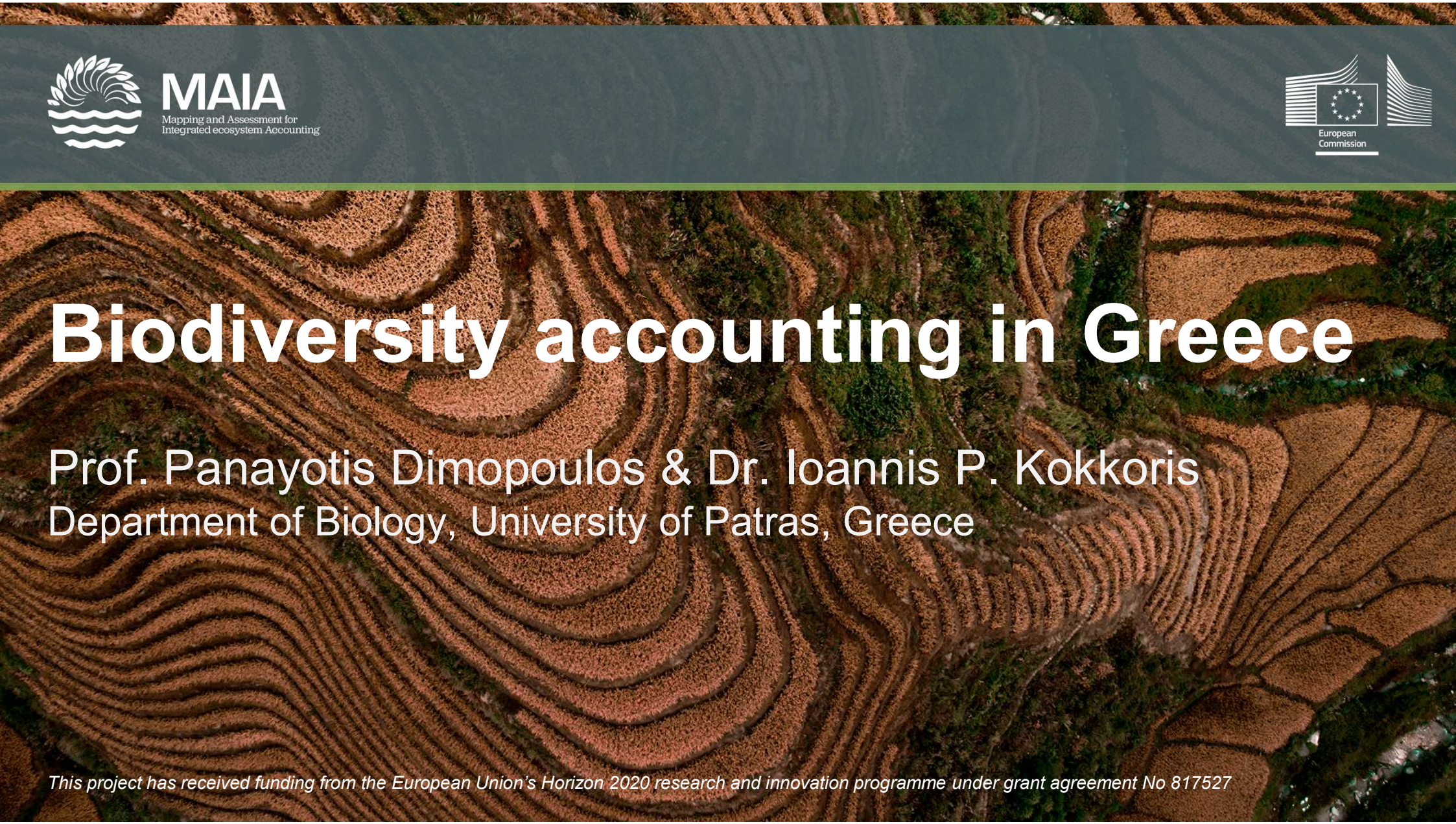

Biodiversity accounting in Greece

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Department of Biology, University of Patras, Greece

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817527

Biodiversity accounting under the SEEA-EEA

Main concerns:

- Scale of accounting
- Data availability (spatial, temporal)
- Quantification
- Habitat-based biodiversity metrics / indicators
- Integration into current monitoring schemes
- Integration into current development strategies

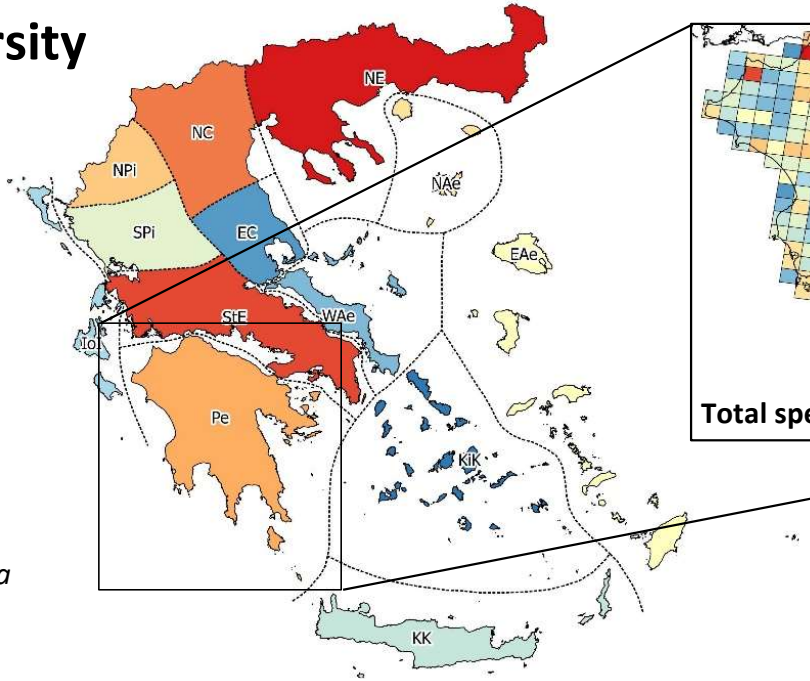
The Greek flora: diversity and proxy indicators

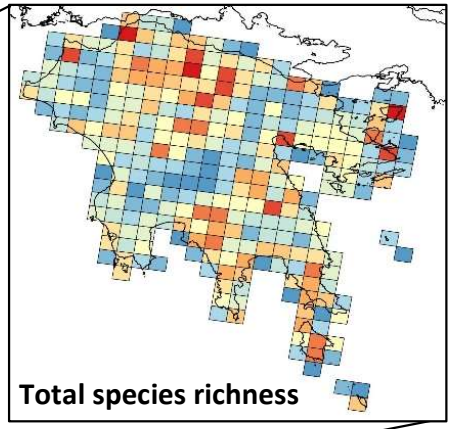
Diversity of flora taxa (species and sub-species)*

