Ecosystem Accounts in Spain:

Update of the SEEA-EA implementation at national level

Fernando Santos Martín, Adrián García Bruzón

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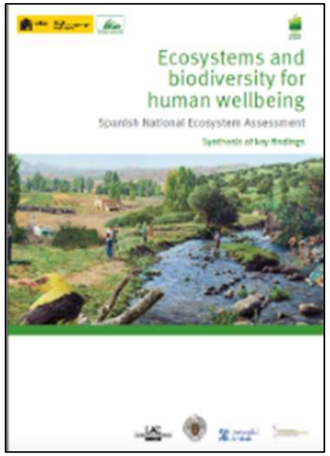
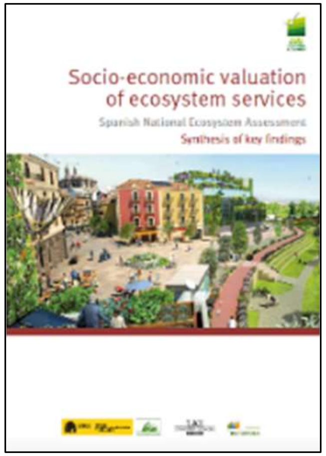
Ecosystem Accounts in Spain

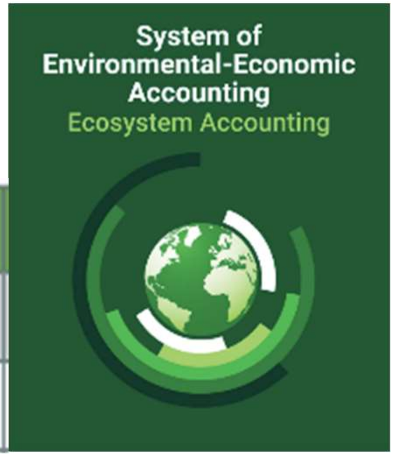
MAIA
Mapping and Assessment for Integrated ecosystem Accounting

In Spain we have been working on Mapping and Assessment Ecosystem and their Services at national scale since 2010

Ecosystem accounting is an approach consistent with the assessment, valuation and mapping of ecosystems and their services.







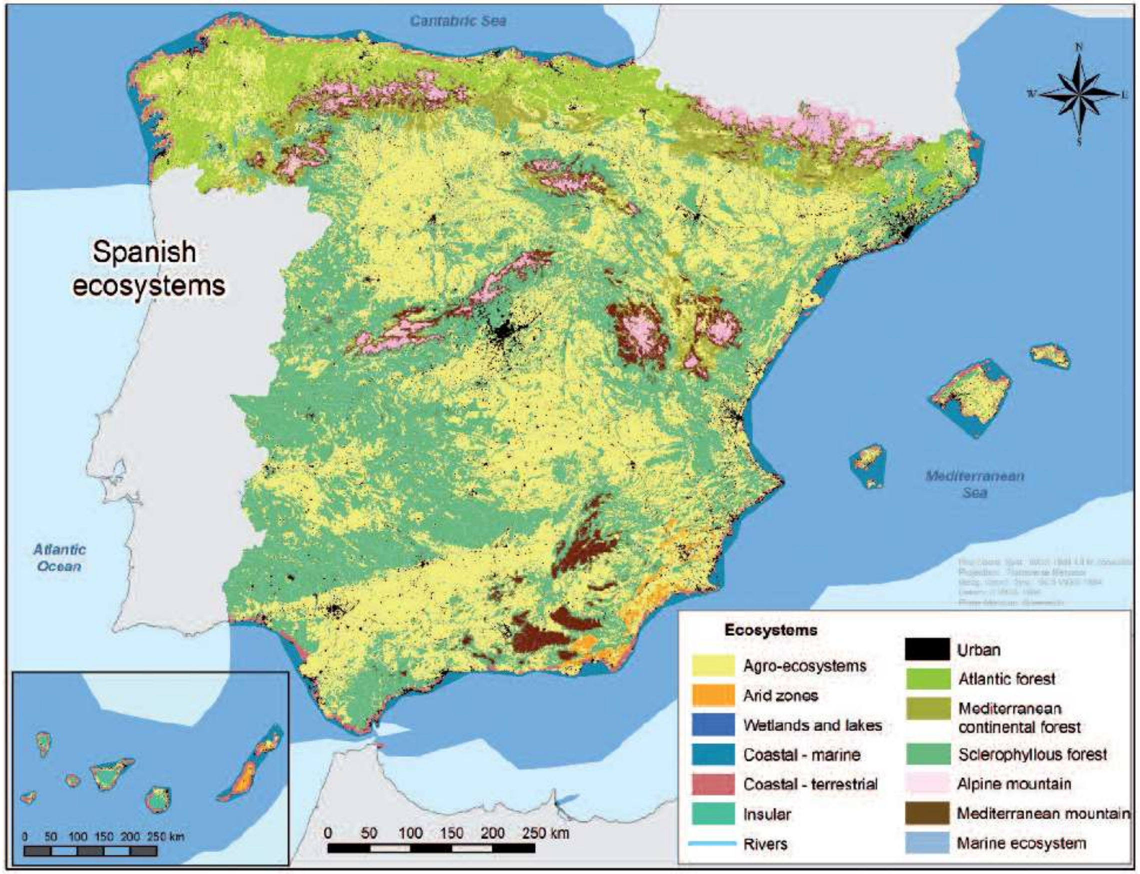
Involved partners and stakeholders

Based on D5.1 (Annex 10 section 2); European NCA stakeholder day

Government	Research
Ministry of Ecological Transition (MITECO)	Universidad Rey Juan Carlos de Madrid (URJC)
National Institute of Statistics of Spain (INE)	Spanish National Research Council (CSIC)

Spanish ecosystem classification (EME, 2012)

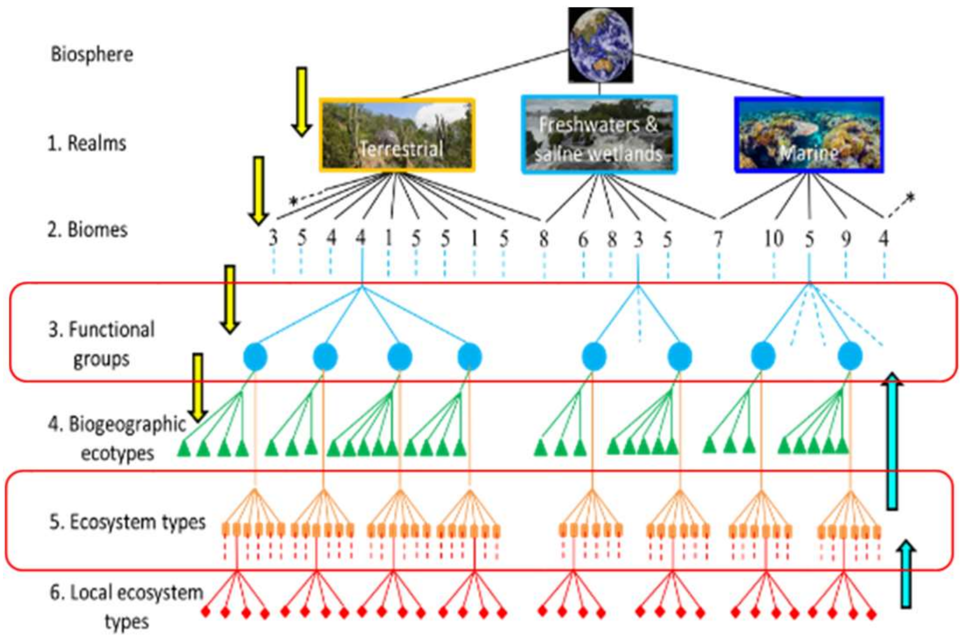
Ecosystem types	
Forest	Sclerophyllous Mediterranean
	Continental Mediterranean
	Mountain Mediterranean
	Atlantic
	Alpine
	Insular
Grassland	Sclerophyllous Mediterranean
	Continental Mediterranean
	Mountain Mediterranean
	Atlantic
	Alpine
	Insular
Shrubland	Sclerophyllous Mediterranean
	Continental Mediterranean
	Mountain Mediterranean
	Atlantic
	Alpine
	Insular
Other lands	Arid zones
	Coastal areas
	Other land
Aquatic	Wetlands
	Rivers and lakes
Cropland	Perennial woody crops
	Annual crops
Settlements	Urban



Ecosystem Accounts in Spain

We have developed crosswalks between Spanish Ecosystems, IUCN, MAES and LULUCF ecosystem types

IUCN Global Ecosystem Typology



LULUCF_level_1	id_1	MAES_level_1	LULUCF_level_2	id_2
Forest land	100	Forest and woodland	Broadleaved	110
			Coniferous	120
			Mixed	130
			Other Forests	100
Grassland	200	Grassland	Woodland	210
		Heathland and shrub	Shrubland	220
		Grassland	Perennial	230
			Other Grassland	200
Other Land	400	Sparsely vegetated land	Other Land	400
Wetlands	500	Inlands wetlands	Wetlands and Peatlands	500
		Rivers and lakes	Inland	510
		Marine inlets	Seaside	520
Cropland	700	Cropland	Perennial woody crops	710
			Annual crops	720
			Other Crops	700
Settlements	800	Urban	Settlements	800

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In Spain we are using LULUCF (Land Use, Land Use Change and Forestry) a multisource dataset for ecosystem accounting. LULUCF provide a high spatial resolution (25 meters per pixel) information for a significant time period (1970-2015).

