System of Environmental Economic Accounting

Land, Ecosystem Extent and Ecosystem Condition Accounts

Jessica Ying Chan

Environmental-Economic Accounts Section

United Nations Statistics Division

United Nations

Why account for land and ecosystems?

- Answers wide range of policy questions→ from urban planning, to conservation, to climate change and beyond
- Land and ecosystem accounts can inform multiple (inter)national initiatives
- Post-2020 Global Biodiversity Framework
  - > E.g. Goal A: Integrity of all ecosystems is enhanced, increase in area of natural ecosystems
- Ecosystems perspective for climate change—not just emissions
  - > Carbon accounts, how climate change impacts provision of ecosystem services
- Sustainable Development Goals
  - > E.g. 15.3.1: Proportion of land that is degraded over total land area

Convention on Biological Diversity

United Nations Convention to Combat Desertification

UN CLIMATE CHANGE CONFERENCE UK 2021
IN PARTNERSHIP WITH ITALY

SUSTAINABLE DEVELOPMENT GOALS

15 LIFE ON LAND

Land accounts

Land cover

- *The observed physical and biological cover of the Earth's surface and includes natural vegetation and abiotic (non-living) surfaces*
- Current land cover is a function of natural changes in the environment and of previous and current land use
- Often misinterpreted or combined with land use

Land cover

- Land cover classification (interim)
- Based on definitions from the Land Cover Classification System (LCCS) of the FAO

	Category
1	Artificial surfaces (including urban and associated areas)
2	Herbaceous crops
3	Woody crops
4	Multiple or layered crops
5	Grassland
6	Tree covered areas
7	Mangroves
8	Shrub covered areas
9	Shrubs and/or herbaceous vegetation, aquatic or regularly flooded
10	Sparsely natural vegetated areas
11	Terrestrial barren land
12	Permanent snow and glaciers
13	Inland water bodies
14	Coastal water bodies and inter-tidal areas

Land use

- Land use
  - *reflects both (i) the activities undertaken and (ii) the institutional arrangements put in place; for a given area for the purposes of economic production, or the maintenance and restoration of environmental functions*
  - Land that is "used" implies existence of some human intervention, including active management, e.g. protected areas
  - Land accounts should be complete
    - Includes land in use and land not in use

Land use

- Categories not defined on economic activity, but rather general purpose and role of the user of the area
  - > Often aligns with scope of economic activity, but not always
  - > If multiple uses, go with primary/dominant use

1	**Land**
1.1	Agriculture
1.2	Forestry
1.3	Land used for aquaculture
1.4	Use of built up and related areas
1.5	Land used for maintenance and restoration of environmental functions
1.6	Other uses of land n.e.c.
1.7	Land not in use
2	**Inland waters**
2.1	Inland waters used for aquaculture or holding facilities
2.2	Inland waters used for maintenance and restoration of environmental
2.3	Other uses of inland waters n.e.c.
2.4	Inland waters not in use

Land cover versus land use

- **Land use focuses on social and economic function while land cover focuses on physical and biological surface features**
- Q: Example where land use and land cover do not align?

- Natural tree-covered area in the middle of a city
  - > Land cover: tree-covered area
  - > Land use: built up and related area
- Grazing land
  - > Land cover: grasslands or sparse trees
  - > Agricultural land use

Land account: basic form

	Artificial surfaces	Crops	Grassland	Tree-covered area	Mangroves	Shrub-covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Coastal water and inter-tidal areas
Opening stock of resources	12 292.5	445 431.0	106 180.5	338 514.0	214.5	66 475.5	73.5	1 966.5		12 949.5	19 351.5
Additions to stock											
Managed expansion	183.0	9 357.0									
Natural expansion			64.5								1.5
Upward reappraisals			4.5								
Total additions to stock	183.0	9 357.0	69.0								1.5
Reductions in stock											
Managed regression		147.0	4 704.0	3 118.5	9.0	1 560.0	1.5				
Natural regression					1.5	64.5					
Downward reappraisals						4.5					
Total reductions in stock		147.0	4 704.0	3 118.5	10.5	1 629.0	1.5				
Closing stock	12 475.5	454 641.0	101 545.5	335 395.5	204.0	64 846.5	72.0	1 966.5		12 949.5	19 353.0

- Land cover
  - > Managed→ due to human activity
  - > Natural→ resulting from natural processes
  - > Reappraisals→ reflect changes due to use of updated information (e.g. new satellite imagery)

Land account: change matrix

Land cover change matrix (hectares)

Opening land cover	Closing land cover					
	Artificial surfaces (urban)	Herbaceous crops	Grassland	Inland water bodies	Shrubs..regularly flooded (w	Opening stock
Artificial surfaces (urban)	20	0	0	0	0	**20**
Herbaceous crops	3	142	8	0	0	**153**
Tree-covered areas	0	2	88	0	0	**90**
Inland water bodies	0	0	0	19	0	**19**
Shrubs..regularly flooded (wetlan	0	1	0	0	5	**6**
Closing stock	**23**	**145**	**96**	**19**	**5**	**288**

Land account change matrix: example India

- Extremely useful and policy relevant, as it shows conversions
- Important to remember: these are NET changes/conversions!