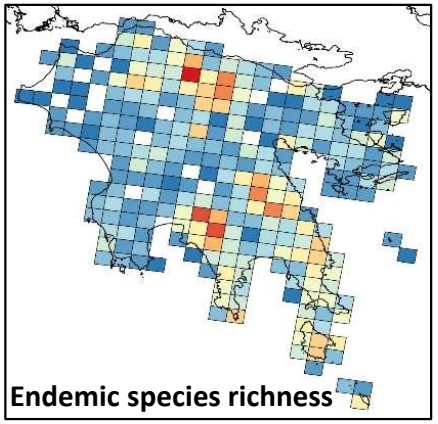
High

Low

**weighted by florist region area*



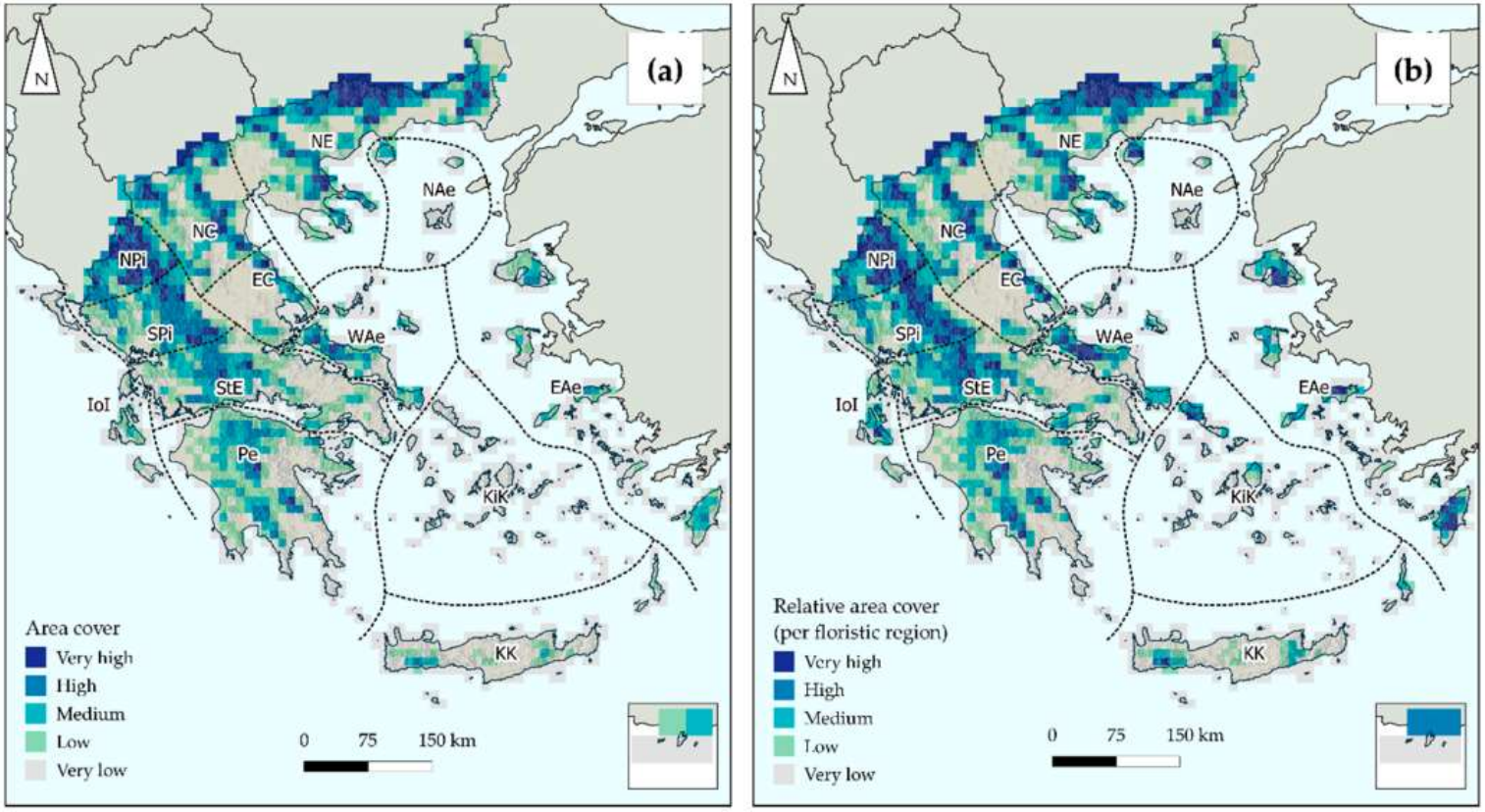




Taxonomic unit	Floristic regions of Greece												
	Greece	EAe	EC	Iol	Kik	KK	NAe	NC	NPi	NE	Pe	SPi	StE	WAe
Family	185	152	144	146	138	146	145	158	147	164	162	155	160	147
Genus	1080	760	714	699	630	705	690	824	746	877	868	797	865	702
Species	5847	2401	2095	1953	1700	2088	1971	3128	2591	3296	3073	2671	3135	2044
Subspecies	1985	662	569	525	467	572	502	1020	839	1059	951	823	987	584
Taxa	6715	3063	2664	2478	2167	2660	2473	4148	3430	4355	4024	3494	4122	2628

Proxy indicators development

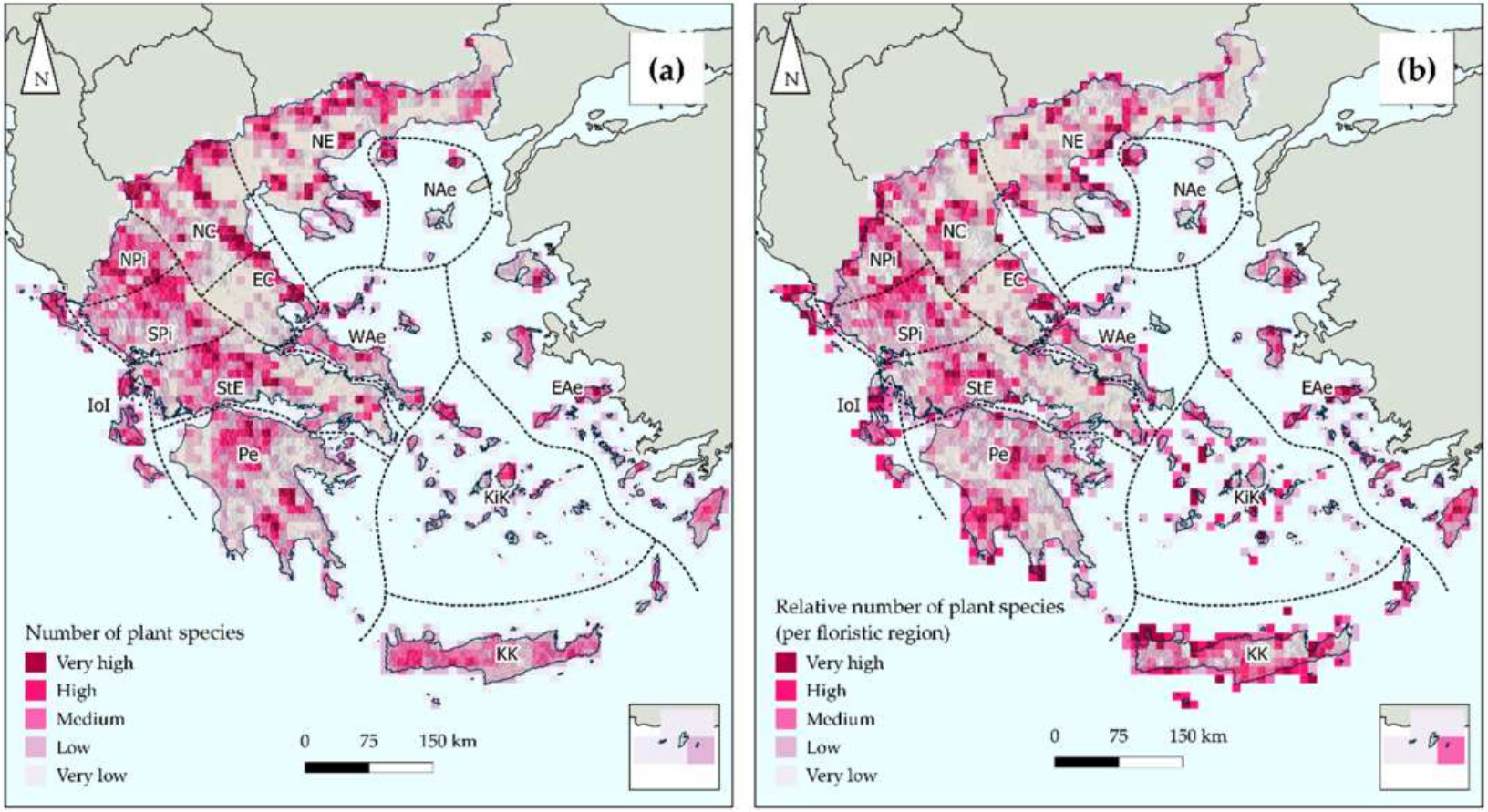
Ecosystem extent for woodland and forest



$$Relative\ area = 100\% * \frac{Ecosystem\ Extent\ in\ grid\ cell\ i}{Total\ Ecosystem\ Extent\ in\ the\ floristic\ region}$$