1970
MFE200 (1986-1997)
MCA (1970-1990)

→ **1990**
CLC90

→ **2000**
CLC2000
MCA2000

→ **2006**
CLC06
MFE50 (1997-2006)

→ **2009**
FF09
SIGPAC09

→ **2012**
CLC12
FF12
SIGPAC12

→ **2015**
FF15
SIGPAC15

Source: *Spanish Ministry for the Ecological Transition and the Demographic challenge*

MFE200: Spanish Forest Map. 1:200.000

MCA: Crop and Harvest Map

CLC: Corine Land Cover

MFE50. Spanish Forest Map. 1:50.000

FF: Update of changes in MFE50

SIGPAC: Geographic Information System of Agricultural Plots

Ecosystem Accounts in Spain

Country	Scale			Accounts				
	National	Regional	Local	Extent	Conditio n	ES Supply and Use	Asset	Biodiversity
Belgium		X (Flanders)		X	X	X	X	X
Bulgaria		X (Plovdiv)	X (Karlovo)	X		X		
Czech	X			X		X	X	
France			X (to be decided)	X	X		X	
Finland	X			X	X	X		X
Germany	X			X		X		
Greece		X (Peloponnesus)		X		X		X
Netherlands	X			X				
Norway		X (Greater Oslo)	X (Oslo)	X	X	X		X
Spain	X	X (Andalusia)		X	X	X		X
Total	5	5	3	10	4	8	3	4

Ecosystem Accounts in Spain

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STATUS OF THE BIOPHYSICAL ECOSYSTEM ACCOUNTS IN SPAIN

FINISHED

IN PROCESS

Biophysical Accounts

Extent

Condition

Ecosystem services

Supply **Use**

Valuation techniques

Supply **Use**

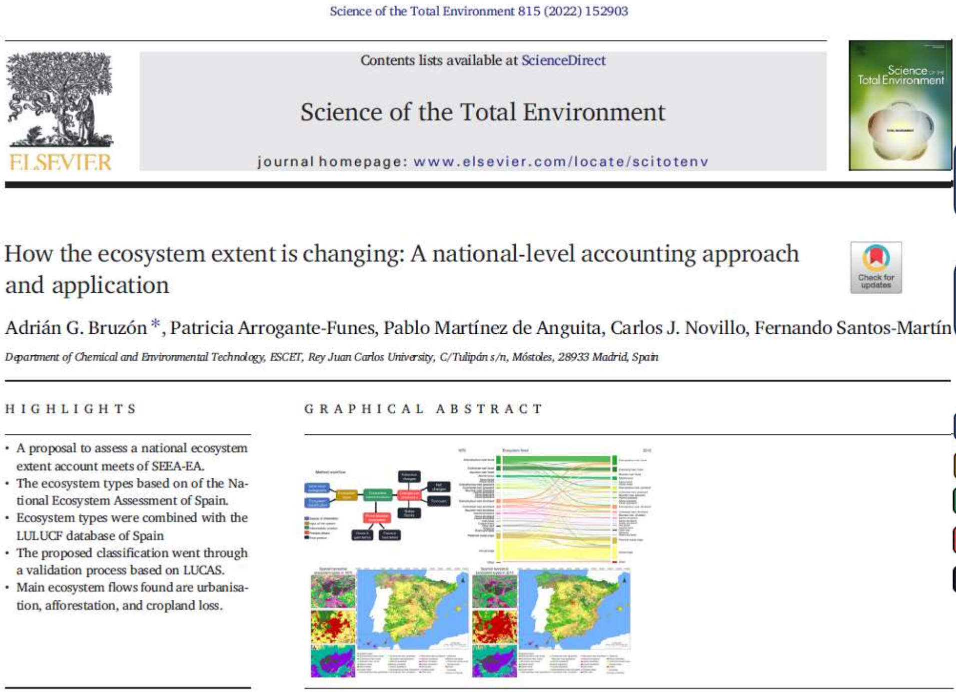
Monetary Accounts

Ecosystem assets

Thematic accounts:
Water,
Marine
Biodiversity

Source: SEEA- Ecosystem Accounting (UN 2021)

1. EXTENT ACCOUNTS: A methodology has been developed and tested at national level following the principles outlined in SEEA-EA (chapter 4), compiling an ecosystem extent account for terrestrial ecosystems.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How the ecosystem extent is changing: A national-level accounting approach and application

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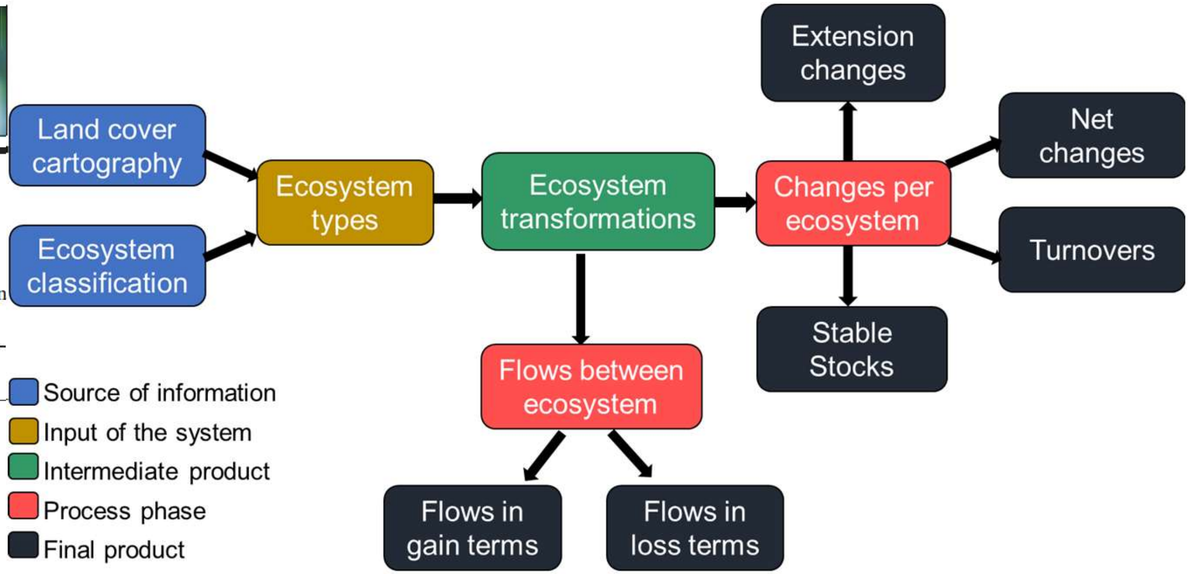
HIGHLIGHTS

- A proposal to assess a national ecosystem extent account meets of SEEA-EA.
- The ecosystem types based on of the National Ecosystem Assessment of Spain.
- Ecosystem types were combined with the LULUCF database of Spain
- The proposed classification went through a validation process based on LUCAS.
- Main ecosystem flows found are urbanisation, afforestation, and cropland loss.

