenica* Halácsy (Lamiaceae, I_{LIT} = 7.00), - *Sideritis clandestina* (Bory & Chaub.) Hayek sp. (Lamiaceae, I_{LIT} = 6.75), - *Beta nana* Boiss. & Heldr. (Brassicaceae, I_{LIT} = 6.67), - *Abies cephalonica* Loudon (Pinaceae, I_{LIT} = 6.67), - *Sideritis clandestina* subsp. *clandestina* (Lamiaceae, I_{LIT} = 6.50), - *Sideritis clandestina* subsp. *peloponnesiaca* (Boiss. & Heldr.) Baden (Lamiaceae, I_{LIT} = 6.25), - *Achillea taygetea* Boiss. & Heldr. (Asteraceae, I_{LIT} = 5.63), - *Conium divaricatum* Boiss. & Orph. (Apiaceae, I_{LIT} = 5.00), - *Centranthus longiflorus* subsp. *junceus* (Boiss. & Heldr.) I.Richardson (Valerianaceae, I_{LIT} = 5.00), - *Ononis spinosa* subsp. *diacantha* (Sieber ex Rchb.) Greuter (Fabaceae, I_1 = 4.50).		
	N° of taxa with I_{LIT} = 0	124 /*494* (25.1%)		
	N° of taxa with I_{LIT} > 0	370 /*494* (74.9%)		
	N° of taxa with I_{LIT} > 2	60 /*494* (12.1%)		

The results of Chemical Interest Index I_{CHEM} are summarised in Table 13.

Table 13.

Main results of the Chemical Interest Index I_{CHEM} applied to the endemic flora of Peloponnese.

I_{CHEM}	Min. value	0.00	Max. value	3.50
	Ten highest ranking taxa	- *Cruciata taurica* subsp. *euboea* (Ehrend.) Ehrend. (Rubiaceae, I_{CHEM} = 3.50), - *Thamnosciadium junceum* (Sm.) Hartvig (Apiaceae, I_{CHEM} = 3.00), - *Satureja hellenica* Halácsy (Lamiaceae, I_{CHEM} = 2.75), - *Sideritis clandestina* (Bory & Chaub.) Hayek sp. (Lamiaceae, I_{CHEM} = 2.75), - *Satureja parnassica* subsp. *parnassica* (Lamiaceae, I_{CHEM} = 2.67), - *Sideritis clandestina* subsp. *clandestina* (Lamiaceae, I_{CHEM} = 2.5), - *Inula candida* subsp. *limonella* (Halácsy) Rech.f. (Asteraceae, I_{CHEM} = 2.38), - *Inula candida* (L.) Cass. sp. (Asteraceae, I_{CHEM} = 2.38), - *Sideritis clandestina* subsp. *peloponnesiaca* (Boiss. & Heldr.) Baden (Lamiaceae, I_{CHEM} = 2.38), - *Phlomis cretica* C.Presl (Lamiaceae, I_{CHEM} = 2.25).		
	N° of taxa with I_{CHEM} = 0	282 /*494* (57.1%)		
	N° of taxa with I_{CHEM} > 0	212 /*494* (42.9%)		
	N° of taxa with I_{CHEM} > 2	19 /*494* (3.85%)		

The values of the Chemical Interest index reflect the extent of available knowledge on extracts' chemical compositions for the taxa of an RTN. They express the average number of groups of components documented for a taxon of the RTN. A total of **212** taxa out of 494 Peloponnese endemics (i.e. 42.9%) rank above zero for their I_{CHEM} value. The

most represented families amongst these taxa are Asteraceae (48 taxa with $I_1 > 0$), Lamiaceae (44), Rubiaceae (23) and Boraginaceae (18).

Study Interest Index (I_2)

The results of Study Interest Index I_2 are summarised in Table 14.

Table 14.
Main results of the Study Interest Index I_2 applied to the endemic flora of Peloponnese.

I_2	Min. value	-0.40	Max. value	1.70
	Ten highest ranking taxa	- *Sideritis clandestina* (Bory & Chaub.) Hayek sp. (Lamiaceae, I_2 = 1.70), - *Origanum lirium* Heldr. ex Halácsy (Lamiaceae, I_2 = 1.66), - *Melilotus graecus* (Boiss. & Spruner) Lassen (Fabaceae, I_2 = 1.56), - *Satureja hellenica* Halácsy (Lamiaceae, I_2 = 1.41), - *Thymus laconicus* Jalas (Lamiaceae, I_2 = 1.36), - *Cruciata taurica* subsp. *euboea* (Ehrend.) Ehrend. (Rubiaceae, I_2 = 1.35), - *Beta nana* Boiss. & Heldr (Chenopodiaceae, I_2 = 1.32), - *Ononis spinosa* subsp. *diacantha* (Sieber ex Rchb.) Greuter (Fabaceae, I_2 = 1.30), - *Verbascum epixanthinum* Boiss. et Heldr. (Scrophulariaceae, I_2 = 1.26), - *Polygala helenae* Greuter (Polygalaceae, I_2 = 1.26).		
	N° of taxa with $I_2 < 0$	49 /*494* (9.92%)		
	N° of taxa with $I_2 = 0$	79 /*494* (16.0%)		
	N° of taxa with $I_2 > 0$	366 /*494* (74.1%)		
	N° of taxa with $I_2 > 1$	24 /*494* (4.86%)		

The Study Interest index balances the three indicators, as well as other factors of interest for the taxa of a flora in order to distinguish the ones of scientific priority for medicinal, aromatic or chemical uses. Its value is a grade out of five, with its higher values to be considered as of higher priority. A total of **366** taxa out of 494 Peloponnese endemics (i.e. 74.1%) rank above zero for their I_2 value. The most represented families amongst these taxa are Asteraceae (71 taxa with $I_2 > 0$), Caryophyllaceae (37), Lamiaceae (36), Rubiaceae (20) and Boraginaceae (19).

A total of **24** taxa ranges between 1.0 and the maximal I_2 grade of 1.70, whereas 137 of them range between 0.0001 and 0.1000. Regarding the lowest results, **79** taxa obtain a null grade and **49** obtain a negative grade. Only five families, with all their endemic taxa, received a null grade: Orobanchaceae (four taxa), Aceraceae, Araceae, Resedaceae, Saxifragaceae (one taxon each).

Mean index values for the flora of Peloponnese

In addition to the evaluation of each taxon for its MAP potential, average values of the indicators were calculated at the scale of the studied flora. It allows an insight into the interest of this type of flora in terms of MAP research.

The endemic flora of Peloponnese and its 494 taxa obtain the following mean values:

- MAP index (I_1): $\mathbf{I_{1\ EndPe}}$ **= 1.05** (property categories per taxon), with Standard Deviation (SD) = 1.76;
- Literature Volume Index (I_{LIT}): $\mathbf{I_{LIT\ EndPe}}$ **= 0.72** (expected article per taxon), with SD = 1.12;
- Chemical Interest Index (I_{CHEM}): $\mathbf{I_{CHEM\ EndPe}}$ **= 0.35** (group of components per taxon), with SD = 0.58;
- Study Interest Index (I_2): $\mathbf{I_{2\ EndPe}}$ **= 0.22** (grade out of 5), with SD = 0.33.

The main results for each indicator at the taxon and at the flora's level are summarised in the following diagram (Fig. 3).

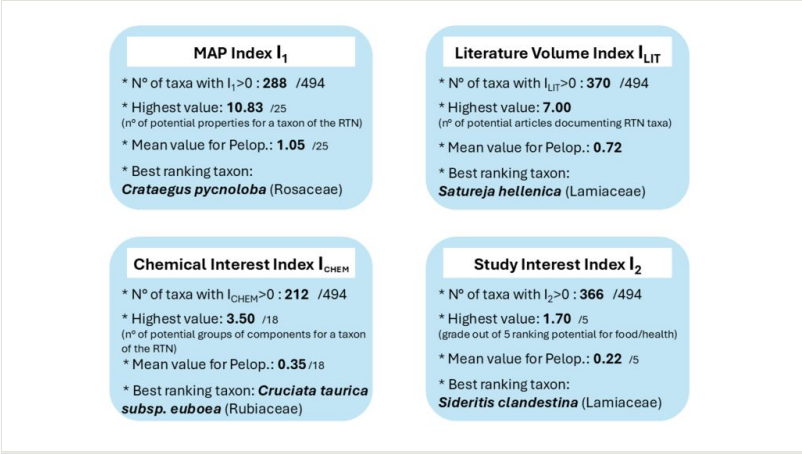

Figure 3.