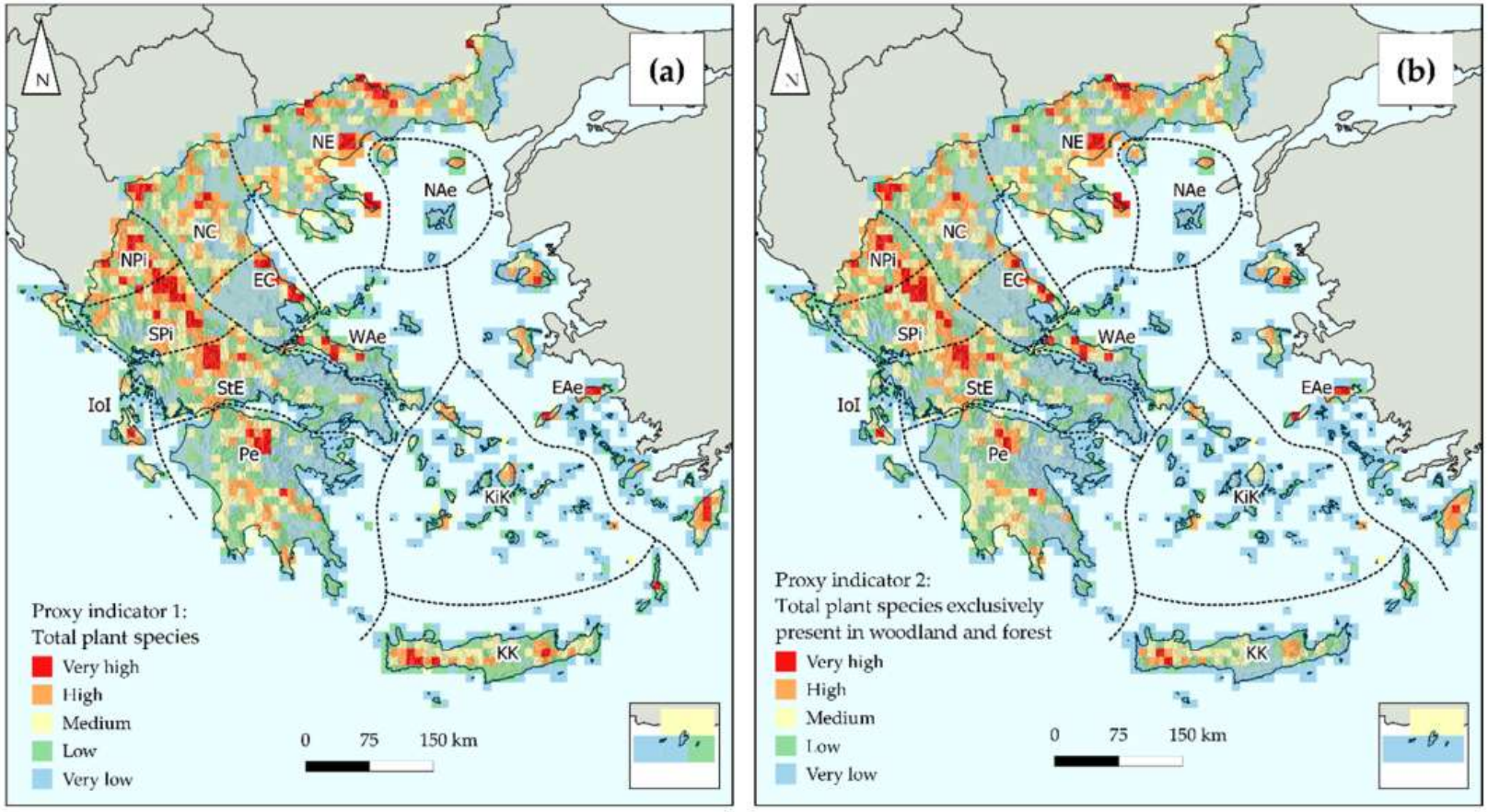
Proxy indicators development

Total species richness in woodland and forests



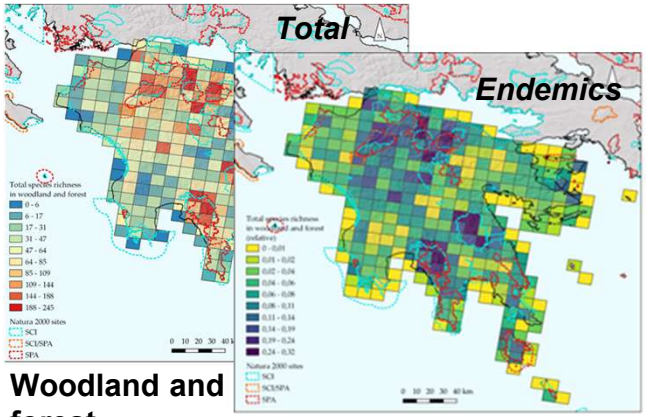
Proxy indicators

Proxy indicator for biodiversity accounting based on woodland and forest extent

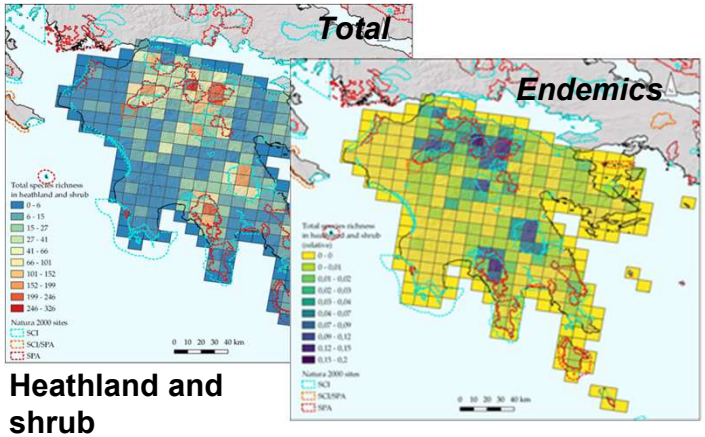


Accounting and valuation: baseline for the Peloponnese

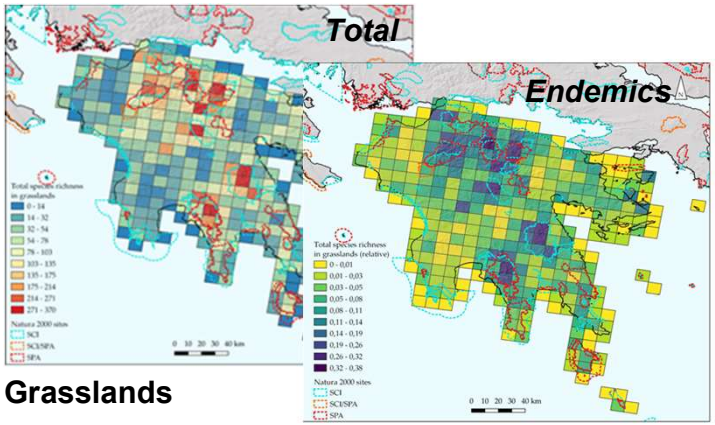
Ecosystem Types	Regional Number of Species	Regional Unique Species	Regional Endemics	Regional Unique Endemics
Woodland and forest	775	319	66	22
Cropland	1321	726	39	12
Heathland and shrub	1604	538	282	132
Grassland	981	249	121	52
Sparcely vegetated land_(low lands)	296	181	38	32
Sparcely vegetated land_(mountainous)	415	167	159	90
Wetlands/Rivers and lakes	487	266	8	5



Woodland and forest



Heathland and shrub



Grasslands

Accounting and valuation

Total biodiversity value (V_b) for woodland and forest:

$$V_b = Area * N * P$$

Area = ecosystem type area (Ha),
N = naturalness coefficient for different types of woodland and forest areas (0,1 to 1,0 from an officially adopted by the Greek State relevant table, for each woodland and forest category).
P = 120 euro/Ha (maximum biodiversity value for woodland and forest)

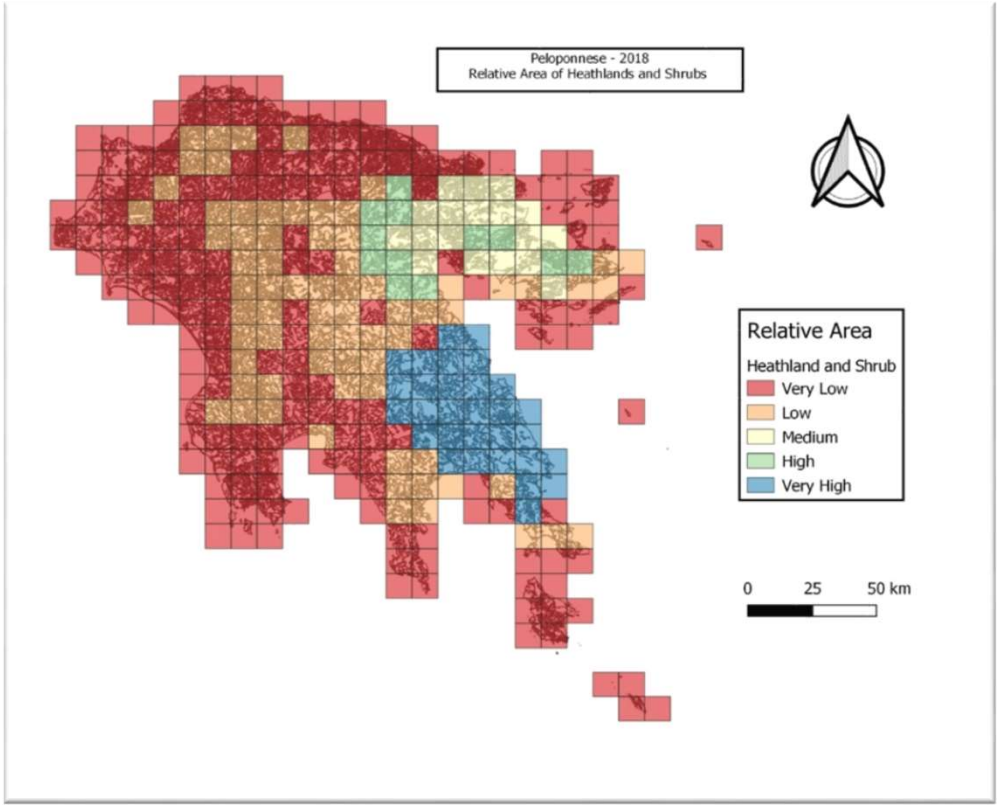
- ✓ Integrating the area parameter provides a straightforward solution for creating accounting tables based on woodland and forest area change through time.