GRAPHICAL ABSTRACT

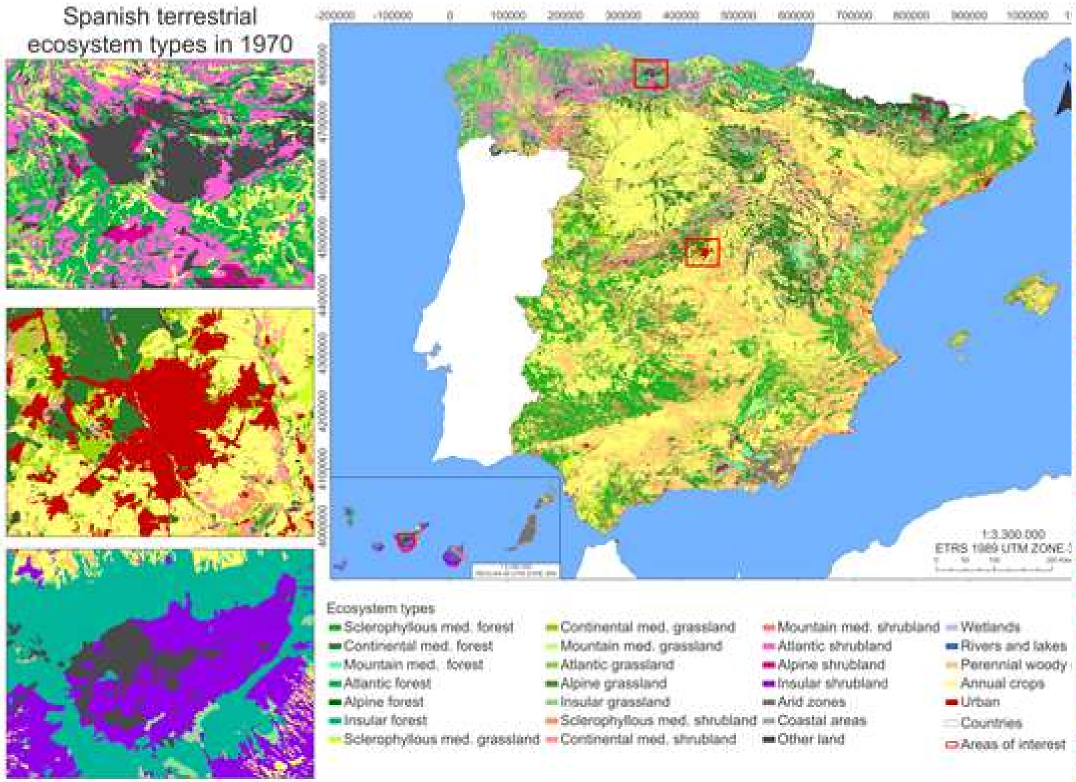


G. Bruzón et al. 2021

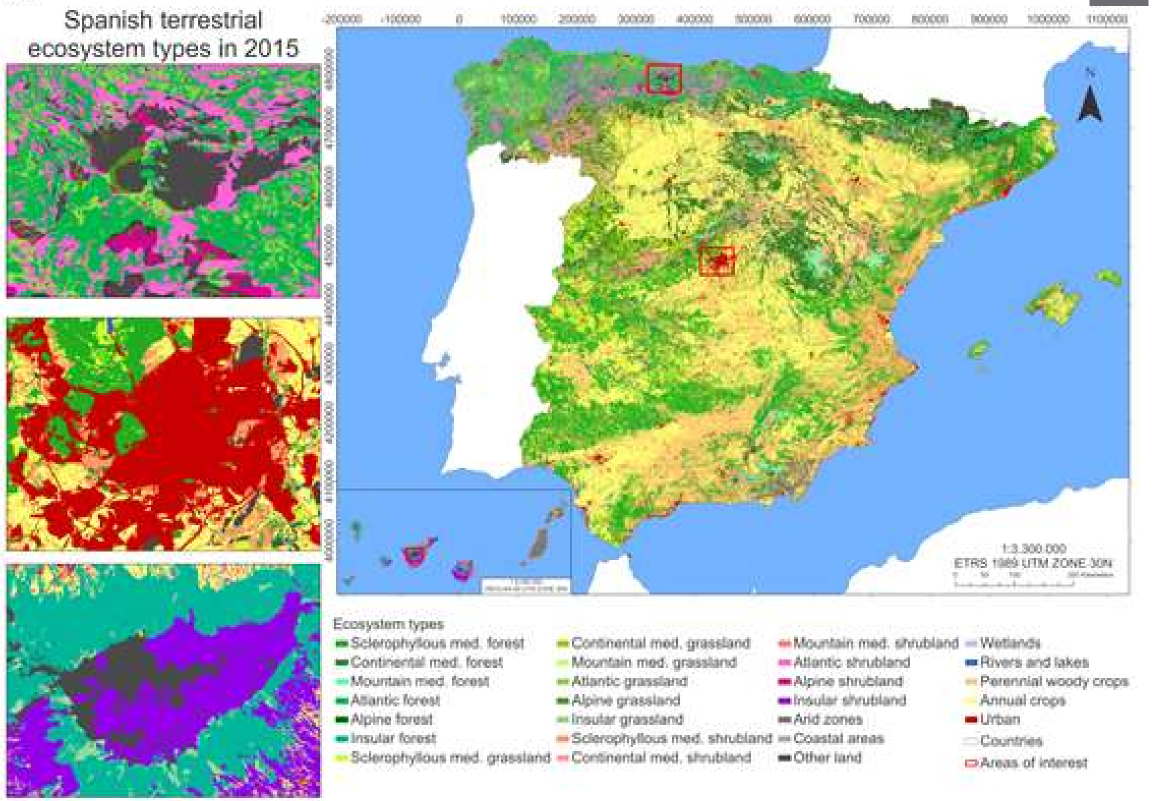
Ecosystem Accounts in Spain

1. EXTENT ACCOUNTS: ecosystem extent account results are presented for terrestrial ecosystems for different time periods between 1970-2015 (1970, 1990, 2000, 2006, 2009, 2012, 2015).

1970



2015

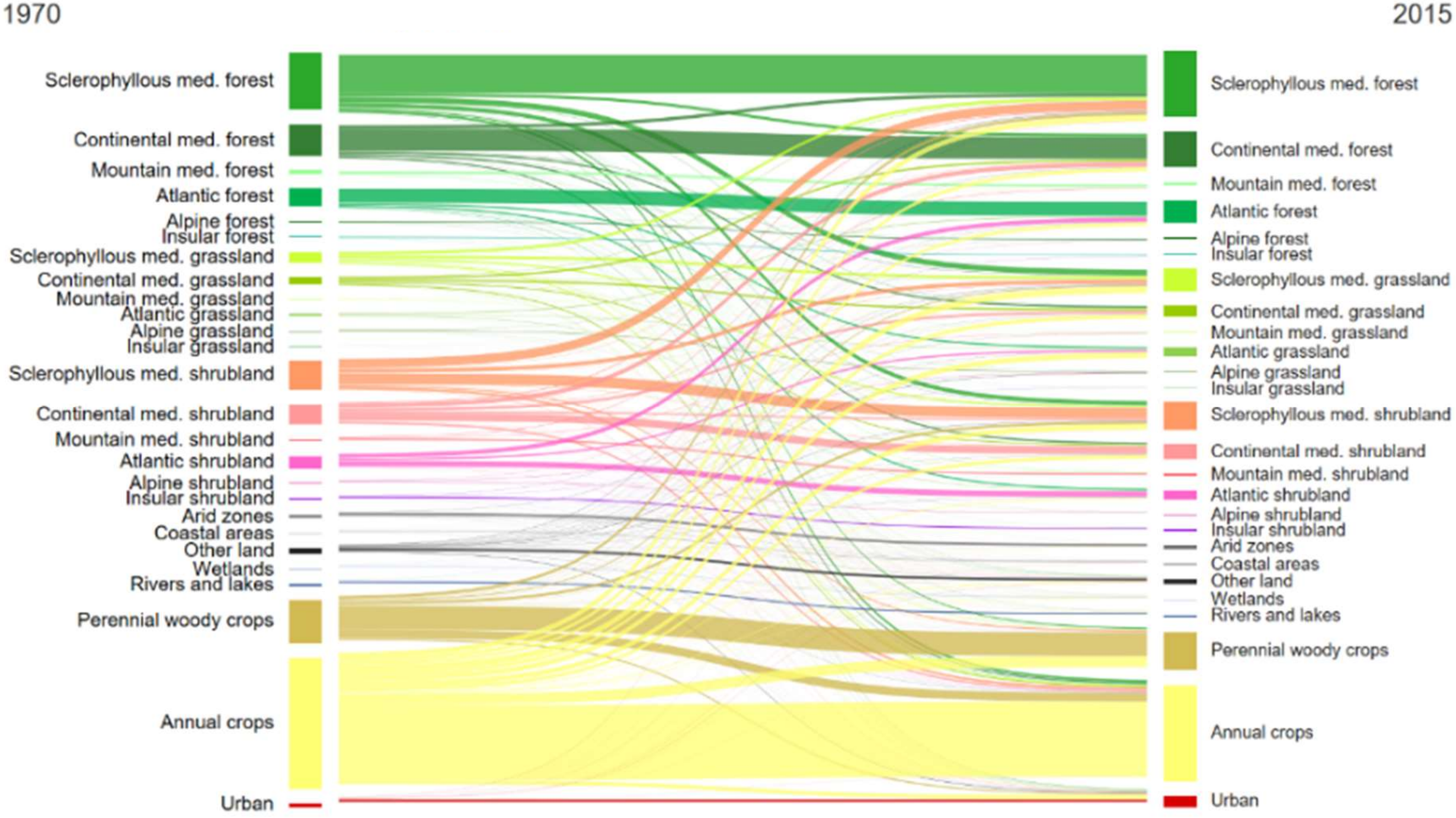


1. EXTENT ACCOUNTS: ecosystem extent accounts tables are presented for terrestrial ecosystems for different time periods between 1970-2015 (1970, 1990, 2000, 2006, 2009, 2012, 2015).