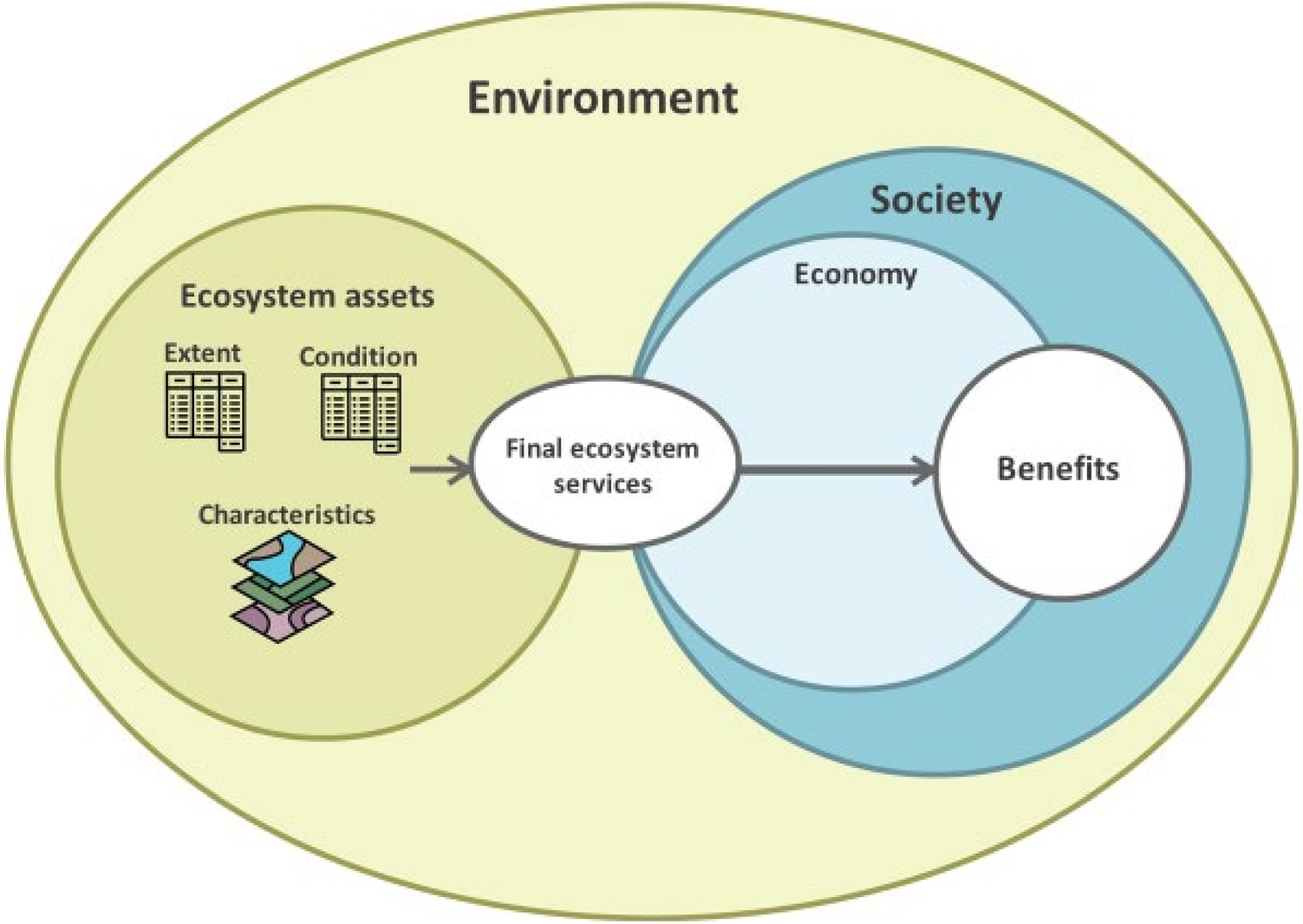
Table 1: *Extent account for India's land use and land cover between 2011-12 and 2015-16*

Land use / land cover classes		2015-16							Grand total (2011-12)	
		Agriculture	**Barren / un-culturable**	**Built-up**	**Forest**	**Grass / grazing**	**Snow and glacier**	**Wetlands / water bodies**	**Area**	**% of geo-graphic area**
2011 -12	Agriculture	1,809,033	5,103	2,648	2,299	94	8	2,547	**1,821,732**	**55.41**
	Barren / unculturable	4,237	348,460	589	2,285	61	68,471	614	**424,717**	**12.92**
	Built-up	238	442	118,239	48	2	0	29	**118,998**	**3.62**
	Forest	5,085	6,838	205	712,342	207	637	230	**725,543**	**22.07**
	Grass / grazing	147	408	118	368	22,502	1,333	521	**25,397**	**0.77**
	Snow and glacier	0	1,643	0	131	7	30,799	1	**32,581**	**0.99**
	Wetlands / water bodies	2,536	966	49	155	679	77	133,833	**138,294**	**4.21**
Grand total (2015-16)	**Area**	**1,821,276**	**363,860**	**121,848**	**717,629**	**23,551**	**101,325**	**137,774**	**3,287,263**	**99.99**
	% of geo-graphic area	**55.40**	**11.07**	**3.71**	**21.83**	**0.72**	**3.08**	**4.19**	**99.99**	