Summary of the main results for the set of indicators.

Discussion

Analysis of the validity test of the indicators

The values of accuracy are 70.5% for I_1 and 70.7% for I_2. Based on this test, both indicators accurately predict the high or low medicinal/study interest in about 70% of the cases.

I_1 obtains a sensitivity of 67.9% when compared to the expert feedback, while I_2 reaches 56.5%. Based on this test, the MAP index correctly predicts a taxon as medicinal for about 70% of the situations.

I_1 obtains a specificity of 75.0%, while I_2 obtains 88.9%. Based on this test, the Study Interest index correctly evaluates taxa as of low interest for further study in almost 90% of cases.

From the comparison with expert knowledge, it is evident that **the indicators present correct values of accuracy**, with I_1 presenting a higher sensitivity and I_2 a higher specificity. These results are not identical with the expert's opinion, but are proved closer than random results. These two tools can be considered useful to fulfil their purpose: triggering scientific interest in taxa with relatively higher chances of medicinal and/or aromatic properties.

On the one hand, the differences between the results of the indicators and the expectations of the expert could provide an **additional insight** for suggesting new taxa of interest that the expert may not have suspected. For instance, *Telephium imperati* subsp. *pauciflorum* (Greuter) Greuter & Burdet is suggested by the indices as of medicinal potential against the expert's opinion: the comparison with its SL relatives (*Telephium imperati* L. sp. and *Telephium imperati* subsp. *orientale* (Boiss.) Nyman), documented for traditional medicine and aromatic uses, enhances the MAP interest of the taxon even though it remains so far poorly known. Amongst the 100 taxa of the test, the inclusion of related taxa in the indicator I_2 resulted, for three taxa, in an opposition between indicator and expert expectations: they obtained positive grades of MAP interest when the expert suggested an absence of MAP interest (see Table 9): *Jancaea heldreichii* (Boiss.) Boiss. (its I_2 grade increases with the inclusion of its phylogenic relative: *Ramonda myconi* (L.) Rchb.), *Crocus flavus* subsp. *atticus* Kit Tan, Zograf. & Mermygkas (two medicinal SL relatives), *Linum euboeum* Bornm. (outstanding relative: *Linum usitatissimum* L.).

On the other hand, the results that oppose a positive expert's interest to a negative interest by the indicator, introduce the notion that the indicators both expand thanks to and are **limited by the existing literature** (see the Comments on indicator's results). Some of the genera the expert considered as of interest against the indicators (e.g. *Peucedanum* L., *Seseli* L., *Atriplex* L., *Micromeria* Benth), can contain a variety of taxa already documented as beneficial. However, if the literature and legislation do not establish a bond with a studied relative, the indicators remain blind and cannot suggest the endemic species as material of interest.

It is worth noting that, out of the 100 taxa initially listed for the test, only 44 and 41 taxa were approved by both expert and indicator's results as clear 'No' or 'Yes', respectively for the MAP potential and study interest and could, thus. be used in the evaluation of the accuracy. Concerning the taxa falling in the '**Maybe' category** for the expert, I_1 distributes evenly the 56 taxa amongst positive and negative results (48% of 'Yes' and 52% of 'No'), while I_2 ranks most of the 59 taxa with uncertain study interest according to the expert, as of low priority (23% of 'Yes' and 87% of 'No'). Indicators may here give an insight on a taxon, based on references or related taxa the expert is not aware of and thus suggest new taxa of interest.

MAP, literature and chemical indices applied to the flora of Peloponnese

The results of the first three indicators applied to the endemic flora of Peloponnese highlighted Asteraceae, Lamiaceae, Caryophyllaceae and Boraginaceae as the main families with the highest number of properties, articles and components, mostly due to

their high number of taxa in the studied flora. Application of the indicators to another flora may highlight other families, according to the composition of this flora and to the documentation of its taxa and their relatives: for example, the endemic floras of Peru (the most represented families are Asteraceae, Piperaceae and Orchidaceae) or Ecuador (dominated by Orchidaceae, Asteraceae and Melastomataceae) would provide different rankings if studied by the indicators (van der Werff and Consiglio 2004). These indicators also allow the inclusion of some families for which the Greek endemic taxa are under-documented (e.g. Orchidaceae, Plumbaginaceae, Polygalaceae, Rutaceae etc.).

This becomes possible due to the integration of related taxa's data, expanding the scope of research further than the data of the endemic taxa themselves. The influence of these relatives and the extent of their documentation is made clear by the results analysis of the **MAP Index I_1**. The calculation of this index includes 'outstanding' relatives, especially herbal medicinal products. These taxa are approved by international organisations for safe and beneficial use and are highly documented: the 57 herbal relatives obtain an average of 12.98 property categories per taxon, whereas the 63 documented endemics obtain an average of 1.52 property categories per taxon. For I_1, the inclusion of 'outstanding' relatives highly influences the ranking of the taxa: amongst the ten highest ranks, eight would not be present if they did not rely on their relatives. The same weight has been maintained to all relative taxa in the formula, despite this extreme difference in documentation. The indicators aim to highlight under-documented taxa of interest, whilst the presence of relatives with such a wide array of properties can only underline the importance of the selected taxa. Species with no 'famous' outstanding relatives, such as *Sideritis clandestina* (Bory & Chaub.) Hayek, *Satureja hellenica* Halácsy, *Abies cephalonica* Loudon etc. that reach high positions in the I_1 ranking should not be overlooked.

The MAP index highlights 25 taxa of high MAP interest, but also delivers negative results for eight taxa. These negative numbers of properties are obtained in the case of an RTN with presently low documentation by a restricted number of articles and explained either by proof of toxicity within the RTN (*Teucrium* L.) or by a lack of antiviral benefit as the only studied property (*Onopordum* L., *Malcolmia graeca* subsp. *graeca* and *Aristolochia microstoma* Boiss. & Spruner).

The **Literature Volume Index** is developed to assess the extent of documentation of an RTN. Its highest values are highlighting genera with an already strong scientific interest. To target genera with low documentation, this indicator should be analysed in constant comparison with the number of taxa in an RTN and with the number of articles documenting properties for the central taxon itself. Its main use is to include the dimension of scientific emulation to the evaluation of the interest for new studies: if the RTN of a taxon is already highly studied, even though it has considerable values for I_1 and I_{CHEM}, it may not be a priority for immediate additional investigation and should thus have a lower I_2.

The **Chemical Interest Index** aims:

- to extend the scope of what can be considered an article of use for the set of indicators and, thus, the number of taxa it can evaluate;
- to include the potential uses that the chemical composition of a taxon could offer.

This index highlights the families and genera with an RTN studied for its components (e.g. Asteraceae with *Inula* L. and *Achillea* L. or Lamiaceae with *Sideritis* L. and *Satureja* L. etc.), to point out taxa from this RTN that have not yet been studied.

The Chemical Interest Index is the only index of the set that indirectly includes a subjective expert opinion, in the choice of the components groups of interest. Instead of using groups, the I_{CHEM} could have been calculated, based on the properties documented in literature for each detected component. This option was excluded as, apart from adding a second time-consuming level of literature review, it also increases the impact of knowledge gaps: many components amongst groups of interest may have not been studied systematically yet for *in vivo* or *in vitro* benefits.

Analysis of the results of I_2 applied to the whole flora

The main aim of the developed set of indicators is to spot taxa of interest from the flora of an area, for future pharmaceutical or food uses, using the available literature. The index I_2 is the main value of the set to fulfil this purpose, as it leads to the final prioritisation of the taxa, amongst those of highest potential with low documentation.

When applied to the endemic taxa of Peloponnese, the results highlight specifically **24 taxa** that obtain a grade above one (scale 1 to 5). If taxa of Lamiaceae are predominant in this ranking, especially amongst the ten highest-ranking taxa, a variety of families is also represented despite the restricted documentation for their Peloponnesian taxa (e.g. Chenopodiaceae, Polygalaceae, Rosaceae, Linaceae etc.). The taxa obtain high values mostly thanks to the properties of their 'outstanding' relatives (e.g. *Origanum* L., *Polygala* Tourn. ex L., *Beta* L. etc.), to the interest of their components (e.g. *Cruciata* Mill., *Satureja* L. etc.) or to the properties of their phylogeny relatives (e.g. *Sideritis* L. etc.).