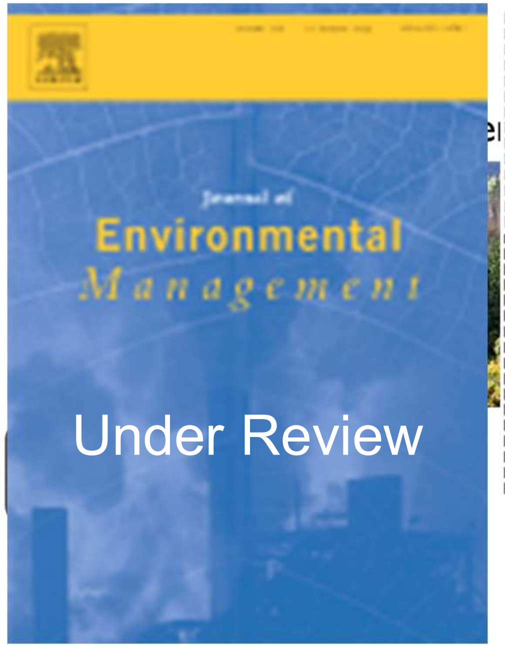
Extent accounts of forest ecosystems in Spain (1970-2015)

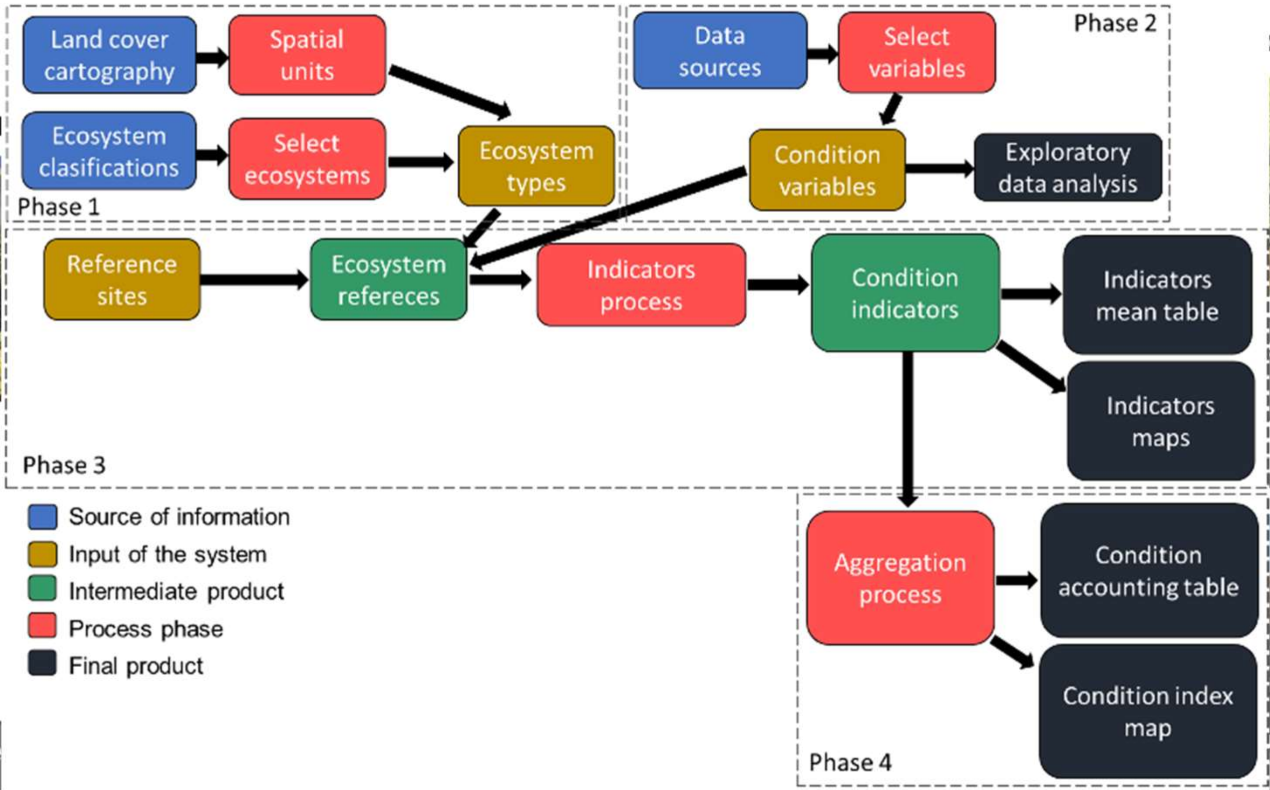
Ecosystems	Sclerophyllous med. forest	Continental med. forest	Mountain med. forest	Atlantic forest	Alpine forest	Insular forest
Initial Extent	73324.90	41020.50	4209.00	23493.30	1484.70	1228.50
Reductions	23157.10	12124.80	936.30	5417.90	432.00	247.90
Additions	34231.60	18155.30	1044.10	11416.00	586.80	375.00
Net Additions	11074.50	6030.60	107.70	5998.10	154.80	127.10
Net_%	2.19	1.19	0.02	1.18	0.03	0.03
Total turnover	57388.80	30280.10	1980.40	16833.80	1018.90	623.00
Turnover_%	11.33	5.98	0.39	3.32	0.20	0.12
Stable Stock	50167.70	28895.80	3272.70	18075.40	1052.60	980.60
Stable_%	9.91	5.71	0.65	3.57	0.21	0.19
Final Extent	84399.60	47051.10	4316.70	29491.50	1639.50	1355.60

1. EXTENT ACCOUNTS: ecosystem **change** results are presented for terrestrial ecosystems for the same time periods between 1970-2015.



2. CONDITIONS ACCOUNTS: A methodology has been developed at national level following the principles outlined in SEEA-EA (chapter 5) for **forest ecosystem** for the time period 2000-2015.





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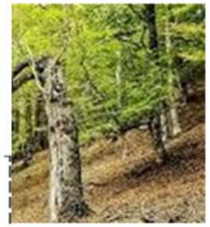


gation on x

dition

Phase reference areas

Reference areas

hase 5: Report in accounting tables

2. CONDITIONS ACCOUNTS: The SEEA-EA condition is a metric that captures, through a set of key indicators, the state and functioning of the ecosystem in relation to both its ecological condition and its capacity to provide ecosystem services.

Indicators used in the forest condition in Spain

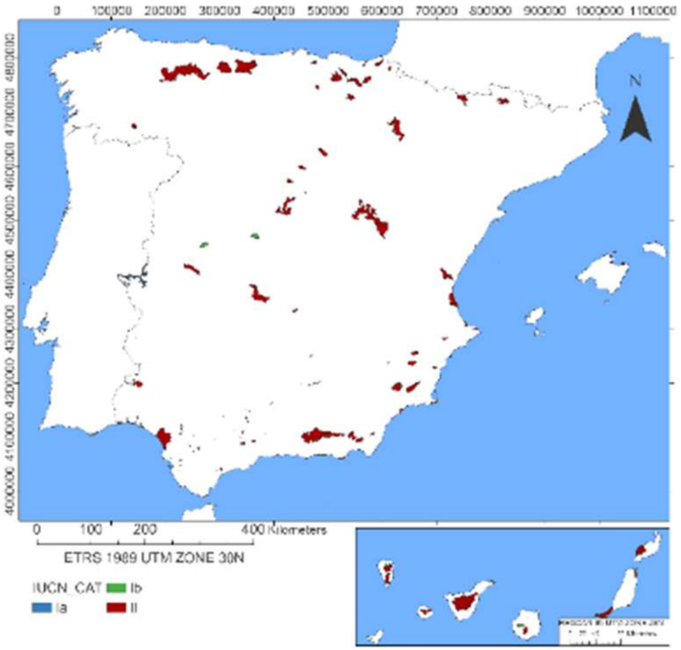
Group	Class	Weigth	Indicator	Source	Resolution (m)
Abiotic characteristics	Physical state	0,07	NDWI	Landsat	30
		0,07	Soil organic carbon	Lucas	1000
	Chemical state	0,07	Ozone (AOT40f)	EEA	2000
		0,07	Nitrogen Deposition (Critical Loads)	EEA	5000
Biotic characteristics	Composition state	0,1	Forest bird richness	MITERD	1000
		0,1	Richness of forest flora	MITERD	1000
	Structural state	0,12	Tree cover	Modis	250
	Functional state	0,1	NDVI	Landsat	30
		0,08	Gross primary production	Modis	500
Landscape characteristics	Landscape characteristics	0,12	Forest area density	Guidos	50
		0,1	Naturalness index	Guidos	50

Ecosystem Accounts in Spain

MAIA Mapping and Assessment for Integrated ecosystem Accounting

Based on **areas of least disturbance**, in forests that meet these two criteria:

- We use the forest areas included in the protected areas classified in the IUCN categories of level I, II.
- We include forests that have not undergone changes in cover since 1970.