Source: India Policy Brief 2021

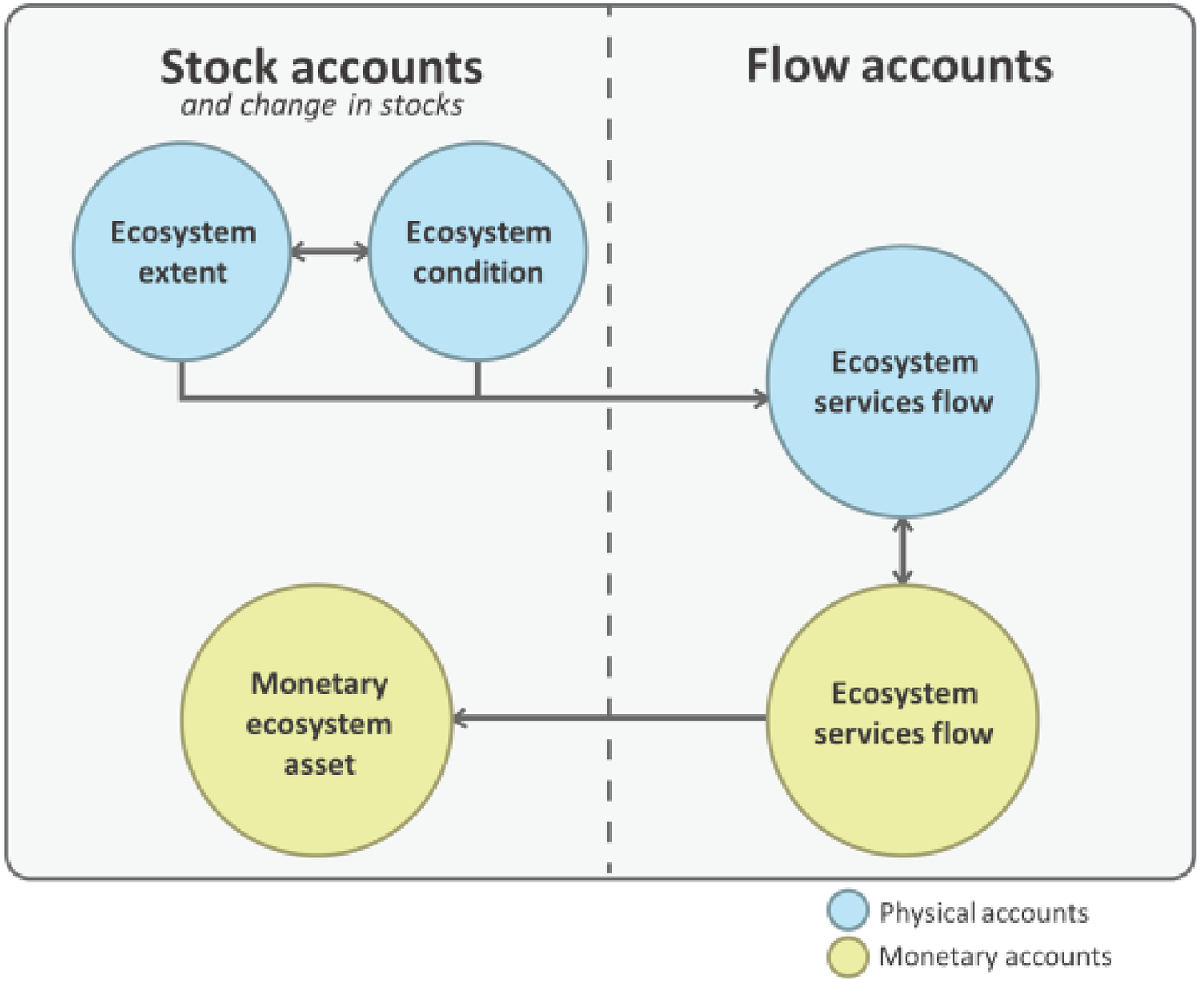
Ecosystem accounts

Conceptual Framework



SEEA

Ecosystem accounts



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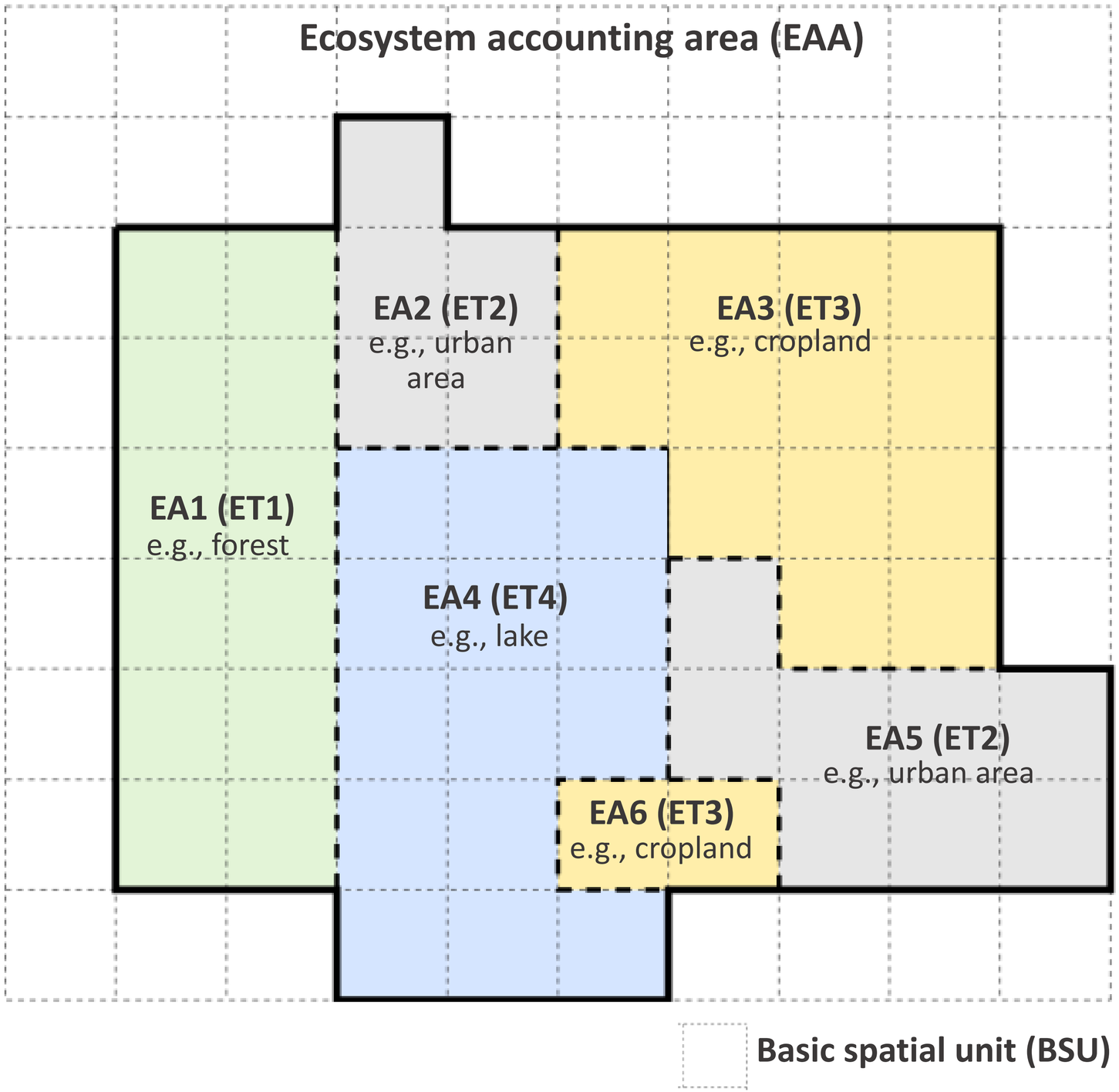