Special attention should be given to the presence of *Isoetes heldreichii* Wettst. amongst these 24 taxa: the taxon obtains a grade of $I_2 = 1.01$, based on the chemical composition of a phylogeny relative and of its IUCN status, bearing a ‘flag’ as **Extinct** species. This species and its potential ecosystem services are lost, whereas the study of its relatives suggests that it could have had a scientific interest. This fact underlines one of the arguments that led to the construction of the present indicators as tools in plant conservation debates: plant species provide meaningful and crucial ecosystem services and the degradation of their habitats and populations does not only lead to a loss of biodiversity, but also to a loss of benefits for both the environment and human society (Egoh et al. 2009).

The taxa that obtain a **null grade** of I_2 emphasise RTN and genera that have not been studied yet. Eight genera from the endemic flora of Peloponnese: *Acer* L., *Biarum* Schott, *Odontites* Ludw., *Orobanche* L., *Phelipanche* Pomel, *Reseda* Tourn. ex L., *Rhinanthus* L. and *Saxifraga* Tourn. ex L. are absent from MAP documentation and, thus, it is not possible to obtain a Study Interest grade for their families.

The **45 negative grades** for the Peloponnese endemic taxa can be related to either:

1. a lack of need for additional studies, as these are **already studied** for themselves or for their RTN (e.g. *Centaurea achaia* Boiss. & Heldr., *Stachys spinosa* L. etc.) or
2. to **detrimental or absent properties**, with taxa for which toxicity was proven or the only investigated property proved to be absent (e.g. *Malcolmia graeca* subsp. *graeca* etc. is only documented for not being antiviral).

The first mentioned lack of need is mostly related to a slightly deficient balance between the benefits of the RTN and the number of own articles or properties, rather than to a clear over-documentation of an endemic taxon.

The taxa that have been ranked as of higher interest are suggested for further studies on their medicinal properties and components of use (see the highest-ranking taxa for the set of indicators in Appendix D). As a matter of fact, some of these taxa have already been investigated since the end of the review. *Sideritis clandestina* (Bory & Chaub.) Hayek is the taxon with the highest Study Interest Index grade (I_2 = 1.70) amongst the endemic flora of Peloponnese. The species has been used in chemical and pharmaceutical tests and proved to be of chemical interest (iridoids, phenols, diterpenes etc.), as well as antioxidant, aromatic properties and a beneficial effect of the extract and its sideridiol and verbascoside ingredients against Alzheimer's disease mechanisms (Dimaki et al. 2022, Gioran et al. 2024, Dimaki et al. 2024). These results suggest good quality of prediction by the indicators.

Limitations and comments on the indicators

Formulation of the indicators

The present methodology is based on a set of four indicators, giving numerical values to MAP potential, literature extent, chemical interest and study interest that were here applied to the endemic flora of Greece. The closest studies are the ones which led on the endemic floras of Crete, the Rif-Mediterranean coast of Morocco and Tunisia (Bourgou et al. 2021, Krigas et al. 2021, Libiad et al. 2021). They build indicators of medicinal/ cosmetic, agro-alimentary and ornamental potential, respectively. Sharing the objective of I_1 in suggesting of new taxa of use, the methodology they present differs in its stronger need for expert feedback: their methods partly require expert feedback on certain characteristics of the taxon to evaluate its potential (e.g. taste, superfood potential, attractiveness etc.), whereas the present study reduces subjective parameters to aim for a process that could be more automated and standardised. Similar to I_1, but in a property-specific approach, is the neuroprotective potential index developed by Liu et al. (2016)

that is based not on literature analysis or on expert feedback, but on direct experimental results (e.g. antioxidant capacity, inhibitory effect on glycation of plant extracts etc.). It provides a strong index value, but requires six experimental steps that practically limit the number of taxa it can analyse. Other indices from literature (see Introduction) are based on measured availability and local demand of some medicinal taxa (Martínez et al. 2006), on number of reports of use of medicinal taxa by local experts (Heinrich et al. 1998) or on parameters of economic value of medicinal plants (Suneetha and Chandrakanth 2006).

If all indicators offer different approaches, learning can be drawn from their comparison, in view of a future broader set of indicators of ecosystem services potential: the inclusion of cultivation and availability parameters (Libiad et al. 2021), the perception of various stakeholders in plant use and conservation (Suneetha and Chandrakanth 2006), modulation factors depending on the potency of a specific property (Liu et al. 2016) etc.

Looking back at the indicators proposed in present study, we see that their formulations have left aside three points that could be supplementary modifications for an even more accurate calculation of potential. They are considered beneficial, but not essential and have not been included in the present calculations. These three points are related to:

- *Multiple counts*: For one taxon of the considered flora, one of its 'related' taxa can happen to be simultaneously phylogeny, SL, GL and/or 'outstanding' relative. In the current formulation of the indicators, this related taxon is then counted several times and the grades increase (e.g. *Marrubium velutinum* Sm. has in its RTN its subspecies *velutinum* and *cylleneum* both as SL and GL relatives). These multiple *counts* were kept as they allow us to give more importance in the formulas to related taxa that are very close to the taxon of interest;
- *Traditional uses*: The treatment of the literature review in the MAP index (I_1) considers traditional uses of a taxon as equal, in terms of weight in the formula, to proven medicinal applications. In the Scientific Interest Index (I_2), a parameter is integrated to split traditional and medical uses and raise interest for more studies for the taxa that have been widely used in folk medicine without being experimentally tested for these uses. However, the recording of traditional uses for the endemic taxa of Peloponnese is far from thorough and such a parameter could be expanded at the RTN level to target genera of empirical interest deprived of experimental background. It could also take into account the number of use reports for each taxon, as a weight for the taxon's importance in folk medicines.
- *Documentation*: The calculation of the Literature Volume Index (I_{LIT}) is based on several articles documenting ecosystem services or characteristics of interest for a taxon. This covers medicinal and aromatic properties, environmental or industrial uses (e.g. uses as solvents, wood, ornamental, heavy metal accumulator etc.), as well as articles on karyology and extinction status. As these mentions were less frequent than MAP properties, we used these in the calculations to highlight taxa that have raised scientific interest, in one way or the other.

The formulas have been developed to be simple enough to fit all situations and floras. Their use, as well as the floras they could be applied on, may need to add parameters, especially related to these three suggestions or as 'Bonus' in the Study Interest Index. According to the needs, supplementary parameters could indeed be included to improve grades for monospecific taxa, rare families amongst the flora etc. However, modifications in the formulation of the indicators applied to studies of different floras can impact their capacity to compare one flora with another.

Comments on indicators' results

It is important to stress that these indicators are **calculated according to the available literature**. Some taxa could be of high interest, but are not present in the obtained results, as these taxa and their RTN are not studied or have not been tested for a wide variety of properties. Some species of high potential, such as a *Hypericum* endemic taxa (*Hypericum taygeteum* Quézel & Contandr. or *Hypericum tymphresteum* Boiss. & Spruner), with $I_1 = 0.75$ for both and $I_2 = 0.75$ and $I_2 = 0.25$, respectively, obtain relatively low grades due to a low number of relatives (only little documented GL relatives, no documented phylogeny, no 'outstanding' relative) and to the absence of specific studies. The result of I_2 increases for *H. taygeteum* only based on its 'Vulnerable' status. On the other hand, some taxa (up to the genus level) are very little studied for their properties, but obtain high grades as various components of interest are documented for one taxon of the RTN (e.g. *Galium* L. taxa). If the indicators are here used to extract the taxa with the highest potential, they can also be used in reverse and suggest the ones with little documentation. The extent of literature available on a flora will also rely on the ability of a country to finance relevant research (Frame 2019): indicators' results will be impacted by a poorly-studied flora, but hopefully complemented by documentation on related taxa, out of the flora.

Another goal of this set of indicators is to **open new perspectives for a defined flora**, by extracting from the mass taxa that would be left behind despite their potential. Whereas only 63 taxa of the Peloponnesian endemic flora (12.75%) were documented as MAP, the application of the indicators allows us to consider a wider array of taxa as of potential interest: I_1 is non-null for 297 taxa (60.12%), I_{LIT} for 370 taxa (74.90%), I_{CHEM} for 210 taxa (42.51%) and I_2 for 415 taxa (84.01%).