Values of the coefficient (N) for different forest types.

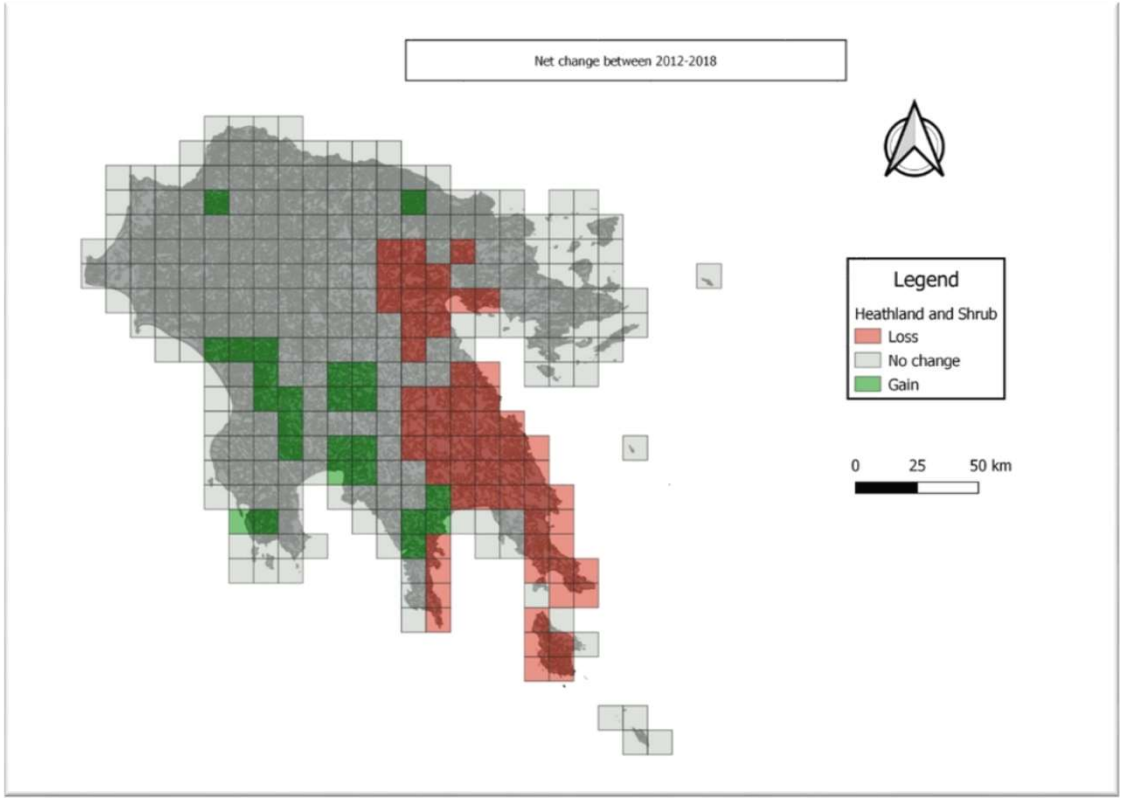
Forest ecosystem	N coefficient
Foreign species fast grown plantations	0.1
Monoculture of regularly managed deciduous forests	0.2
Mixed mangrove forests regularly managed	0.3
Shrubs and Mediterranean maquis	0.4
Complex deciduous forests	0.5
Bush forests under transition to high forests	0.6
High forest monoculture	0.7
Mixed high forests	0.8
Reforestation in the phase of conversion into natural forest	0.8
Multi-storey mixed high forests and riparian forests	0.9
Virgin or primordial forests	1.0

Source: *Table 4.14 of Ministerial Decision 115963/6070.*

Relative area 2018



Net change 2012-2018



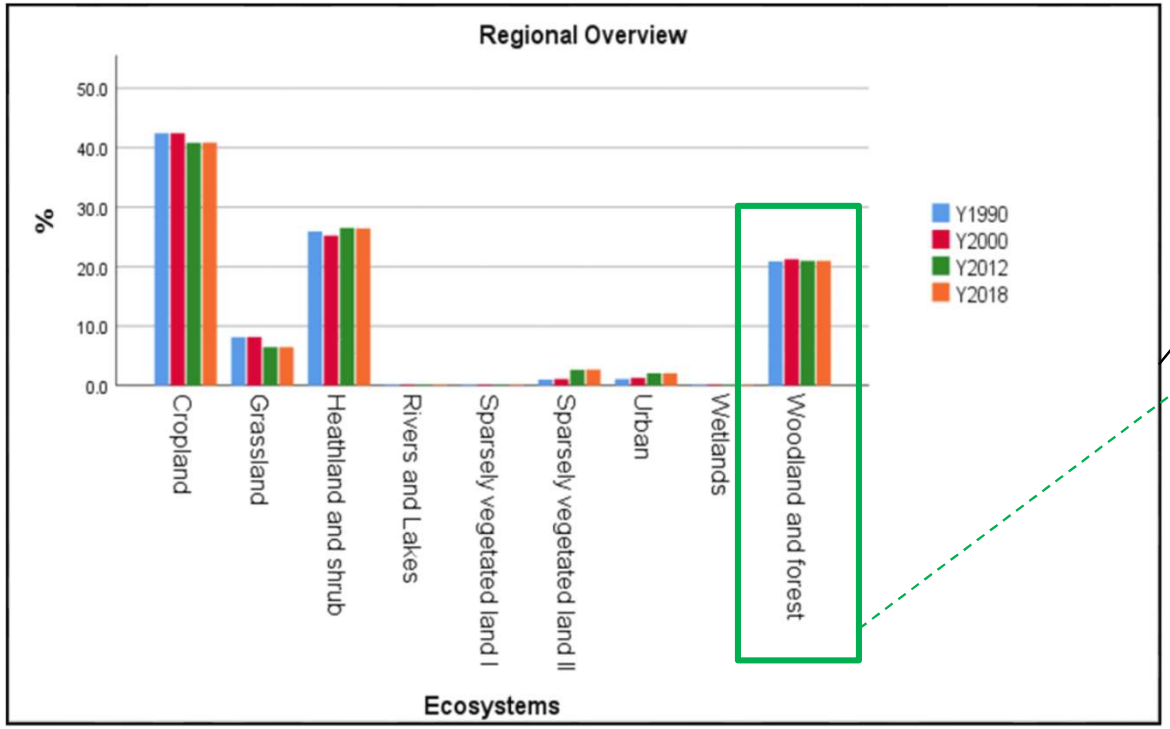
$$Total\ Extent = \sum_{i=1}^{N} Extent_i$$

$$Net\ Change = Total\ Extent_{t+1} - Total\ Extent_t$$

i: grid cell i
N: total number of grid cells
t: year

$$Relative\ change = 100\% * \frac{Extent_{t+1} - Extent_t}{|Net\ change\ [t, t+1]|}$$

Accounting and valuation



Past and present period

V_b = Area * N * P

Accounting tables

Future predictions

Climatic scenarios

Management scenarios

Future area change

Biodiversity accounting in the Natura 2000 network sites:

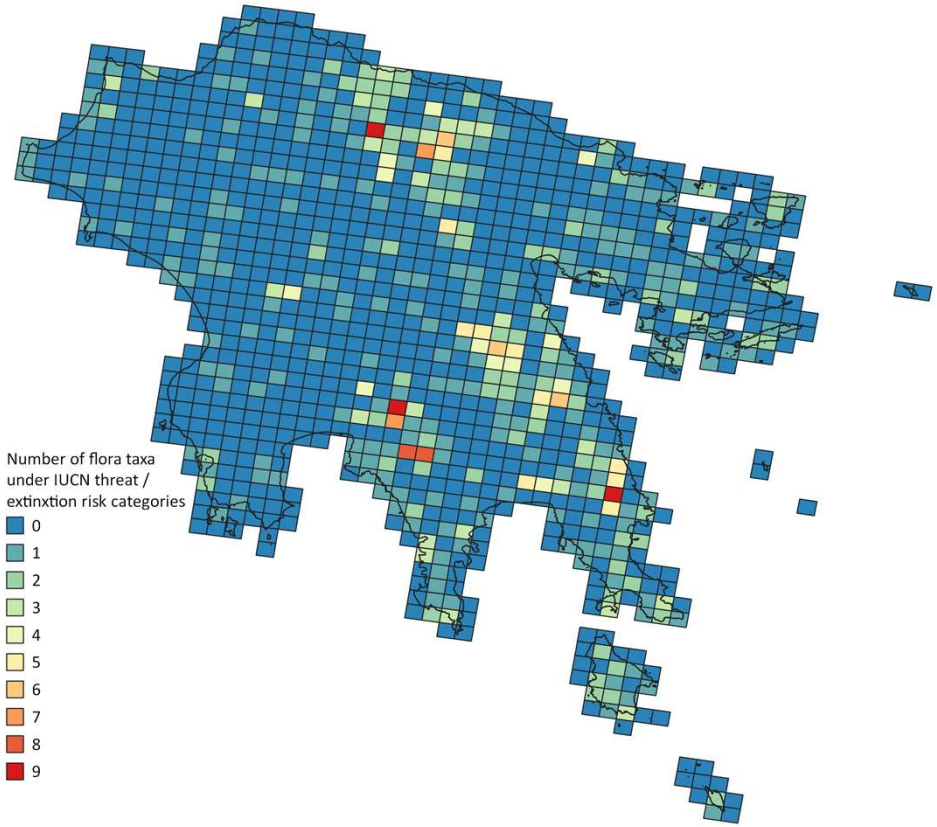
- Ecosystem types (MAES level 3)
- Habitat types
- Priority habitat types
- Species listed under IUCN threat categories
- Annex I species of Directive 92/43/EEC

	MAES - LEVEL 3 (2000)	MAES - LEVEL 3 (2015)	**Net Change (2000 to 2015)**	Habitat types (2000)	Habitat types (2015)	**Net Change (2000 to 2015)**	Priority Habitat types (2000)	Priority Habitat types (2015)	**Net Change (2000 to 2015)**	Species listed in IUCN threat categories (2000)	Species listed in IUCN threat categories (2015)	**Net Change (2000 to 2015)**	Annex I species of Directive 92/43/EEC (2000)	Annex I species of Directive 92/43/EE (2015)	**Net Change (2000 to 2015)**
Peloponnese (Total)	**13**	**16**	3	**37**	**50**	**13**	**5**	**9**	**4**	**23**	**10**	**-13**	**4**	**4**	**0**
Prefecture of Achaia	12	14	2	29	31	2	5	5	0	6	4	-2	2	2	0
Prefecture of Argolis	3	3	0	3	3	0	0	0	0	0	0	0	0	0	0
Prefecture of Arkadia	12	15	3	22	27	5	3	4	1	7	3	-4	1	1	0
Prefecture of Corinthia	10	12	2	16	19	3	3	3	0	6	3	-3	1	1	0
Prefecture of Ilia	12	15	3	21	35	14	1	4	3	1	1	0	0	0	0
Prefecture of Lakonia	11	13	2	21	27	6	2	3	1	5	3	-2	1	1	0
Prefecture of Messinia	12	13	1	26	33	7	3	6	3	10	1	-9	2	2	0

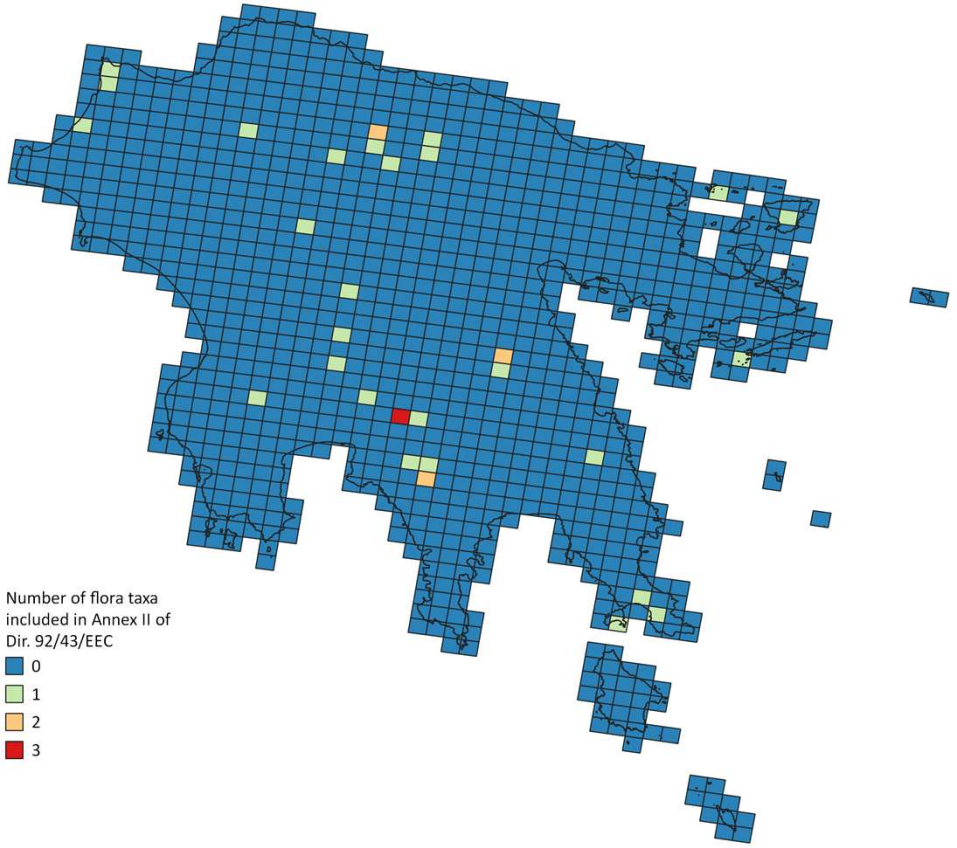
Regions and ecosystem types	Species under IUCN category (2000)	Species under IUCN category (2015)	Net change	Annex I species of Directive 92/43/EEC (2000)	Annex I species of Directive 92/43/EE (2015)	Net change
Prefecture of Achaia	**6**	**4**	**-2**	**2**	**2**	0
Beaches, dunes, sands	1	0	-1	0	0	0
Coastal lagoons	No data	0	N/A	No data	0	N/A
Floodplain forests (Riparian forest/Fluvial forest)	1	0	-1	0	0	0
Inland freshwater marshes	0	0	0	0	0	0
Inland saline marshes	0	0	0	0	0	0
Mediterranean coniferous forests	2	1	-1	0	0	0
Mediterranean deciduous forests	0	0	0	0	0	0
Mediterranean sclerophyllous forests	0	1	1	0	0	0
Moors and heathland	2	0	-2	1	1	0
Natural grasslands with woody species (W.C.D. < 30%)	0	1	1	0	0	0
Reforestation	No data	0	N/A	No data	0	N/A
Sclerophyllous vegetation	2	1	-1	0	0	0
Sparsely vegetated land	3	1	-2	1	1	0
Temperate mountainous coniferous forests	1	0	-1	0	0	0

- Forest (mega) fires ?
- Wind parks ?