Ecosystem accounting area (EAA)
EA2 (ET2)
e.g., urban area
EA3 (ET3)
e.g., cropland
EA1 (ET1)
e.g., forest
EA4 (ET4)
e.g., lake
EA5 (ET2)
e.g., urban area
EA6 (ET3)
e.g., cropland
Basic spatial unit (BSU)

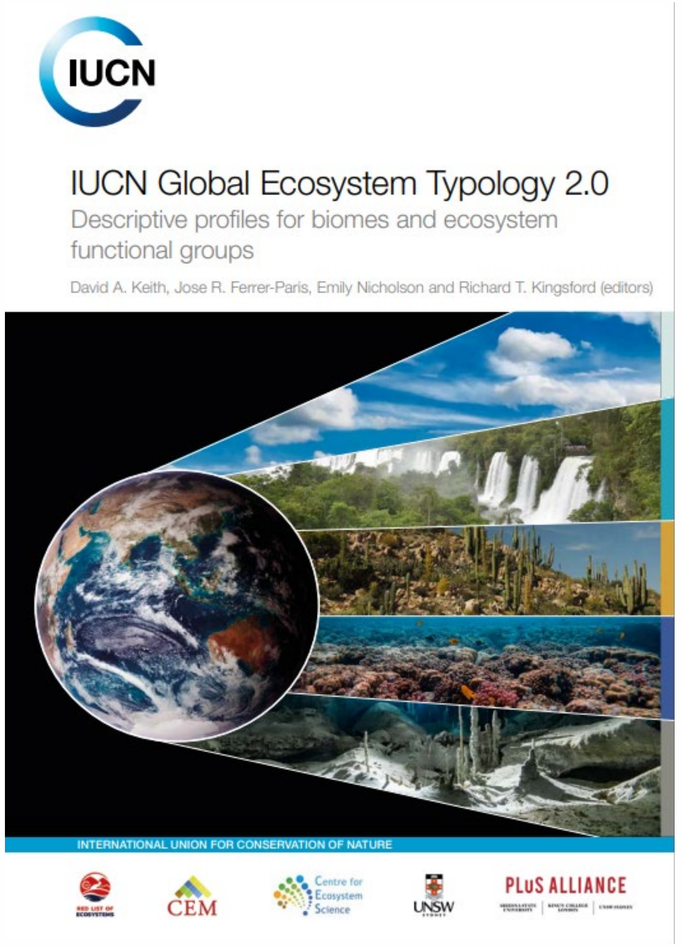
Ecosystem extent accounts

Linking land cover and ecosystem accounting

- Both are spatially explicit
- Land accounts, particularly land cover, are a basis for ecosystem accounting
- For terrestrial and freshwater areas, should be a reasonable concordance between land cover and ecosystem extent
- But key differences between land cover and ecosystems
  - > Definition of ecosystems in SEEA EA: *a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit*
  - > vs. definition of land cover: *the observed physical and biological cover of the Earth's surface and includes natural vegetation and abiotic (non-living) surfaces*

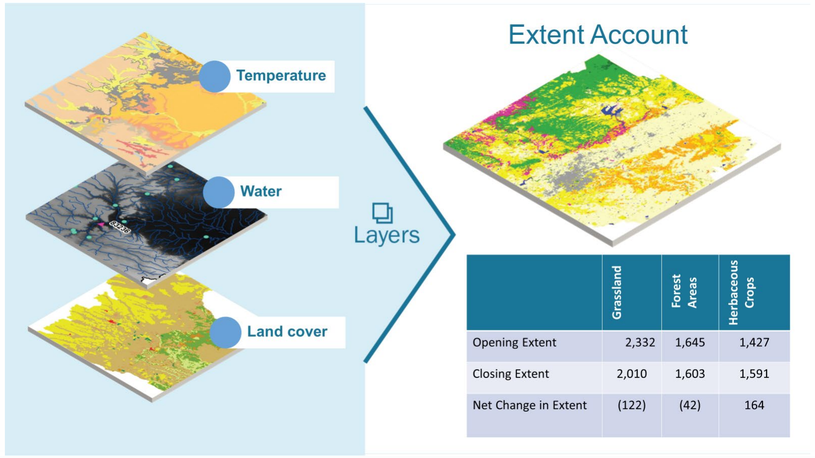
Land accounts vs ecosystem extent accounts