More taxa of the studied flora are considered of interest as the indicators also involve their relatives, based on taxonomic (same-species, same-genus) or phylogenetic proximity, as well as same-genus taxa acknowledged as herbal medicines or edible crops. The use of this set of indicators offers a snapshot at a defined time: addition of new knowledge leads to the modification of the results of the literature-based indicators. An optimal and comprehensive use of these indicators would require an automation of the method. The extensive literature review, necessary to the application of the indicators, could be assisted by AI tools or data extraction software (Danler et al. 2024). A network relational database should be coupled with platforms of data storage, calculation tools and a web portal where the calculation of the indicators and handling, storage and

display of the data will be held. Similar complex databases have already been created for other purposes, for example, to document chemical interactions with ConsensusPathDB (Herwig et al. 2016) or for proteins, genes and chemical pathways, with bioDBnet (Mudunuri et al. 2009).

Applications and implications

This set of indicators proposed in the present study eventually:

1. Highlights **ecosystem services** which a selected flora could provide (i.e. provision services: medicinal plants, food);
2. **Suggests properties** that taxa of this flora may eventually prove to have if they were more studied;
3. Evaluates the available literature material from various sources, origins, periods and for a wide array of species, to **extend the documentation** considered relevant when specific articles are rare and, thus, reduce the knowledge gaps;
4. Offers **new insight on taxa** that would otherwise only be considered unused, since it creates a new type of information from already published studies;
5. Offers **four simple numeric scores** to summarise the usually intricate and multifactorial concept of ecosystem services, in an attempt of standardisation of ESP evaluations (Banzhaf and Boyd 2012).

This new perspective could be used as an argument to support **plant and environmental protection** and conservation policies, especially with the MAP Index (I_1) or, to a lesser extent, with the Chemical Interest Index (I_{CHEM}). Such indicators can be applied, for instance, to the flora of an area considered for a future national park, to a region assessed for construction works or at the country scale for general assessments, including natural capital accounting (see, for example, United Nations et al. (2021)). It can be a tool to eventually argue that not only the degradation of a region would result in a loss of general biodiversity or increase the pressure on restricted taxa, but it would also jeopardise the potential of this region to provide a variety of ecosystem services with benefits for human alimentation or health. The presence of a taxon that should be studied for its properties can stimulate the need for a protection procedure to safeguard this taxon or its area. The systems of properties and components classification in categories and groups allow us to compare I_1 and I_{CHEM} results obtained by various areas/taxa and prioritise their treatment by science or management bodies. The present tools allow comparing the potential of various habitats, ecosystems or regions in terms of MAP interest and study priority, documenting an inert part of the country's Natural Capital.

The Study Interest Index (I_2) is developed to be directly exploited by all fields related to ecosystem services and plant sciences (i.e. any field studying plants for essential oils, new natural products, medicinal properties, food uses). The present article suggests a list of taxa that should be considered as priorities for the study of the endemic taxa of Peloponnese, but the calculation of these indicators can be undertaken on specific floras of interest worldwide, allowing to compare one flora to the other. This Study Interest

generally offers a new tool to select species for studies and to select new taxa of potential interest despite their current lack of documentation.

In the Study Interest formula, the IUCN status of the taxa is considered a factor of interest: a higher threat leads to a higher value of I_2. This choice was made to prioritise taxa that may be under persisting pressures and/or taxa that suffer from population decline, in order to be studied and assessed before their populations reach a critical state. However, the set of indicators should not be the only information to start a scientific project, for these threatened taxa as well as for other taxa. Other factors have to be taken into account for the organisation of such a work: the size and genetic diversity of the population and threat posed by a new plant collection, the volume of plant material needed for the experiments compared to the biomass productivity of the population, accessibility of the site, financial and technical needs and means etc. (Norton et al. 1994, Parra-Quijano et al. 2011, Krell and Wheeler 2014). The maintenance of the taxon should be considered as the absolute priority over the hypothetical benefits human-kind could extract from it.

Regarding the flora of Greece, the present study provides a new insight on the ecosystem services provision and potential provision of endemic taxa. The development of these indicators contributes to the national efforts for the Mapping and Assessment of Ecosystems and their Services (MAES) implementation in Greece, including natural capital documentation and baseline development, following the LIFE IP 4 Natura guidelines (Kokkoris et al. 2020).

Conclusions

The present study creates a set of indicators to assess: (a) the medicinal and aromatic potential and (b) the general interest for further studies of taxa for a selected flora.

The set consists of four indicators: two main indicators, Medicinal and Aromatic Properties Index (I_1) and Study Interest Index (I_2) and two secondary indicators, Literature Volume Index (I_{LIT}) and Chemical Interest Index (I_{CHEM}). They are based on all available literature documenting properties for the taxa of this defined flora, as well as for related taxa (phylogeny, same-species, same-genus or 'outstanding' relatives with acknowledged herbal or food uses). After testing, this set of indicators is experimentally applied to the endemic flora of the Peloponnese and leads to the selection of 25 taxa with high MAP interest and of 24 taxa to be prioritised for further study. The Study Interest Index' higher values are obtained by the following taxa: *Sideritis clandestina* (Bory & Chaub.) Hayek sp., *Origanum lirium* Heldr. ex Halácsy, *Melilotus graecus* (Boiss. & Spruner) Lassen, *Satureja hellenica* Halácsy, *Thymus laconicus* Jalas and *Cruciata taurica* subsp. *euboea* (Ehrend.) Ehrend. Through this new methodology, based on literature data, this study applies for the first time indicators of ecosystem services potential to Greek endemic plant taxa and aims to provide tools for the selection of future scientific plant material and arguments in favour of sustainable products, alongside environmental management and conservation policies.

Appendix A

Details of the properties integrated into each property category, with mention of their Economic Botany Data Standards code (Table 15).

Table 15.

Details of the properties integrated into each property category, with mention of their Economic Botany Data Standards code.

N°	EBDS code	Property category	Detailed properties
1	1101	Unspecified medicinal disorders	Pharmaceutical, Traditional medicine (mentions)
2	1103	Blood system disorders	Blood protection, Antiscorbutic, Detoxifying
3	1104	Circulatory system disorders	Cardioprotective / Hypotensive, Circulatory system protection
4	1105	Digestive system disorders	Carminative, Vs gastrointestinal disorders, Antispasmodic, Bifidogenic, Digestive, Purgative / Emetic, Anti-nausea / Antiemetic, Vs constipation, Antidiarrhoeic
5	1106	Endocrine system disorders	Estrogenic, Antidiabetic
6	1107	Genitourinary system disorders	Aphrodisiac / Vs impotence, Gynecological use, Diuretic / Urinary tract disorders, Fertility improvement
7	1109	Immune system disorders	Immunoregulatory (stimulant or depressant)
8	1110	Infections/ Infestations	Antiviral, Antiviral HIV, Antiviral hepatitis, Antifungal, Antibacterial, Anti-yeast, Anti-parasitic / Anthelmintic, Vermifuge, Anti-malarial, Anti-influenza, Febrifuge, Vs cold / flu
9	1111	Inflammation	Anti-inflammatory, Anticatarrhal
10	1112	Injuries	Cicatrizing / Wound healing / Anti-platelet aggregation, Vs bruises, Vs bleeding disorders, Astringent
11	1113	Mental disorders	Relaxant / Sedative / Anesthetizing, Antianxiety / Antidepressant / Anxiolytic, Mental disorders (hysteria, hypochondria, etc.), Hypnotic / Psychedelic, Neuroprotective / Memory enhancer / Vs Alzheimer, Vs insomnia
12	1114	Metabolic system disorders	Chemoprotective, Cytoprotective, Anti-acetylcholinesterase / Anti-butyrylcholinesterase, Enzyme inhibition, Heating / Warming, Hepatoprotective, Kidney protection, Gall bladder protection, Thyroid protection, Other organs' protection (prostate, spleen etc.), Diaphoretic, Hypolipidemic, Anticholesterolemic, Vs jaundice
13	1115	Muscular-skeletal system disorders	Tooth/Throat/Mouth aches, Body/Muscle aches, Rheumatisms, Bone protection
14	1116	Neoplasms (tumours)	Antitumor / Anticancer, Cytotoxic, Antileukemic
15	1117	Nervous system disorders	Neurostimulant, Vs Parkinson, Anticonvulsive / Vs epilepsy

N°	EBDS code	Property category	Detailed properties
16	1118	Nutritional disorders	Antioxidant, Tonic, Appetite regulator, Vs obesity / Weight regulator
17	1119	Pain	Antinociceptive / Pain relief / Analgesic
18	1120	Poisonings	Vs allergies, Antidotal / Anti-poison (reptile bites, insect stings, risk of rabid)
19	1121	Pregnancy/Birth/ Puerperium disorders	Birth facilitator / Abortifacient / Galactagogue
20	1122	Respiratory system disorders	Anti-asthmatic, Expectorant / Antitussive, Vs respiratory disorders
21	1123	Sensory system disorders	Eye care / Sight improvement, Earing improvement
22	1124	Skin/Subcutaneous cellular tissue disorders	Vs smallpox / measle, Skin care, Vs eczema, Vs ulcers, Anti-hemorrhoidal, UV protection / Radiation protection, Anti-ageing, Hair-care
23	0101	Food (unspecified parts)	Food use (spices, vegetables, ingredient), Food use (beverages)
24	0200	Food additives (unspecified parts)	Food preservative / Food additive (aroma, emulsifier, etc.)
25	0906	Vertebrate poisons (Mammals)	Toxicity / Mutagenicity / Vs fertility / General health risks

Appendix B

Methodological supplement: comments on the development of the indicators.