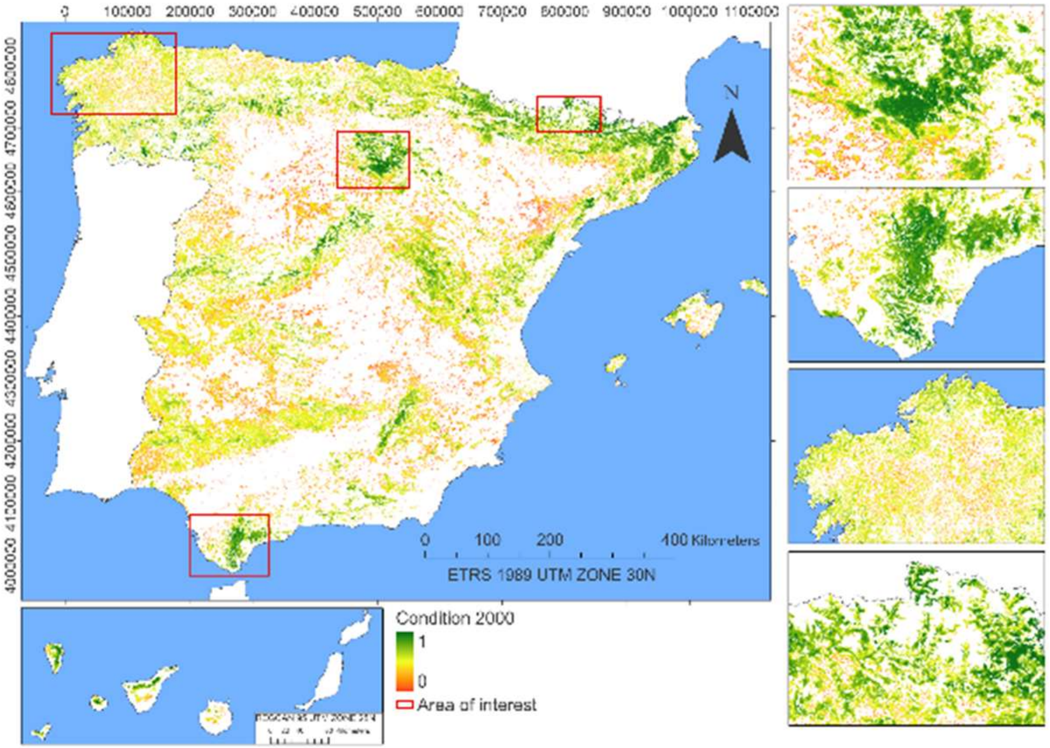
Reference table

Ecosystem type	Ecosytem	Alpine			
	Forest type	Broadleaved		Coniferous	
ECT class	Indicator	Ref Max	Ref Min	Ref Max	Ref Min
Physical state	NDWI	0,22	0,1	0,29	0,11
	SOC	0,12	0,05	0,10	0,03
Structural state	FCC	0,98	0,64	0,94	0,58
	NDVI	0.48	0.27	0.51	0.22
Landscape characteristics	FAD	0,80	0,4	0,79	0,45

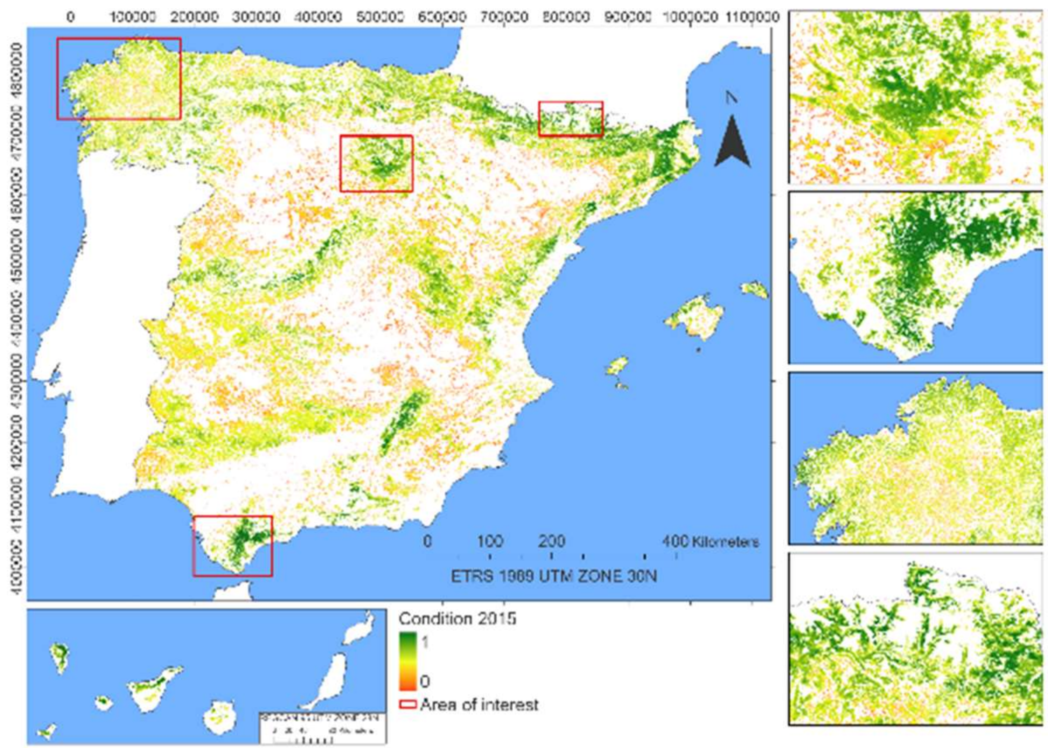
A different reference is generated for each indicator and forest type.

2. CONDITIONS ACCOUNTS: results are presented in maps for forest ecosystems for different time periods between 2000-2015.

2000



2015



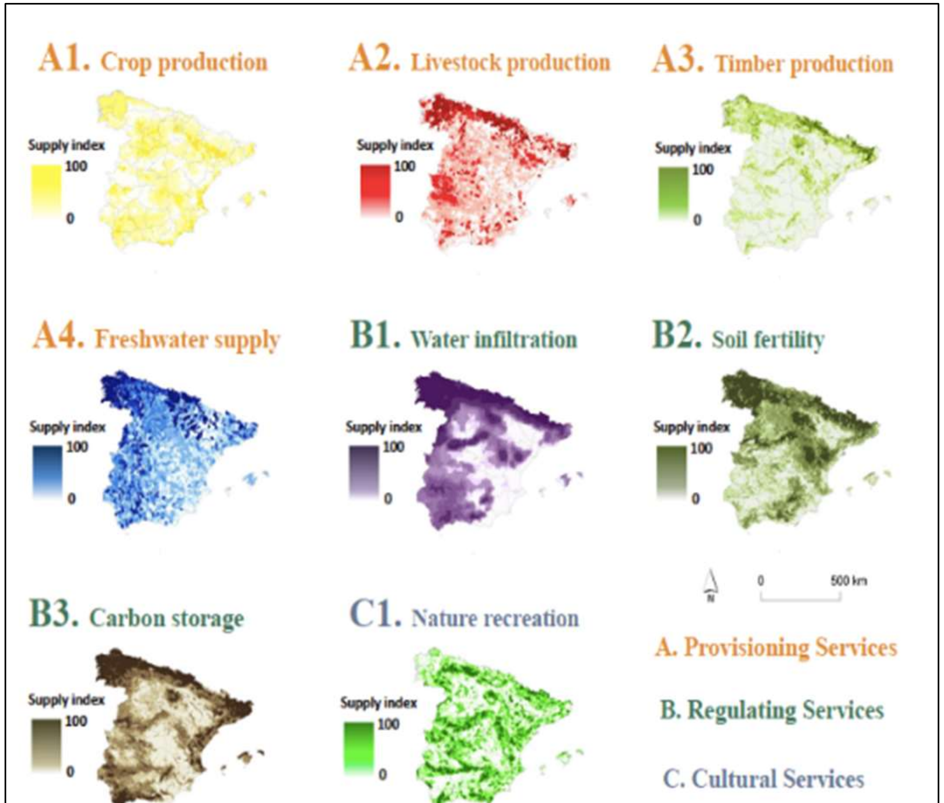
2. CONDITIONS ACCOUNTS: results are presented in **accounting tables** for forest ecosystems for different time periods between 2000-2015.