- Land cover is a fundamental layer, but extent requires more.
  - > Identification of ecosystem types through delineation of various ecosystem characteristics (temperature, aridity, topography/elevation maps)
  - > Example: land cover = trees; temperature > 30 C = tropical forest
- IUCN GET (Global Ecosystem Typology) as reference classification of SEEA EA
  - > Realms (terrestrial) -> biomes (tropical forest) -> Ecosystem Functional Groups (EFGs) -> montane tropical forest
  - > 98 different EFGs
  - > National classifications (vegetation, ecozones) can be crosswalked



Compiling extent accounts

- Maps based on ecological ground-truthing would be ideal, but maybe not practical/feasible
- Model extent on the basis of a multi-dimensional look-up table
  - > Inputs: land cover map, digital elevation model, temperature and water data, climate data, etc.
    - Time series of land cover maps
    - Comparable maps (i.e. same classification; preferably also same techniques)
  - > Model derives which ecosystem type is to be found where.
  - > Easy to derive other accounts in ARIES.



	Grassland	Forest Areas	Herbaceous Crops
Opening Extent	2,332	1,645	1,427
Closing Extent	2,010	1,603	1,591
Net Change in Extent	(122)	(42)	164

ARIES for SEEA extent model

Methods

Maps **29 ecosystem functional groups** (EFGs, primarily terrestrial & wetland) based on IUCN GET 2.0 methods.[1] Consulted virtually with D. Keith & colleagues.

Data

Lookup table to model **IUCN EFGs,** based on: **temperature, landform, elevation, aridity, land cover**

Outputs

Net change, additions & reductions, change matrix for ecosystems & land cover types

Current work

Expanding to 39 terrestrial/wetland EFGs, including all forest EFGs, collaborating with IUCN GET team, expand to further freshwater/marine EFGs in future

1: **Keith, D. et al. 2020**. IUCN Global Ecosystem Typology 2.0. IUCN: Gland, Switzerland. - **2:** Using thresholds from **Sayre, R., et al. 2020**. An assessment of the representation of ecosystems in global protected areas using new maps of World Climate Regions and World Ecosystems. Global Ecology and Conservation 21:e00860.

Multi-dimensional look-up table

IUCN Global Ecosystem Typology v. 2.0 (SEEA)			ARIES Ecosystem Types Parameters					
Level 1 (realms)	Level 2 (biomes)	Level 3 (functional group)	**ARIES ecosystem types**	*Landcover*	*Aridity index*	*Annual mean temp. (C)*	*Landform*	*Elevation (m)*
		T1.1 Tropical-subtropical lowland rainforest	Tropical-subtropical lowland rainforest	Forest	> 0.65	> 18	all but mountain	all
		T1.2 Tropical-subtropical dry forests & thicket	Tropical-subtropical dry forest and thicket	Forest	0.05-0.65	> 18	all	all
		T1.3 Tropical-subtropical montane rainforests	Tropical-subtropical montane rainforest	Forest	> 0.65	> 18	mountain	all

Examples ecosystem extent

Example Brazil – SEEA and Goal A monitoring

Ecosystem extent accounts in Brazil (2000-2018)

- The ecosystem extent accounts (2000-2018), by biomes, show that Brazilian terrestrial biomes lost about 500 thousand km² of their natural areas, due to conversion into modified areas such as land used for crops and grazing.

Source: (IBGE 2020), Ecosystem Accounts: Land Use in Brazilian Biomes 2000-2018

Example Brazil – SEEA and Goal A monitoring

Variáveis	Total		Bioma			
			Amazônia		Cerrado	
	Áreas naturais	Áreas antro-pizadas	Áreas naturais	Áreas antro-pizadas	Áreas naturais	Áreas antro-pizadas
2000						
Extensão de abertura	**5 877 298**	**2 510 306**	**3 684 512**	**450 865**	**1 185 192**	**790 693**
Adições	2 955	460 530	1 282	248 427	509	135 983
Reduções	326 066	137 419	193 539	56 170	96 274	40 218
2010						
Extensão	5 554 187	2 833 417	3 492 255	643 122	1 089 427	886 458
Adições	1 509	107 787	385	39 064	284	37 357
Reduções	69 316	39 980	27 376	12 073	23 068	14 573
2012						
Extensão	5 486 380	2 901 224	3 465 264	670 113	1 066 643	909 242
Adições	3 592	93 615	2 043	39 654	320	35 913
Reduções	49 030	48 177	21 123	20 574	18 392	17 841
2014						
Extensão	5 440 942	2 946 662	3 446 184	689 193	1 048 571	927 314
Adições	2 118	60 715	644	36 413	314	16 599
Reduções	36 435	26 398	23 541	13 516	8 417	8 496
2016						
Extensão	5 406 625	2 980 979	3 423 287	712 090	1 040 468	935 417
Adições	12 894	74 296	8 185	38 566	2 706	25 583
Reduções	32 098	55 245	16 761	30 057	10 688	17 671
2018						
Extensão final	**5 387 421**	**3 000 030**	**3 414 711**	**720 599**	**1 032 486**	**943 329**
Saldo das mudanças						
Absoluto (km²)	(-) 489 877	489 724	(-) 269 801	269 734	(-) 152 706	152 636
Percentual (%)	(-) 8,34	19,51	(-) 7,32	59,83	(-) 12,88	19,30
Movimentação						
Absoluto (km²)	536 013	1104 162	294 879	534 514	160 972	350 234
Percentual (%)	9,12	43,99	8,00	118,55	13,58	44,29