During the creation of the set of indices, some suggestions and comments have been made on alternative formulations. These comments do not directly concern the final formulation of the indicators, but remain relevant to discuss the formulation process. They are gathered as an Appendix so as not to burden the article.

The following notes are added for the justification of the formulation of the **MAP index I_1**:

- It was suggested to integrate the **frequency** to which a category of property was mentioned as a reinforcement of its importance in the MAP index of a taxon. It is nonetheless decided that a single mention is (for this index) enough to stimulate an interest in the presence of a property. The amount of documentation available on properties is rather integrated into the Literature Volume Index (see the < a target="_blank" href="#formulation_of_the_literature_volume_index_isublitsub">Formulation
- It was suggested to modulate the **weight** of the phylogenetic relatives' properties in the formula by multiplying their grades by the genetic distance between each relative (sp_{Px}) and the considered taxon (sp_1). This factor was removed as its values were more or less regular amongst all close taxa and similar weights could not be applied to the other types of relatives (e.g. SL relatives);

- This index can be applied to various scales of flora (local, regional, national). Rather than to individual taxa, as it is here, it can also be applied to higher taxonomic **scales** (evaluation at the genus level based on a selection of plant species) or to a smaller scale (comparison within a selection of species).

The following notes are added to the justification of the formulation of the **Study Interest Index I_2**:

- If only the factors quoted here are taken into account, the Study Interest Index should give a **grade ranking from -5 to 5** (the grade may be negative if sp_1 is the main documented species of its Related Taxa Network). If there is a need for a more modulated selection of the taxon, a graphical representation in a spider chart with five branches can be suggested (the taxa with the most study interest being the one with the widest area covered by their spider chart): this can allow a quick view on the relative impact of each parameter included in the Study Interest;
- The study interest index could be used as a base for the development of an **Agronomy interest index** that would include various additional factors conditioning a sustainable use of the resource (successful germination/ propagation rates, yields in essential oils or biomass, suitability for cultivation, evaluation of the pressure on local populations etc.). A relevant idea was developed in a Sustainable Exploitation Feasibility index (Libiad et al. 2021);
- The **IUCN extinction status** are here integrated as a promoting factor for a taxon: the rarer it is, the higher the priority for its analysis, as its pharmaceutical or chemical peculiarities could be used as an additional argument for the launch of conservation measures. However, its extinction risk should be noted amongst the results of the indicators for the taxon, to highlight the need for special care to the size and balance of the taxon's populations before any study can be envisioned. The category 'Extinct' is also considered as a promoting factor here, to show not the value of the existing flora, but the loss this flora has already suffered.

Appendix C

List of 100 Greek endemic taxa selected for the validation test of the indicators (Table 16).

Table 16.

List of 100 Greek endemic taxa selected for the validation test of the indicators.

Taxonomy					Results of the indicators				Expert's results	
Family	Genus	Species	Sub-species	Status	Value I_1	Value I_2	MAP Interest Yes/No	Study Interest Yes/No	MAP Interest Yes/No	Study Interest Yes/No
Acanthaceae	*Acanthus*	*carolialexandri*		NE	2.000	0.251	YES	NO	YES	MAYBE
Alliaceae	*Allium*	*heldreichii*		DD	1.189	0.036	YES	NO	MAYBE	NO
Amaryllidaceae	*Galanthus*	*ikariae*		VU	2.286	0.685	YES	YES	YES	YES
Apiaceae	*Bunium*	*tenerum*		NE	0.000	0.000	NO	NO	YES	NO

Taxonomy					Results of the indicators				Expert's results	
Family	Genus	Species	Sub-species	Status	Value I 1	Value I 2	MAP Interest Yes/No	Study Interest Yes/No	MAP Interest Yes/No	Study Interest Yes/No
Apiaceae	*Bupleurum*	*kakiskalae*		CR	5.875	1.282	YES	YES	YES	YES
Apiaceae	*Geocaryum*	*bornmuelleri*		NE	0.000	0.025	NO	NO	YES	MAYBE
Apiaceae	*Ligusticum*	*olympicum*		NE	5.250	0.395	YES	NO	YES	YES
Apiaceae	*Peucedanum*	*gabrielae*		NE	0.000	0.033	NO	NO	YES	YES
Apiaceae	*Pimpinella*	*tragium*	*depressa*	NE	2.364	0.689	YES	YES	YES	YES
Apiaceae	*Seseli*	*parnassicum*		NE	0.000	-0.026	NO	NO	YES	YES
Apocynaceae	*Vincetoxicum*	*creticum*		NE	1.000	0.259	YES	NO	YES	YES
Araceae	*Arum*	*purpureospathum*		VU	3.778	1.126	YES	YES	YES	YES
Asparagaceae	*Prospero*	*idaeum*		DD	0.000	0.000	NO	NO	YES	MAYBE
Aspleniaceae	*Asplenium*	*creticum*		VU	0.000	0.500	NO	YES	MAYBE	MAYBE
Asteraceae	*Achillea*	*absinthoides*		NE	3.042	0.461	YES	YES	YES	YES
Asteraceae	*Anthemis*	*rhodensis*		NE	0.034	0.028	NO	NO	MAYBE	MAYBE
Asteraceae	*Bellis*	*longifolia*		NE	0.000	-0.115	NO	NO	MAYBE	MAYBE
Asteraceae	*Carlina*	*sitiensis*		NE	0.167	0.116	NO	NO	MAYBE	MAYBE
Asteraceae	*Carthamus*	*rechingeri*		NE	4.700	0.465	YES	YES	MAYBE	MAYBE
Asteraceae	*Centaurea*	*huljakii*		NE	0.163	0.003	NO	NO	YES	MAYBE
Asteraceae	*Crepis*	*athoa*		NE	0.000	-0.060	NO	NO	MAYBE	MAYBE
Asteraceae	*Filago*	*cretensis*	*cycladum*	NE	0.000	0.008	NO	NO	MAYBE	MAYBE
Asteraceae	*Helichrysum*	*sibthorpii*		NE	3.611	0.669	YES	YES	MAYBE	MAYBE
Asteraceae	*Hieracium*	*bractolympicum*		NE	0.009	0.004	NO	NO	MAYBE	MAYBE
Asteraceae	*Hieracium*	*racolympicum*	*lycopifoliopsis*	NE	0.009	0.004	NO	NO	MAYBE	MAYBE
Asteraceae	*Lamyropsis*	*carpini*		NE	0.000	-0.026	NO	NO	MAYBE	MAYBE
Asteraceae	*Onopordum*	*rhodense*		NE	-0.167	-0.038	NO	NO	MAYBE	MAYBE
Asteraceae	*Senecio*	*eubaeus*		NE	0.333	-0.001	NO	NO	MAYBE	MAYBE
Asteraceae	*Tragopogon*	*lassithicus*		NE	0.000	0.000	NO	NO	MAYBE	MAYBE
Boraginaceae	*Anchusa*	*cespitosa*		LC	2.714	0.390	YES	NO	MAYBE	MAYBE
Boraginaceae	*Cynoglossum*	*sphacioticum*		NE	1.500	0.246	YES	NO	MAYBE	MAYBE
Boraginaceae	*Symphytum*	*davisii*		NE	0.091	0.034	NO	NO	MAYBE	MAYBE
Brassicaceae	*Aethionema*	*retsina*		CR	0.000	0.960	NO	YES	MAYBE	MAYBE
Brassicaceae	*Alyssum*	*euboeum*		NE	0.000	-0.085	NO	NO	NO	NO
Brassicaceae	*Arabis*	*cretica*		NE	0.000	0.000	NO	NO	NO	NO
Brassicaceae	*Bornmuellera*	*tymphaea*		NE	0.000	-0.267	NO	NO	NO	NO
Brassicaceae	*Brassica*	*cadmea*		DD	1.200	0.639	YES	YES	MAYBE	MAYBE
Brassicaceae	*Draba*	*cretica*		NE	0.000	-0.083	NO	NO	NO	NO
Brassicaceae	*Erysimum*	*krendlii*		NE	0.154	-0.019	NO	NO	MAYBE	MAYBE
Brassicaceae	*Iberis*	*epirota*		NE	0.000	0.000	NO	NO	MAYBE	MAYBE
Brassicaceae	*Isatis*	*tinctoria*	*athoa*	NE	6.571	1.115	YES	YES	YES	YES