Baseline maps for future accounting, using a 5x5 km modified EEA Reference Grid for Greece

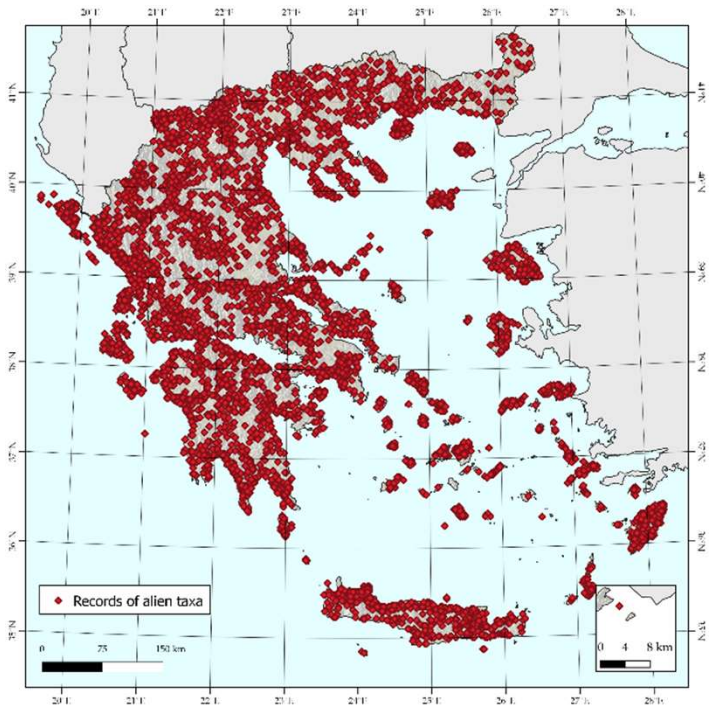


Number of flora taxa under IUCN threat / extinction risk categories in the Peloponnese

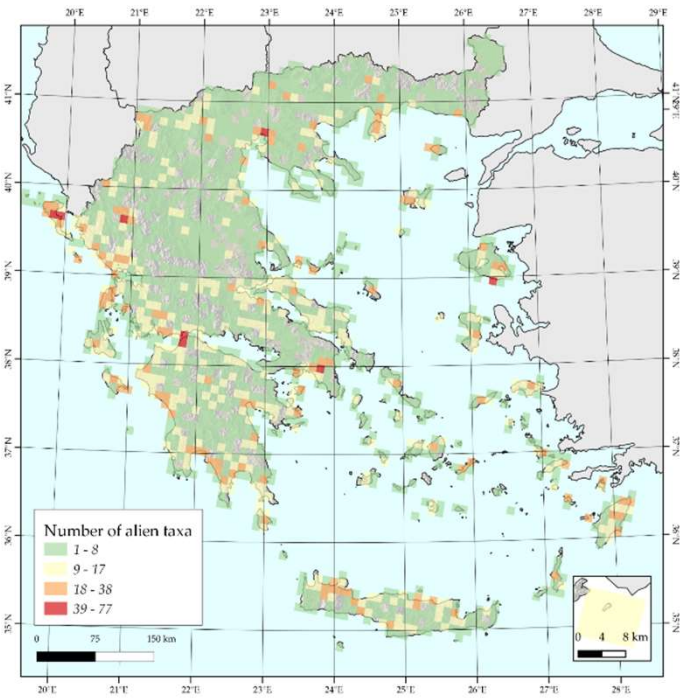


Number of Annex II (Dir. 92/43/EEC) flora taxa in the Peloponnese

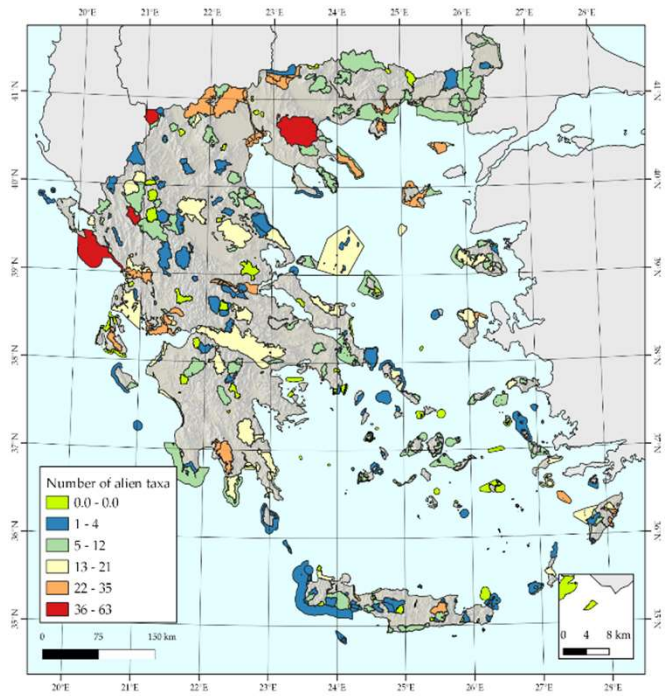
Accounting based on alien and invasive species



Occurrences



10x10 km EEA reference grid



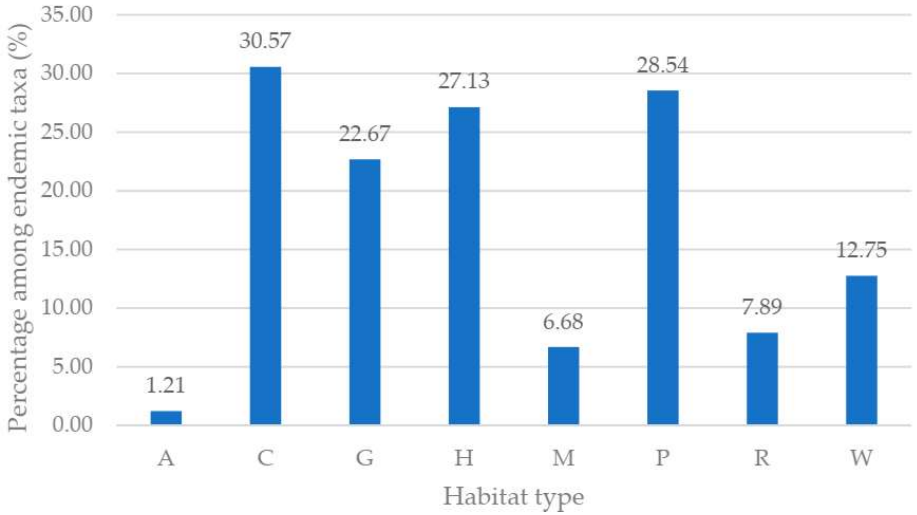
Natura 2000 SACs

- ❑ 457 alien taxa out of 6760 taxa in Greece (7% of the Greek flora).
- ❑ 282 established (62%)

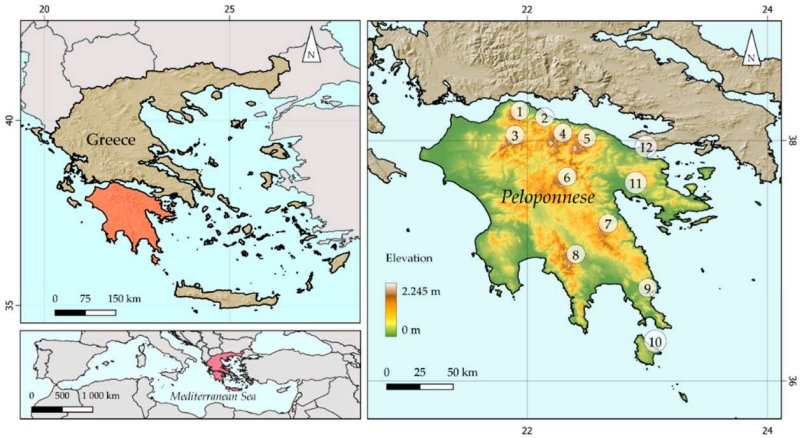
- 2000
- 2015
- 2022 (on going)

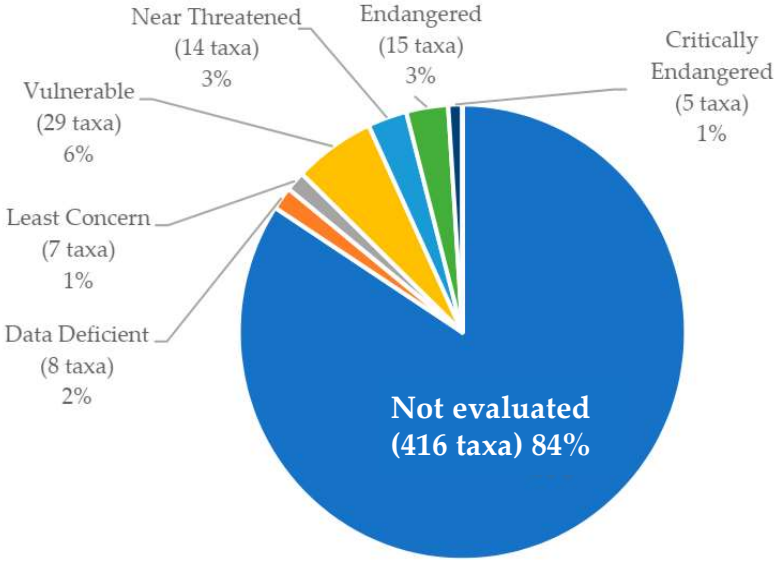
Accounting baseline for endemic Medicinal and Aromatic Plants