The higher absolute totals of natural area reduction were concentrated on the Amazônia and Cerrado biomes (86,2%)

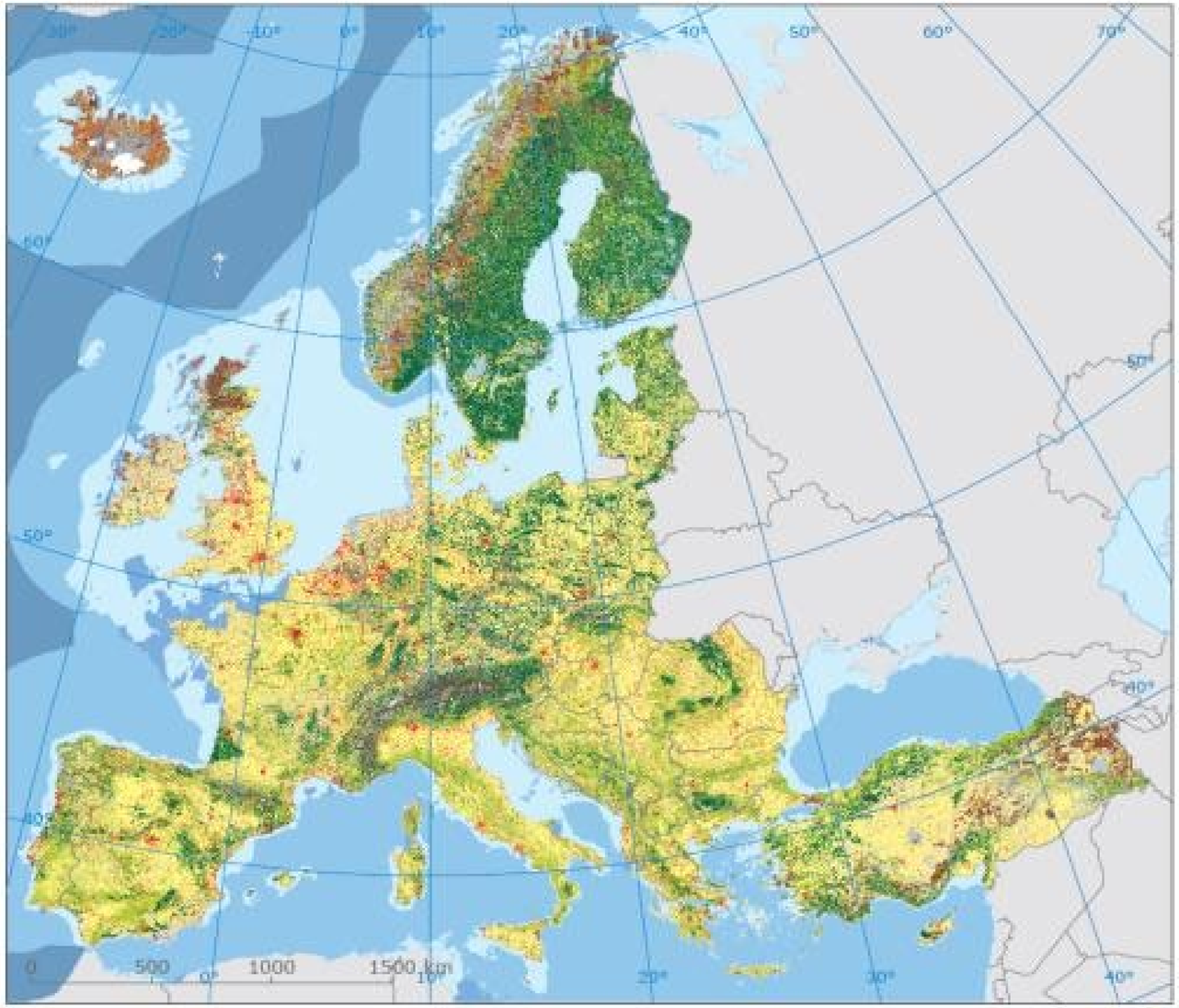
Source: (IBGE 2020), Ecosystem Accounts: Land Use in Brazilian Biomes 2000-2018

Example: ecosystem extent accounts in EU (1/3)

- In 2015, the EU launched a pilot project for an integrated system of ecosystem accounting, INCA
  - > Resulted in the compilation of extent, condition and ecosystem services accounts (Vysna et al., 2021)
- 2011 EU Directive on Environmental-economic accounts covers 6 modules
  - > Being expanded to include also ecosystems accounts; forest accounts and accounts for environmental subsidies + similar transfers

SEEA

Ecosystem extent account (2/3)



Inland vegetation and habitats
- Tundra
- Arctic, alpine and subalpine scrub and grassland
- Mediterranean-mountain scrub and brushes
- Heathland scrub
- Grasslands and land dominated by forbs
- Regularly or recently cultivated agricultural, horticultural and domestic habitats
- Sparsely wooded grasslands
- Broad leaved deciduous and evergreen woodland
- Mixed deciduous and coniferous woodland
- Coniferous and broad leaved evergreen woodland
- Mires, bogs and fens

Inland unvegetated or sparsely vegetated habitats
- Screes, inland cliffs
- Snow or ice-dominated habitats
- Miscellaneous inland habitats with very sparse or no vegetation

Human made constructions and habitats
- Constructed, industrial and other artificial habitats

Non classified areas
- Unclassified areas
- Outside area of interest

Ecosystem map (aggregated)