Taxonomy					Results of the indicators				Expert's results	
Family	Genus	Species	Sub-species	Status	Value I [1]	Value I [2]	MAP Interest Yes/No	Study Interest Yes/No	MAP Interest Yes/No	Study Interest Yes/No
Campanulaceae	*Campanula*	*carpatha*		NE	0.023	0.045	NO	NO	NO	NO
Caryophyllaceae	*Agrostemma*	*githago*	*thessalum*	NE	6.000	1.413	YES	YES	YES	YES
Caryophyllaceae	*Bufonia*	*ophiolithica*		NE	0.000	0.000	NO	NO	MAYBE	MAYBE
Caryophyllaceae	*Dianthus*	*gracilis*	*xanthianus*	NE	0.114	0.034	NO	NO	MAYBE	MAYBE
Caryophyllaceae	*Heliosperma*	*intonsum*		NE	0.000	0.000	NO	NO	NO	NO
Caryophyllaceae	*Minuartia*	*eurytanica*		NE	0.000	0.018	NO	NO	MAYBE	MAYBE
Caryophyllaceae	*Paronychia*	*bornmuelleri*		NE	0.000	0.000	NO	NO	MAYBE	MAYBE
Caryophyllaceae	*Petrorhagia*	*laconica*		NE	0.000	0.015	NO	NO	NO	NO
Caryophyllaceae	*Silene*	*antri-jovis*		NE	0.024	-0.041	NO	NO	NO	NO
Caryophyllaceae	*Telephium*	*imperati*	*pauciflorum*	NE	3.500	0.511	YES	YES	NO	NO
Chenopo -diaceae	*Atriplex*	*recurva*		NE	0.000	0.000	NO	NO	YES	YES
Cistaceae	*Fumana*	*paphlagonica*	*alpina*	NE	0.000	0.000	NO	NO	MAYBE	MAYBE
Crassulaceae	*Sedum*	*praesidis*		NE	0.000	0.030	NO	NO	MAYBE	MAYBE
Dipsacaceae	*Lomelosia*	*albocincta*		NE	0.000	-0.033	NO	NO	YES	YES
Fabaceae	*Anthyllis*	*splendens*		NE	1.500	0.108	YES	NO	MAYBE	MAYBE
Fabaceae	*Astragalus*	*dolinicola*		NE	1.667	0.185	YES	NO	MAYBE	MAYBE
Fabaceae	*Lathyrus*	*neurolobus*		NE	1.750	0.184	YES	NO	MAYBE	MAYBE
Fabaceae	*Ononis*	*verae*		NE	3.500	0.312	YES	NO	MAYBE	MAYBE
Fabaceae	*Trifolium*	*praetermissum*		NE	1.000	0.083	YES	NO	MAYBE	MAYBE
Fagaceae	*Quercus*	*trojana*	*euboica*	LC	1.400	0.122	YES	NO	MAYBE	MAYBE
Fumariaceae	*Corydalis*	*thasia*		NE	2.833	0.227	YES	NO	MAYBE	MAYBE
Gesneriaceae	*Jancaea*	*heldreichii*		NE	5.500	0.775	YES	YES	NO	NO
Hyacinthaceae	*Muscari*	*dionysicum*		NE	0.150	0.038	NO	NO	MAYBE	MAYBE
Hyacinthaceae	*Scilla*	*nana*		NE	0.000	0.011	NO	NO	MAYBE	MAYBE
Hypericaceae	*Hypericum*	*delphicum*		NE	2.214	0.100	YES	NO	YES	YES
Hypericaceae	*Hypericum*	*trichocaulon*		NE	1.972	0.326	YES	NO	YES	YES
Iridaceae	*Crocus*	*flavus*	*atticus*	NE	1.045	0.138	YES	NO	NO	NO
Iridaceae	*Iris*	*unguicularis*	*cretensis*	NE	1.438	0.084	YES	NO	MAYBE	MAYBE
Lamiaceae	*Micromeria*	*hispida*		NE	0.250	0.018	NO	NO	YES	YES
Lamiaceae	*Origanum*	*calcaratum*		VU	7.154	1.733	YES	YES	YES	YES
Lamiaceae	*Phlomis*	*lanata*		NE	2.333	0.037	YES	NO	MAYBE	MAYBE
Lamiaceae	*Salvia*	*eichleriana*		NE	13.286	1.028	YES	YES	YES	YES
Lamiaceae	*Satureja*	*montana*	*macedonica*	NE	3.950	1.229	YES	YES	MAYBE	MAYBE
Lamiaceae	*Sideritis*	*raeseri*	*attica*	NE	6.833	0.690	YES	YES	YES	YES
Lamiaceae	*Thymus*	*dolopicus*		NE	4.214	0.478	YES	YES	MAYBE	MAYBE
Liliaceae	*Fritillaria*	*ehrhartii*		LC	0.889	0.079	YES	NO	MAYBE	MAYBE

Taxonomy					Results of the indicators				Expert's results	
Family	Genus	Species	Sub-species	Status	Value I 1	Value I 2	MAP Interest Yes/No	Study Interest Yes/No	MAP Interest Yes/No	Study Interest Yes/No
Liliaceae	*Tulipa*	*cretica*		LC	0.143	-0.018	NO	NO	MAYBE	MAYBE
Linaceae	*Linum*	*euboeum*		NE	1.667	0.132	YES	NO	NO	NO
Orchidaceae	*Orchis*	*sitiaca*		EN	2.750	1.254	YES	YES	MAYBE	MAYBE
Orchidaceae	*Serapias*	*cordigera*	*cretica*	LC	0.333	0.044	NO	NO	MAYBE	MAYBE
Paeoniaceae	*Paeonia*	*clusii*		NE	6.909	0.926	YES	YES	YES	YES
Paeoniaceae	*Paeonia*	*parnassica*		EN	7.563	1.093	YES	YES	YES	YES
Plumbaginaceae	*Armeria*	*johnsenii*		NE	0.000	0.000	NO	NO	MAYBE	MAYBE
Plumbaginaceae	*Limonium*	*antipaxorum*		NE	0.013	-0.173	NO	NO	NO	NO
Poaceae	*Festuca*	*grandiaristata*		NE	0.042	0.036	NO	NO	NO	NO
Poaceae	*Hordeum*	*murinum*	*setariurum*	NE	2.833	0.421	YES	YES	MAYBE	MAYBE
Poaceae	*Poa*	*cephalonica*		NE	0.000	-0.050	NO	NO	NO	NO
Polygonaceae	*Polygonum*	*papillosum*		NE	8.000	0.602	YES	YES	MAYBE	MAYBE
Rosaceae	*Potentilla*	*deorum*		NE	2.800	0.244	YES	NO	MAYBE	MAYBE
Rosaceae	*Sanguisorba*	*cretica*		NE	8.500	0.640	YES	YES	MAYBE	MAYBE
Rubiaceae	*Asperula*	*brachyphylla*		NE	0.000	0.031	NO	NO	MAYBE	MAYBE
Rubiaceae	*Galium*	*pastorale*		NE	0.000	0.025	NO	NO	MAYBE	MAYBE
Scrophulariaceae	*Verbascum*	*boissieri*		NE	1.348	0.122	YES	NO	MAYBE	MAYBE
Tamaricaceae	*Tamarix*	*minoa*		DD	3.667	0.576	YES	YES	MAYBE	MAYBE
Thesicaceae	*Thesium*	*vlachorum*		NE	5.500	0.973	YES	YES	MAYBE	MAYBE
Valerianaceae	*Valeriana*	*asarifolia*		NE	3.750	0.282	YES	NO	YES	YES
Veronicaceae	*Cymbalaria*	*spetae*		NE	0.000	0.029	NO	NO	NO	NO
Violaceae	*Viola*	*alba*	*cretica*	NE	1.203	0.098	YES	NO	MAYBE	MAYBE
Viscaceae	*Viscum*	*album*	*creticum*	NE	3.429	0.562	YES	YES	YES	YES

Appendix D

The fifty taxa with the highest grades obtained for the set of indicators.