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



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





sustainability

MDPI

Review

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

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

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

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1. Introduction

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

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

Accounting baseline for endemic Medicinal and Aromatic Plants

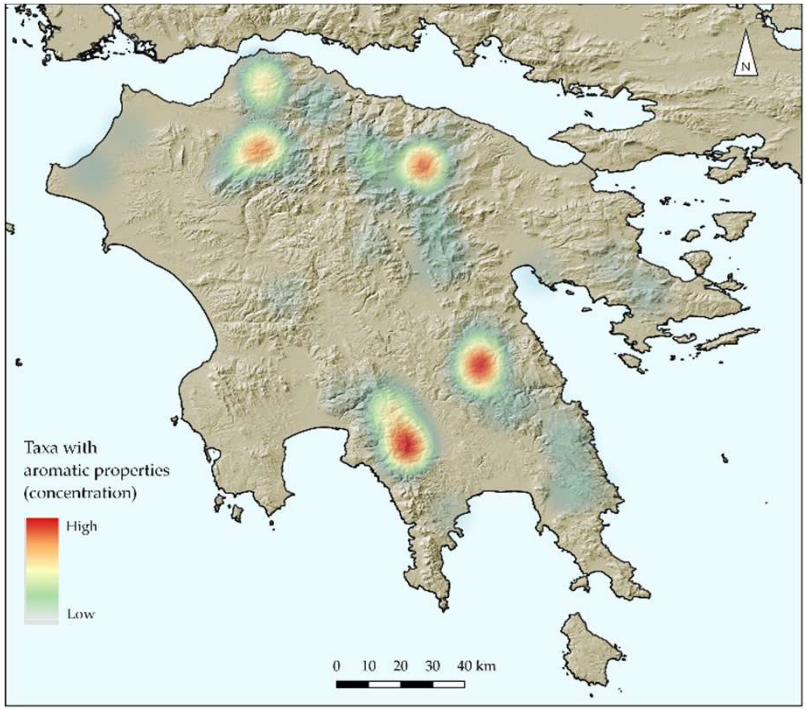
- **Summary of the ecosystem services** provided by the endemic taxa of Peloponnese

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

Accounting baseline for endemic Medicinal and Aromatic Plants

- **Aromatic properties** documented for the endemic taxa of Peloponnese (x: taxa with proved properties, M: taxa with suggested properties)

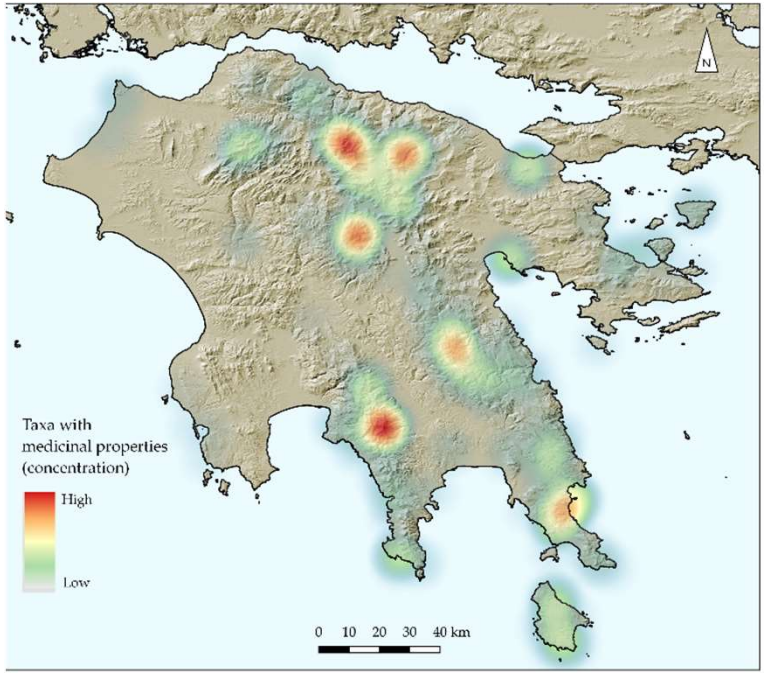
	N° of Pe. Endemic Taxa Concerned		
Properties	**x**	**M**	**Total**
Food use (spice/food/aromatic)	10	5	15
Food use (beverage)	6	0	6
Food preservative	1	1	2
Perfume/Fragrance/Incense	0	1	1



Accounting baseline for endemic Medicinal and Aromatic Plants

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

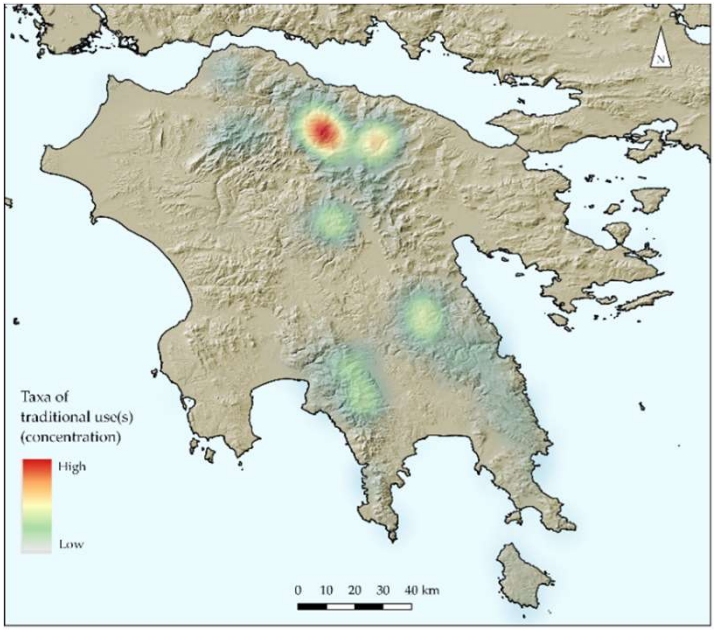
	N° of Pe. Endemic Taxa Concerned			
Properties	**x**	**M**	**No**	**Total**
Antioxidant/Radical scavenging	17	1	1	19
Anti-tumor/Anticancer	12	0	1	13
Cytotoxic	8	1	1	10
Estrogenic/Vs Endometriosis	4	0	2	6
Anti-inflammatory	5	0	0	5
Health, fertility or DNA risk	1	1	1	3
Enzyme inhibition	2	1	0	3
Anti-acetylcholinesterase/Anticholinesterase/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



Accounting baseline for endemic Medicinal and Aromatic Plants

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

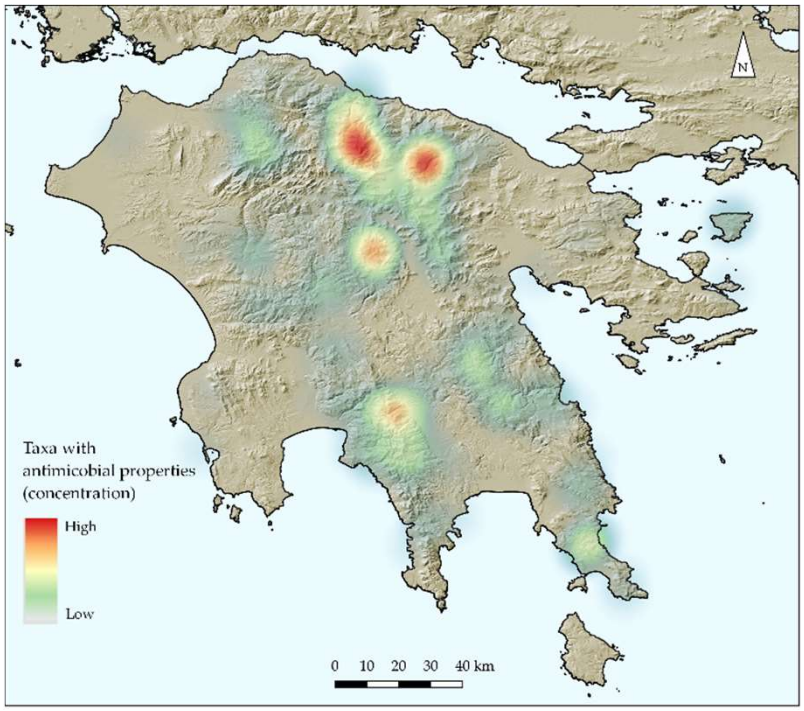
	N° of Pe. Endemic Taxa Concerned		
Properties	**x**	**M**	**Total**
Anti-inflammatory	1	0	1
Cicatrizant	1	0	1
Relaxant/Sedative	1	0	1
Tonic	1	0	1
Carminative	1	0	1
Skin care	1	0	1
Vs Eczema	1	0	1
Anti-hemorrhoids	2	0	2
Gastrointestinal protection	2	0	2
Digestive	1	0	1
Anti-asthmatic	1	0	1
Expectorant/Antitussive	2	0	2
Vs Respiratory illnesses	1	0	1
Astringent	2	0	2
Other traditional uses	1	2	3