Marine waters
- European regional seas
- Open waters

Marine seabed and coastal habitats
- Sublittoral sediment
- Infralittoral and circalittoral rock and other hard substrata
- Marine habitats
- Coastal habitats

Inland surface waters
- Inland waters and shores

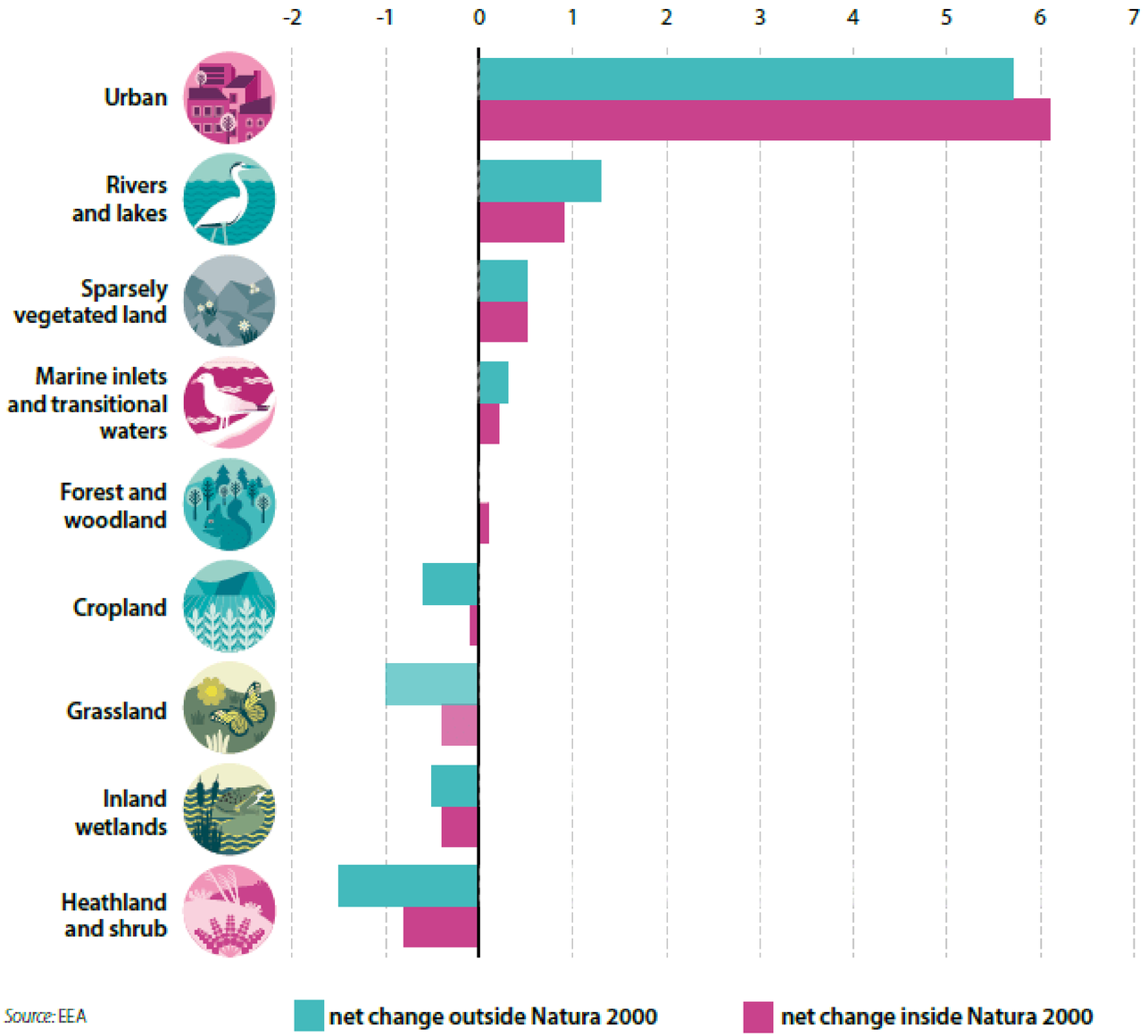
- Built on Corine LC data, aggregated into 9 broad ETs

Source: EEA, 2015a, *European ecosystem assessment: Concept, data, and implementation,* EEA Technical Report No 6/2015, European Environment Agency

Extent example, cont. (3/3)

- Some of the findings are:
  - > Urban ecosystems increased in extent by 5.8% (2000 – 2018) at the expense of farmland and semi-natural ecosystem.
  - > Changes in the extent of semi-natural ecosystem types are mostly smaller within the Natura 2000 protected areas than outside.

Figure 3: Changes in ecosystem extent inside and outside Natura 2000 areas, 2000-2018, EU28 (%)



Source: EEA

SEEA

Ecosystem condition accounts

Ecosystem condition accounts

- Link to ecosystem services
- Insight into ecosystem integrity—i.e. ecosystem's capacity to maintain its characteristic composition, structure, functioning and self-organization over time within a natural range of variability
- Ecosystem condition: **quality of an ecosystem** measured in terms of its abiotic and biotic characteristics.
  - > Characteristics => properties of ecosystems and its (a)biotic components (water, soil, topography, vegetation, biomass, habitat, species)
- Ecosystem condition accounts are diverse—dependent on measurement focus and what compiler has defined and selected as ecosystem characteristics
- Important information in terms of protecting, maintaining and restoring condition
  - > Ecosystem condition is often defined by measuring the similarity (or the distance) of a current ecosystem to a reference state, such as minimally impacted by people or a historical state

Ecosystem condition typology

- Hierarchical typology for organizing data on ecosystem condition characteristics
- Can be used as a template for variable/indicator selection and provide a structure for aggregation