Condition index by forest type

Forest Type	2000	2015	Change	Forest Type	2000	2015	Change
Mixed Alpine	0.764	0.794	3.10%	Con. Insular	0.585	0.618	3.30%
Con. Alpine	0.737	0.749	1.30%	Con. Mountain Med.	0.609	0.614	0.50%
Broad. Alpine	0.666	0.709	4.30%	Con. Continental Med.	0.595	0.607	1.10%
Mixed Insular	0.654	0.68	2.60%	Mixed Mountain Med.	0.589	0.607	1.70%
Broad. Insular	0.661	0.677	1.60%	Broad. Mountain Med.	0.604	0.602	-0.23%
Con. Atlantic	0.618	0.653	3.50%	Mixed Sclerophyllous Med.	0.57	0.601	3.10%
Mixed Atlantic	0.588	0.632	4.50%	Broad. Continental Med.	0.553	0.572	1.90%
Broad. Atlantic	0.582	0.62	3.80%	Con. Sclerophyllous Med.	0.542	0.57	2.80%
Mixed Continental Med.	0.605	0.618	1.30%	Broad. Sclerophyllous Med.	0.536	0.562	2.60%

Ecosystem Accounts in Spain

3. ECOSYSTEM SERVICES ACCOUNTS (biophysical): In previous projects we have mapped, valued and assessed multiple ES. Here we only present the work done within MAIA.



Santos-Martín et al., 2018

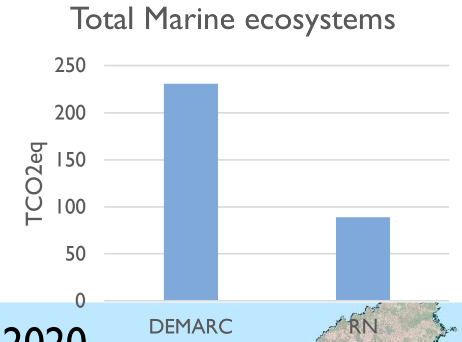
Ecosystem Accounts in Spain

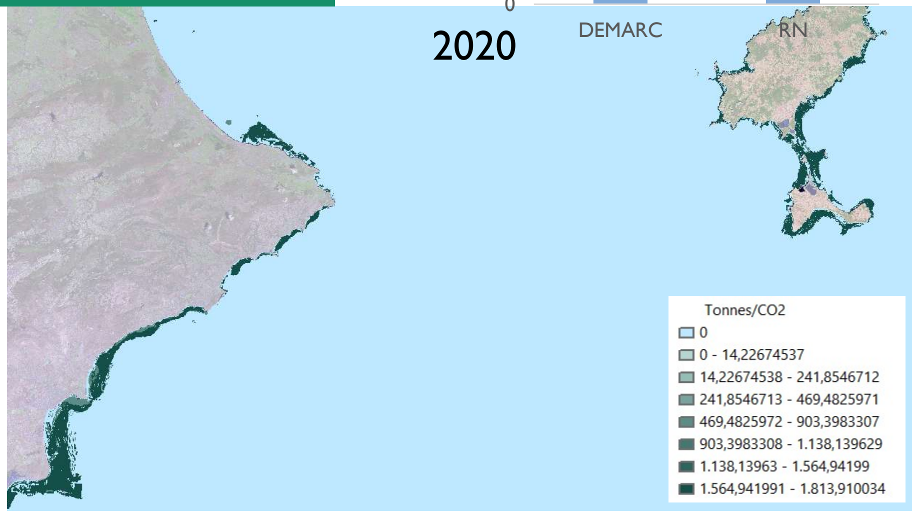
MAIA
Mapping and Assessment for Integrated ecosystem Accounting

3. ECOSYSTEM SERVICES ACCOUNTS (biophysical)

3.1. GLOBAL CLIMATE REGULATION: Marine ecosystem carbon sequestration accounts.

InVEST
integrated valuation of ecosystem services and tradeoffs





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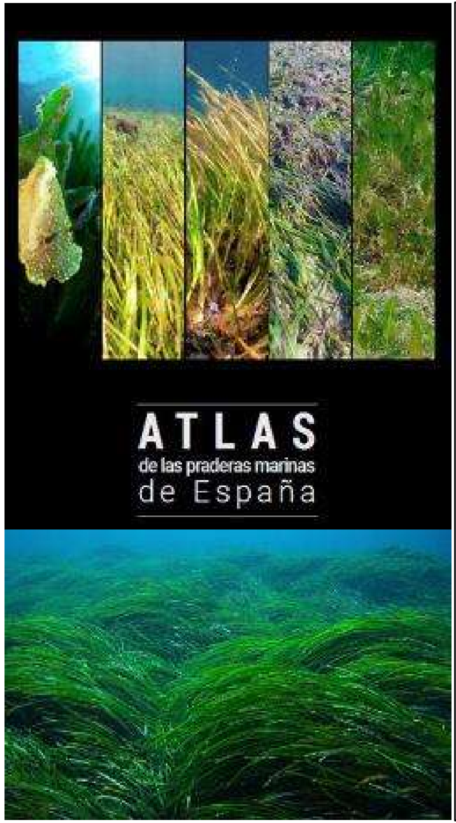

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Full Length Article

National blue carbon assessment in Spain using InVEST: Current state and future perspectives

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[b] Centro de Investigación en Biodiversidad y Cambio Global (CIBC-UAM), Spain
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Protected areas
Future scenarios

ABSTRACT

Coastal and marine ecosystems supply multiple services in which human well-being is highly dependent. However, high-resolution spatial distribution studies of marine ecosystem services are scarce, even if it is known that this information is needed to better manage and conserve these ecosystems. With the aim of filling this gap, in this study we have: (1) mapped and assessed the current capacity of marine phanerogams (*Posidonia oceanica*, *Cymodocea nodosa*, *Zostera noltii*, *Zostera marina*, and *Halophila decipiens*) to store and sequester blue carbon in Spain; (2) mapped and assessed the future capacity of marine phanerogams to store and sequester blue carbon under three plausible futures; and (3) assess the economic implications of these scenarios. Our results are based on the InVEST Blue Carbon model and exhibit high spatial resolution (100 m/pixel) of carbon stored in marine phanerogams. We found that 82% of carbon storage and sequestration by marine phanerogams is currently managed within Natura 2000 areas. However, results from the modeled future scenarios indicate a constant decrease in the amount of carbon stored in these ecosystems by 2050 (24% lost in the business-as-usual scenario). The economic impact of these losses is equivalent to 17,974 million€ (around 1.6% of the Spanish GDP). Finally, we consider that a transformative management change is needed to conserve marine phanerogams in Spain, and we discuss the importance of the Natura 2000 Network in managing marine ecosystems and their services in the near future.

1. Introduction

Marine biodiversity loss is increasingly impairing the ocean's capacity to provide fundamental ecosystem services (ES) for human well-being (Worm et al., 2006). The loss of coastal and marine ecosystems will be further increased by climate change (Short and Neckles, 1999; Harley et al., 2006; Koch et al., 2013) and, ironically, marine ecosystems play a fundamental role in the carbon storage and sequestration processes that contribute to climate change mitigation (Duarte et al., 2013a; Marbà et al., 2014). Several studies have indicated that seagrass habitats, the main contributor to this carbon storage, are declining worldwide due to human impacts, which implies an alarming increase in their extinction risk (Short et al., 2011). Nevertheless, studies on marine ecosystems, especially studies that quantify and spatially assess marine ES, remain scarce (Townsend et al., 2014).

Coastal and marine ecosystems are, and have always been, a source of multiple ES, not only for providing food (fisheries and aquaculture) and the extraction of raw materials (biotic and non-biotic) but also regulating (climate regulation, coastal protection) and cultural services such as tourism and cultural heritage, among others (Peterson and Lubchenko, 1997; Böhnke-Henrichs et al., 2013; Hattam et al., 2015). One of the most important marine ecosystems in terms of ES is seagrass meadows formed by marine phanerogams, such as *Posidonia oceanica*, *Cymodocea nodosa*, or *Zostera noltii*. Marine phanerogams are flowering plants that live totally submerged in shallow marine waters on all continents except Antarctica (Short et al., 2007). They form extensive underwater meadows that provide a wide range of ES, such as providing food and shelter for a wide variety of organisms, acting as fish nursery, protecting the coastline against disturbances, enhancing water purification, and even providing trophic resources and shelter to terrestrial

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3. ECOSYSTEM SERVICES ACCOUNTS (biophysical)

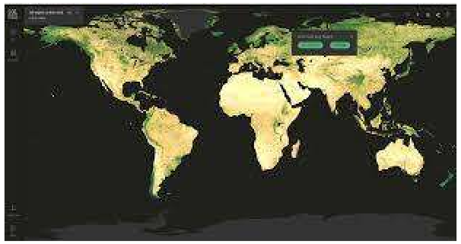
3.1. GLOBAL CLIMATE REGULATION: Terrestrial ecosystems carbon sequestration accounts.