Accounting baseline for endemic Medicinal and Aromatic Plants

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

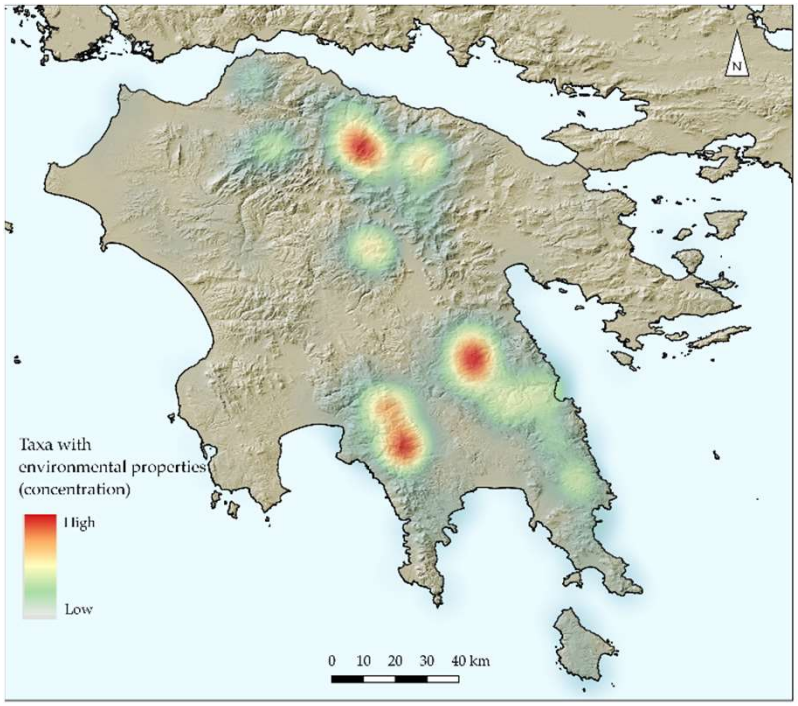
	N° of Pe. Endemic Taxa Concerned			
Properties	**x**	**M**	**No**	**Total**
Antiviral	3	0	6	9
Antifungal	18	0	1	19
Antibacterial/Antiseptic/Desinfectant	28	0	0	28
Anti-yeast	1	0	0	1
Anti-parasitic	1	0	0	1



Accounting baseline for endemic Medicinal and Aromatic Plants

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

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



Accounting based endemic Medicinal and Aromatic Plants

- **Comparison** between the endemic taxa own properties and their potential properties based on the related taxa dataset.

	Aromatic	Medical	Traditional medicine	Antimicrobial	Environment benefit	Industrial / Craft	TOTAL
N° of endemic taxa with own properties	13	28	8	31	71	0	122
N° of endemic taxa with potential properties based on the comparison with their relatives	62	108	79	107	153	15	216
Factor of augmentation	*x 4,77*	*x 3,86*	*x 9,88*	*x 3,45*	*x 2,15*	*• 15*	*x 1,77*

Key insights

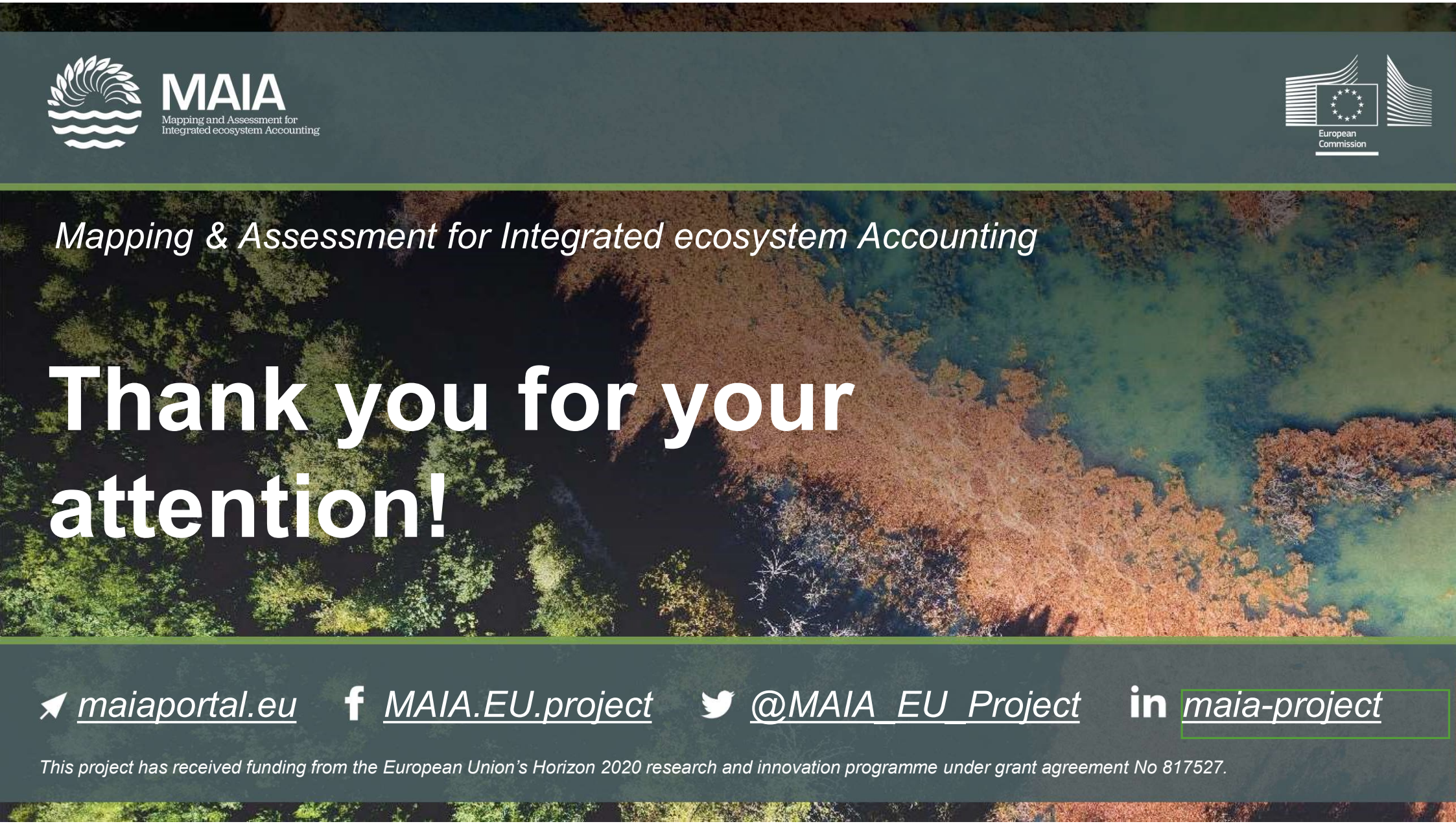
- Integrate biodiversity accounting standards into current monitoring schemes (e.g., Habitats and Birds Directives) is feasible.

- Biodiversity data can support biodiversity, ecosystem condition and ecosystem services indicators for accounting.

- Integrate biodiversity accounting into agricultural production standards, reporting and monitoring (e.g., by monitoring indicator taxa for biodiversity maintenance and/or invasive species).

- Integrate biodiversity accounting into post-fire restoration standards, reporting and monitoring (e.g., by monitoring forest species).

- Combined accounts for biodiversity (e.g., birds and flora/tree species richness type) can be produced for each ecosystem type, providing a streamlined presentation for decision-makers.



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