Legend: In blue: taxa with no documentation on their own properties; In yellow: taxa with own documentation only on their components.

Tables 17, 18, 19, 20

Table 17.

The fifty taxa with the highest grades obtained for the set of indicators: Medicinal and Aromatic Properties Potential (I_1).

Family	Genus	Species	Subspecies	I_1
Rosaceae	*Crataegus*	*pycnoloba*		10.8
Apiaceae	*Pimpinella*	*rigidula*		10.5
Fabaceae	*Cicer*	*graecum*		9.5
Lamiaceae	*Thymus*	*laconicus*		8.1
Lamiaceae	*Thymus*	*leucospermus*		8.1
Fabaceae	*Melilotus*	*graecus*		7.5
Lamiaceae	*Origanum*	*lirium*		7.5
Lamiaceae	*Origanum*	*scabrum*		7.5
Asteraceae	*Achillea*	*taygetea*		7.2
Paeoniaceae	*Paeonia*	*mascula*	*hellenica*	7.0
Rosaceae	*Potentilla*	*arcadiensis*		7.0
Fabaceae	*Ononis*	*spinosa*	*diacantha*	6.8
Linaceae	*Linum*	*hellenicum*		6.7
Linaceae	*Linum*	*phitosianum*		6.7
Fabaceae	*Trigonella*	*corniculata*	*rechingeri*	6.4
Lamiaceae	*Sideritis*	*clandestina*		6.3
Lamiaceae	*Thymus*	*hartvigii*	*hartvigii*	6.3
Lamiaceae	*Thymus*	*hartvigii*		6.3
Lamiaceae	*Sideritis*	*clandestina*	*clandestina*	6.0
Lamiaceae	*Sideritis*	*clandestina*	*peloponnesiaca*	6.0
Lamiaceae	*Satureja*	*hellenica*		5.9
Asteraceae	*Achillea*	*umbellata*		5.3
Pinaceae	*Abies*	*cephalonica*		5.0
Valerianaceae	*Valeriana*	*olenaea*		5.0
Scrophulariaceae	*Verbascum*	*epixanthinum*		4.8
Asteraceae	*Carthamus*	*leucocaulos*		4.7
Caprifoliaceae	*Lonicera*	*alpigena*	*hellenica*	4.6
Boraginaceae	*Lithodora*	*zahnii*		4.3
Fumariaceae	*Corydalis*	*blanda*	*oxelmannii*	4.3
Lamiaceae	*Lamium*	*garganicum*	*pictum*	4.3
Lamiaceae	*Marrubium*	*velutinum*		4.3
Apiaceae	*Carum*	*depressum*		4.2
Rutaceae	*Ruta*	*chalepensis*	*fumariifolia*	4.2

Family	Genus	Species	Subspecies	I_1
Chenopodiaceae	*Beta*	*nana*		4.2
Lamiaceae	*Ballota*	*nigra*	*anomala*	4.1
Lamiaceae	*Marrubium*	*velutinum*	*velutinum*	4.1
Lamiaceae	*Marrubium*	*velutinum*	*cylleneum*	3.9
Iridaceae	*Crocus*	*cartwrightianus*		3.9
Lamiaceae	*Phlomis*	*cretica*		3.8
Hypericaceae	*Hypericum*	*rumeliacum*	*apollinis*	3.7
Scrophulariaceae	*Verbascum*	*acaule*		3.5
Scrophulariaceae	*Verbascum*	*cylleneum*		3.5
Scrophulariaceae	*Verbascum*	*daenzeri*		3.5
Scrophulariaceae	*Verbascum*	*delphicum*		3.5
Scrophulariaceae	*Verbascum*	*hypoleucum*		3.5
Scrophulariaceae	*Verbascum*	*pangaeum*		3.5
Scrophulariaceae	*Verbascum*	*reiseri*		3.5
Valerianaceae	*Centranthus*	*longiflorus*	*junceus*	3.5
Scrophulariaceae	*Verbascum*	*speciosum*	*megaphlomos*	3.2
Gentianaceae	*Centaurium*	*erythraea*	*limoniiforme*	3.2

Table 18.

The fifty taxa with the highest grades obtained for the set of indicators: Literature Volume Index (I_{LIT}).

Family	Genus	Species	Subspecies	I_{LIT}
Lamiaceae	*Satureja*	*hellenica*		7.0
Lamiaceae	*Sideritis*	*clandestina*		6.8
Chenopodiaceae	*Beta*	*nana*		6.7
Pinaceae	*Abies*	*cephalonica*		6.7
Lamiaceae	*Sideritis*	*clandestina*	*clandestina*	6.5
Lamiaceae	*Sideritis*	*clandestina*	*peloponnesiaca*	6.3
Asteraceae	*Achillea*	*taygetea*		5.7
Apiaceae	*Conium*	*divaricatum*		5.0
Valerianaceae	*Centranthus*	*longiflorus*	*junceus*	5.0
Fabaceae	*Ononis*	*spinosa*	*diacantha*	4.5
Lamiaceae	*Ballota*	*nigra*	*anomala*	4.2
Caprifoliaceae	*Lonicera*	*alpigena*	*hellenica*	4.0
Fabaceae	*Genista*	*halacsyi*		4.0
Fabaceae	*Vicia*	*villosa*	*maniatissa*	4.0

Family	Genus	Species	Subspecies	I_{LIT}
Lamiaceae	*Lamium*	*garganicum*	*pictum*	3.9
Lamiaceae	*Phlomis*	*cretica*		3.8
Primulaceae	*Cyclamen*	*hederifolium*	*crassifolium*	3.7
Iridaceae	*Crocus*	*laevigatus*		3.4
Iridaceae	*Crocus*	*cartwrightianus*		3.4
Rutaceae	*Ruta*	*chalepensis*	*fumariifolia*	3.4
Boraginaceae	*Pulmonaria*	*cesatiana*		3.3
Iridaceae	*Crocus*	*goulimyi*		3.1
Iridaceae	*Crocus*	*tournefortii*		3.1
Rubiaceae	*Cruciata*	*taurica*	*euboea*	3.0
Lamiaceae	*Marrubium*	*velutinum*		2.9
Liliaceae	*Tulipa*	*orphanidea*		2.8
Lamiaceae	*Marrubium*	*velutinum*	*velutinum*	2.7
Asteraceae	*Achillea*	*umbellata*		2.7
Boraginaceae	*Lithodora*	*zahnii*		2.7
Lamiaceae	*Satureja*	*parnassica*	*parnassica*	2.7
Scrophulariaceae	*Verbascum*	*epixanthinum*		2.6
Iridaceae	*Crocus*	*robertianus*		2.6
Iridaceae	*Crocus*	*niveus*		2.5
Lamiaceae	*Origanum*	*lirium*		2.5
Lamiaceae	*Origanum*	*scabrum*		2.5
Lamiaceae	*Teucrium*	*flavum*	*hellenicum*	2.4
Lamiaceae	*Marrubium*	*velutinum*	*cylleneum*	2.4
Liliaceae	*Tulipa*	*goulimyi*		2.3
Liliaceae	*Tulipa*	*hageri*		2.3
Gentianaceae	*Centaurium*	*erythraea*	*limoniiforme*	2.3
Lamiaceae	*Teucrium*	*aroanium*		2.3
Lamiaceae	*Teucrium*	*francisci-werneri*		2.3
Lamiaceae	*Teucrium*	*halacsyanum*		2.3
Aristolochiaceae	*Aristolochia*	*microstoma*		2.0
Asteraceae	*Chondrilla*	*ramosissima*		2.0
Asteraceae	*Helichrysum*	*taenari*		2.0
Asteraceae	*Leontodon*	*graecus*		2.0
Boraginaceae	*Anchusella*	*variegata*		2.0
Boraginaceae	*Rindera*	*graeca*		2.0
Caryophyllaceae	*Saponaria*	*jagelii*		2.0

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Table 19.