InVEST
integrated valuation of ecosystem services and tradeoffs

Source of data

Global Aboveground and Belowground Biomass Carbon Density Maps (NASA)

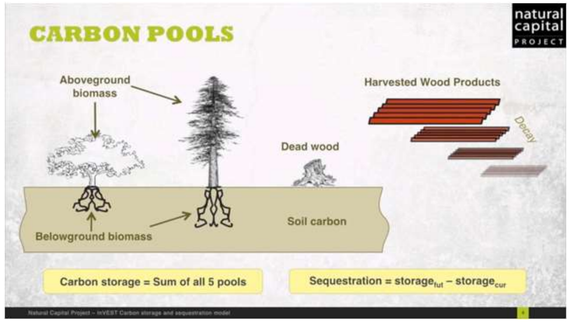
Soil Organic Carbon Stock Maps (ISRIC)



Information on dead wood from the Spanish forest monitoring network (MITERD)

Accumulated carbon in 5 “deposits/pool”:

1. aerial biomass
2. underground biomass
3. dead biomass
4. Soil
5. Biomass of cut wood (not included)

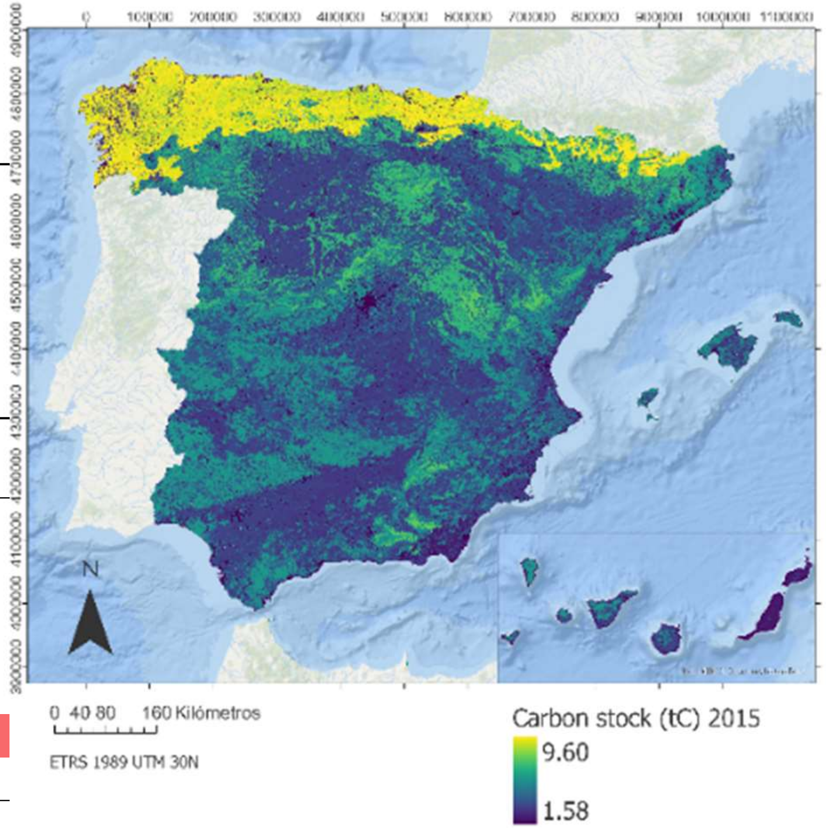


3. ECOSYSTEM SERVICES ACCOUNTS (biophysical)

3.1. GLOBAL CLIMATE REGULATION: Terrestrial ecosystems carbon sequestration accounts.

Carbon sequestration of forest ecosystems in Spain (2000-2015)

	Sclerophyllous med. forest	Continental med. forest	Mountain med. forest	Atlantic forest	Alpine forest	Insular forest
Carbon sequestration(tC/ha/year)	4.74	5.54	6.08	8.62	9.61	4.73
C_above	1.31	1.8	1.93	2.47	3.8	0.5
C_below	0.6	0.7	0.77	0.85	1.2	0.4
C_soil	2.79	3	3.34	5.17	4.35	3.65
C_dead	0.04	0.03	0.04	0.13	0.25	0.18
Carbon sequestration(tC/year)						
Opening (2000)	38522250	25027164	2617813	23956412	1558167	592321
Additions	6381466	3542196	100841	3284237	146404	97394
Reductions	4858163	155665	5811	113596	8077	2996
Net Change	1523303	3386531	95030	3170641	138327	94398
Net Change %	1.6%	3.5%	0.1%	3.3%	0.1%	0.1%
Closing (2015)	40045607	26078713	2625679	25423170	1575344	641783



Ecosystem Accounts in Spain

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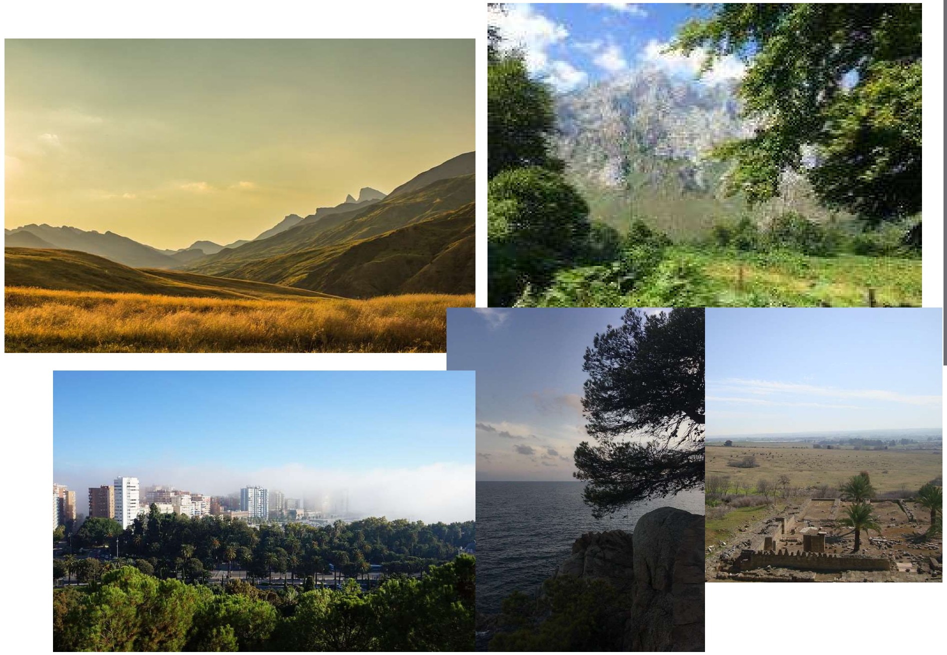
3. ECOSYSTEM SERVICES ACCOUNTS (biophysical)

3.2. AESTHETIC QUALITY OF THE LANDSCAPE :A methodology has been developed at national level using artificial intelligence and social networks (*Havinga, I. et al (2021)*).

National questionnaire in Spain to verify AI model predictions.

Northeast (Barcelona, Gerona, Tarragona, Lérida, Huesca, Zaragoza, Baleares)
East (Castellón, Valencia, Alicante, Murcia, Albacete)
South (Badajoz, Huelva, Sevilla, Córdoba, Jaén, Cádiz, Málaga, Granada, Almería)
Centre (Madrid, Ciudad Real, Cuenca, Teruel, Guadalajara, Soria, Toledo, Ávila, Segovia, Valladolid, Zamora, Salamanca, Cáceres)
North / Northwest (La Coruña, Lugo, Pontevedra, Orense, Asturias, León, Cantabria, Palencia, Burgos, La Rioja, Navarra, Álava, Vizcaya, Guipúzcoa)