The fifty taxa with the highest grades obtained for the set of indicators: Chemical Interest Index (I_{CHEM}).

Family	Genus	Species	Subspecies	I_{CHEM}
Rubiaceae	*Cruciata*	*taurica*	*euboea*	3.5
Apiaceae	*Thamnosciadium*	*junceum*		3.0
Lamiaceae	*Satureja*	*hellenica*		2.8
Lamiaceae	*Sideritis*	*clandestina*		2.8
Lamiaceae	*Satureja*	*parnassica*	*parnassica*	2.7
Lamiaceae	*Sideritis*	*clandestina*	*clandestina*	2.5
Asteraceae	*Inula*	*candida*	*limonella*	2.4
Asteraceae	*Inula*	*candida*		2.4
Lamiaceae	*Sideritis*	*clandestina*	*peloponnesiaca*	2.4
Lamiaceae	*Phlomis*	*cretica*		2.3
Asteraceae	*Achillea*	*taygetea*		2.1
Apiaceae	*Chaerophyllum*	*heldreichii*		2.0
Apiaceae	*Laserpitium*	*pseudomeum*		2.0
Apiaceae	*Pimpinella*	*rigidula*		2.0
Aristolochiaceae	*Aristolochia*	*microstoma*		2.0
Asteraceae	*Achillea*	*umbellata*		2.0
Geraniaceae	*Geranium*	*kikianum*		2.0
Lamiaceae	*Origanum*	*lirium*		2.0
Lamiaceae	*Origanum*	*scabrum*		2.0
Asteraceae	*Inula*	*candida*	*candida*	2.0
Hypericaceae	*Hypericum*	*rumeliacum*	*apollinis*	1.8
Pinaceae	*Abies*	*cephalonica*		1.7
Lamiaceae	*Lamium*	*garganicum*	*pictum*	1.6
Lamiaceae	*Ballota*	*nigra*	*anomala*	1.6
Caprifoliaceae	*Lonicera*	*alpigena*	*hellenica*	1.6
Asteraceae	*Inula*	*verbascifolia*	*methaneae*	1.5
Apiaceae	*Johrenia*	*distans*		1.5
Asteraceae	*Crepis*	*heldreichiana*		1.5
Asteraceae	*Crepis*	*incana*		1.5
Dipsacaceae	*Pterocephalus*	*perennis*	*perennis*	1.5
Lamiaceae	*Nepeta*	*argolica*		1.5
Rosaceae	*Amelanchier*	*parviflora*	*chelmea*	1.5

Family	Genus	Species	Subspecies	I_{CHEM}
Asteraceae	*Inula*	*verbascifolia*	*parnassica*	1.5
Lamiaceae	*Teucrium*	*flavum*	*hellenicum*	1.3
Lamiaceae	*Nepeta*	*argolica*	*argolica*	1.3
Lamiaceae	*Marrubium*	*velutinum*	*cylleneum*	1.3
Lamiaceae	*Marrubium*	*velutinum*	*velutinum*	1.3
Lamiaceae	*Marrubium*	*velutinum*		1.3
Cistaceae	*Halimium*	*voldii*		1.3
Hypericaceae	*Hypericum*	*boehlingraabei*		1.3
Hypericaceae	*Hypericum*	*taygeteum*		1.3
Hypericaceae	*Hypericum*	*tymphresteum*		1.3
Lamiaceae	*Stachys*	*spinosa*		1.3
Lamiaceae	*Thymus*	*laconicus*		1.3
Lamiaceae	*Thymus*	*leucospermus*		1.3
Asteraceae	*Echinops*	*ritro*	*sartorianus*	1.2
Lamiaceae	*Stachys*	*swainsonii*	*argolica*	1.2
Lamiaceae	*Stachys*	*swainsonii*	*melangavica*	1.2
Lamiaceae	*Stachys*	*swainsonii*		1.2
Lamiaceae	*Stachys*	*chrysantha*		1.2

Table 20.

The fifty taxa with the highest grades obtained for the set of indicators: Study Interest Index (I_2).

Family	Genus	Species	Subspecies	I_2
Lamiaceae	*Sideritis*	*clandestina*		1.7
Lamiaceae	*Origanum*	*lirium*		1.7
Fabaceae	*Melilotus*	*graecus*		1.6
Lamiaceae	*Satureja*	*hellenica*		1.4
Lamiaceae	*Thymus*	*laconicus*		1.4
Rubiaceae	*Cruciata*	*taurica*	*euboea*	1.4
Chenopodiaceae	*Beta*	*nana*		1.3
Fabaceae	*Ononis*	*spinosa*	*diacantha*	1.3
Polygalaceae	*Polygala*	*helenae*		1.3
Scrophulariaceae	*Verbascum*	*epixanthinum*		1.3
Lamiaceae	*Sideritis*	*clandestina*	*clandestina*	1.2
Rosaceae	*Potentilla*	*arcadiensis*		1.1
Pinaceae	*Abies*	*cephalonica*		1.1
Linaceae	*Linum*	*hellenicum*		1.1

Family	Genus	Species	Subspecies	I_2
Caprifoliaceae	*Lonicera*	*alpigena*	*hellenica*	1.1
Apiaceae	*Pimpinella*	*rigidula*		1.1
Lamiaceae	*Ballota*	*nigra*	*anomala*	1.1
Caryophyllaceae	*Silene*	*conglomeratica*		1.1
Fabaceae	*Astragalus*	*agraniotii*		1.1
Valerianaceae	*Centranthus*	*longiflorus*	*junceus*	1.0
Campanulaceae	*Campanula*	*papillosa*		1.0
Lamiaceae	*Nepeta*	*scordotis*		1.0
Isotaceae	*Isoetes*	*heldreichii*		1.0
Asteraceae	*Leontodon*	*graecus*		1.0
Rosaceae	*Crataegus*	*pycnoloba*		1.0
Fabaceae	*Astragalus*	*thracicus*	*cylleneus*	1.0
Asteraceae	*Echinops*	*graecus*		0.9
Lamiaceae	*Thymus*	*hartvigii*	*hartvigii*	0.9
Brassicaceae	*Erysimum*	*cephalonicum*		0.9
Asteraceae	*Centaurea*	*pseudocadmea*		0.9
Lamiaceae	*Sideritis*	*clandestina*	*peloponnesiaca*	0.9
Rutaceae	*Ruta*	*chalepensis*	*fumariifolia*	0.9
Asteraceae	*Achillea*	*occulta*		0.9
Scrophulariaceae	*Verbascum*	*delphicum*		0.9
Violaceae	*Viola*	*oligyrtia*		0.9
Liliaceae	*Fritillaria*	*conica*		0.8
Fabaceae	*Cicer*	*graecum*		0.8
Asteraceae	*Achillea*	*taygetea*		0.8
Liliaceae	*Fritillaria*	*rhodocanakis*	*argolica*	0.8
Boraginaceae	*Pulmonaria*	*cesatiana*		0.8
Fabaceae	*Astragalus*	*apollineus*		0.8
Fabaceae	*Astragalus*	*drupaceus*		0.8
Caryophyllaceae	*Arenaria*	*guicciardii*		0.8
Primulaceae	*Cyclamen*	*hederifolium*	*crassifolium*	0.8
Lamiaceae	*Lamium*	*garganicum*	*pictum*	0.8
Boraginaceae	*Alkanna*	*sartoriana*		0.8
Asteraceae	*Phitosia*	*crocifolia*		0.8
Brassicaceae	*Aethionema*	*carlsbergii*		0.8
Ranunculaceae	*Consolida*	*tuntasiana*		0.8
Hypericaceae	*Hypericum*	*taygeteum*		0.7

Data availability

The dataset used for this article (see Table 3) is available on the Mendeley repository platform. The spreadsheet described step by step in 'Material and methods' refers to the document named "FULL- Ecosystem services indicators.xlsx".

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Conflicts of interest

The authors have declared that no competing interests exist.

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Endnotes

*1 Note: (b) corresponds to the number of taxa for which the expert feedback was negative, but the result of the indicator was positive (false positive results). (c) is the opposite: the result the indicator yields is negative, whereas the expert expected a positive result (false negative results).