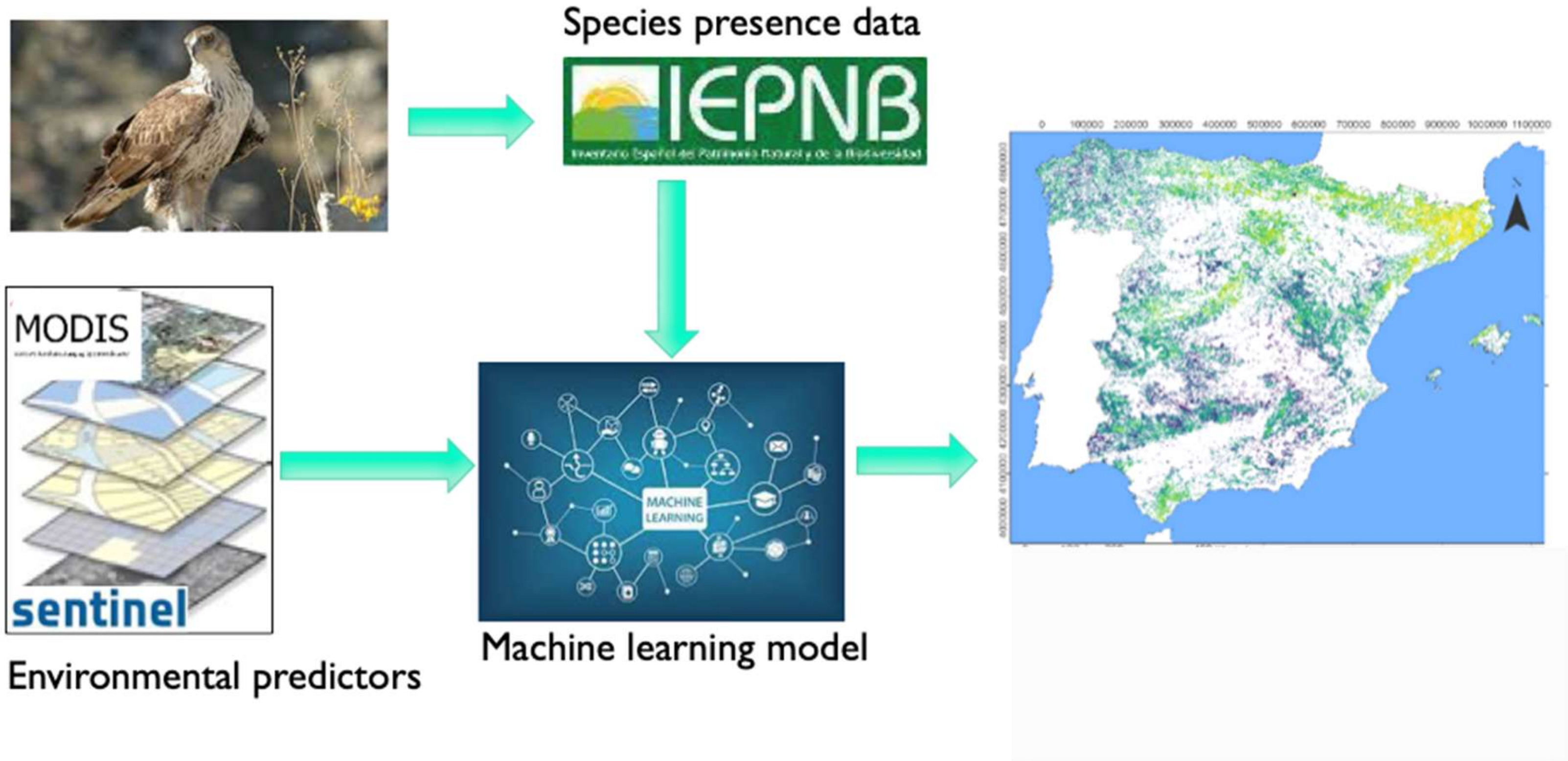
Aesthetic quality prediction based on Flickr and deep learning at 5 km resolution for a single cell



4. THEMATIC ACCOUNTS:

4.1. BIODIVERSITY: Valuation of species in Spain included in Habitats Directive and the Birds Directive.

This account developed using machine learning techniques between the years 2000 and 2015.



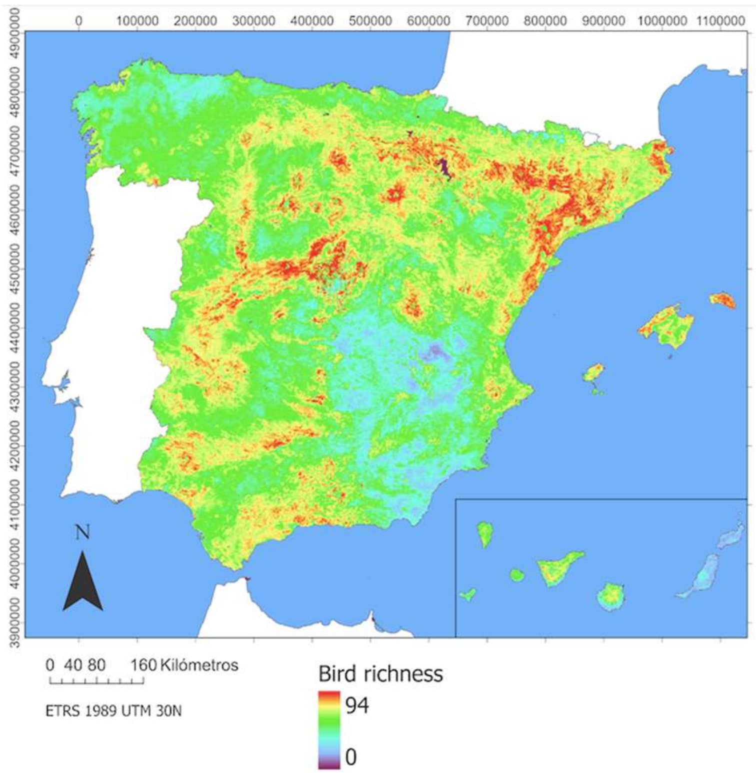
4. THEMATIC ACCOUNTS:

4.1. BIODIVERSITY:

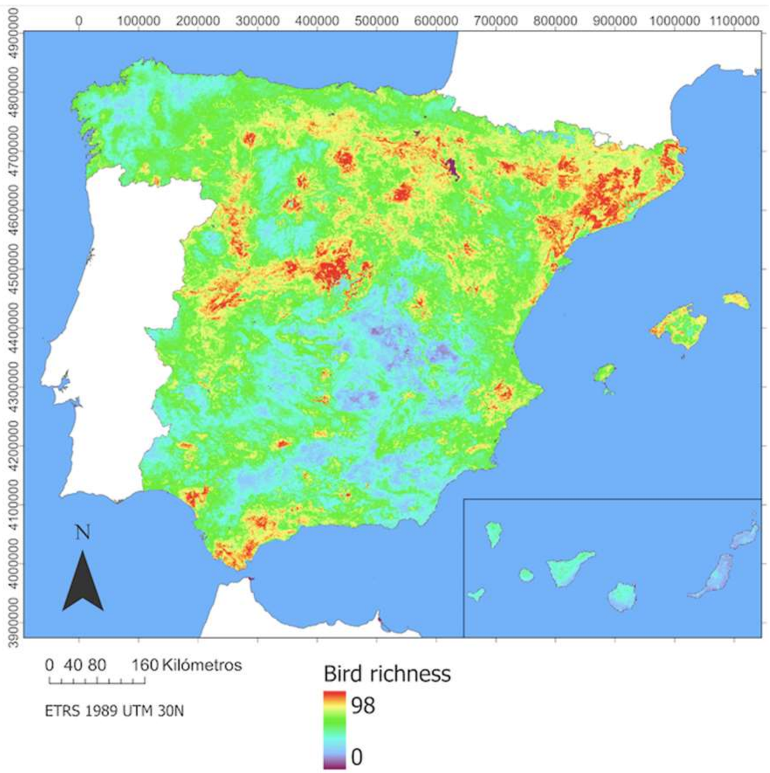
Species include in the account

Taxon	Species
Amphibians	14
Arthropods	26
Birds	230
Mammals	46
Reptiles	27
Vascular plants	178
Total	521

Birds richness 2015



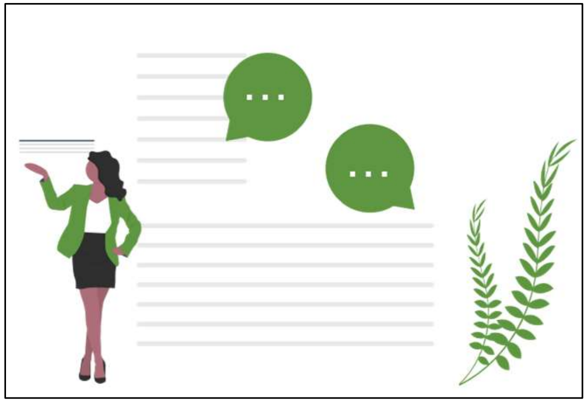
Birds richness 2020



Ecosystem Accounts in Spain

Promote ecosystem accounting through various communication and outreach activities

MAIA ACCOUNT EXPLORER



Promote ecosystem accounting through various communication and outreach activities

https://cuentas-eco-esp-urjc1.hub.arcgis.com/

SPANISH ECOSYSTEM ACCOUNT EXPLORER

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MAIA

Mapping and Assessment for Integrated ecosystem Accounting

Mapping & Assessment for Integrated ecosystem Accounting http://maiaportal.eu/