Table 5.1: The SEEA Ecosystem Condition Typology (ECT)

ECT groups and classes
Group A: Abiotic ecosystem characteristics
Class A1. Physical state characteristics: physical descriptors of the abiotic components of the ecosystem (e.g., soil structure, water availability)
Class A2. Chemical state characteristics: chemical composition of abiotic ecosystem compartments (e.g., soil nutrient levels, water quality, air pollutant concentrations)
Group B: Biotic ecosystem characteristics
Class B1. Compositional state characteristics: composition / diversity of ecological communities at a given location and time (e.g., presence / abundance of key species, diversity of relevant species groups)
Class B2. Structural state characteristics: aggregate properties (e.g., mass, density) of the whole ecosystem or its main biotic components (e.g., total biomass, canopy coverage, annual maximum normalized difference vegetation index (NDVI))
Class B3. Functional state characteristics: summary statistics (e.g., frequency, intensity) of the biological, chemical, and physical interactions between the main ecosystem compartments (e.g., primary productivity, community age, disturbance frequency)
Group C: Landscape level characteristics
Class C1. Landscape and seascape characteristics: metrics describing mosaics of ecosystem types at coarse (landscape, seascape) spatial scales (e.g., landscape diversity, connectivity, fragmentation)

Ecosystem condition typology

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Class B3. Functional state characteristics: summary statistics (e.g., frequency, intensity) of the biological, chemical, and physical interactions betw… primary productivity, community age, disturbance f…
Group C: Landscape level characteristics
Class C1. Landscape and seascape characteristics: r… coarse (landscape, seascape) spatial scales (e.g., lan…

Table 5.2: Ecosystem condition variable account

SEEA Ecosystem Condition Typology Class	Variables		Ecosystem type		
	Descriptor	Measurement unit	Opening value	Closing value	Change
Physical state	Variable 1				
	Variable 2				
Chemical state	Variable 3				
Compositional state	Variable 4				
	Variable 5				
Structural state	Variable 6				
Functional state	Variable 7				
Landscape/seascape characteristics	Variable 8				

SEEA

Approach to compiling ecosystem condition accounts

- The primary spatial units are ecosystem assets and these are expected to be delineated such that they are reasonably homogeneous in terms of their main characteristics
- Aggregation/dissemination by ecosystem type as each type has distinct characteristics
- SEEA EA: a three-stage approach to account for ecosystem condition.
  - Variables → indicators → indices
  - The move from one stage to the next requires a progressive building of data and the use of additional assumptions.
  - Outputs at each stage are relevant for policy and decision making

Reference levels

- A reference level is the value of a variable at the reference condition, against which it is meaningful to compare past, present or future measured values of the variable
- A reference condition is the condition against which past, present and future ecosystem condition is compared to in order to measure relative change over time.

	Possible reference conditions
	Undisturbed or minimally-disturbed condition of an intact ecosystem. The condition of an ecosystem with maximal ecosystem integrity with no or minimal disturbance.
	Historical condition: The condition of an ecosystem at some point or period in its history that is considered to represent the stable natural state (e.g., the pre-industrial period or pre-intensive agriculture).
	Least-disturbed condition: the currently best available condition of an ecosystem.
	Contemporary condition: The condition of an ecosystem at a certain point or period in its recent history for which comparable data are available.

Stage I: Variable account

- Precise structure will depend on selected characteristics, data availability, uses of the accounts and policy applications
- Shown by ecosystem type
- **Variable** = soil organic carbon stock, tC/ha (abiotic characteristic, chemical state)
  - > Opening: 100
  - > Closing: 95

Forest

SEEA Ecosystem Condition Typology Class		Variable descriptor	unit	Variable values (observed)		
				Opening	Closing	Change
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Abiotic characteristics	Physical state	Vegetation water content - NDWI	index (-1 to 1)	0.31	0.29	-0.02
	Chemical state	Soil organic carbon stock	tC/ha	100	95	-5
		Foliar or litter nitrogen concentration	mg N / g dry weight	18	17	-1
Biotic characteristics	Compositional state	Tree species richness	number	6	5	-1
	Structural state	Tree cover	%	81	75	-6
	Functional state	Vegetation index - NDVI	index (-1 to 1)	0.65	0.63	-0.02
Landscape/seascape characteristics		Forest area density	%	74	59	-15

Stage II: Index account

- Ecosystem condition indicators are rescaled versions of ecosystem condition variables
- The simplest conversion uses two reference levels to reflect a high or low condition score.
  - > $I = (V - VL) / (VH - VL)$

    where I is the value of the indicator, V is the value of the variable, VH is the high reference level value and VL is the low reference level value.
- Example:
  - > Pristine state→250 tC/ha
  - > Bare earth→0 tC/ha
  - > Indicator for opening stock of 100 tC/ha and closing stock of 95 tC/ha?

Forest

SEEA Ecosystem Condition Typology Class		Variable descriptor	Measurement unit	Variable values (observed)		Reference level values		Indicator values (rescaled)		
				Opening	Closing	Lower level	Upper level	Opening	Closing	Change
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Abiotic characteristics	Physical state	Vegetation water content - NDWI	index (-1 to 1)	0.31	0.29	-1	1	0.66	0.65	-0.01
	Chemical state	Soil organic carbon stock	tC/ha	100	95	0	250	0.40	0.38	-0.02
		Foliar or litter nitrogen concentration	mg N / g dry weight	18	17	4	40	0.39	0.36	-0.03
Biotic characteristics	Compositional state	Tree species richness	number	6	5	0	10	0.60	0.50	-0.10
	Structural state	Tree cover	%	81	75	0	100	0.81	0.75	-0.06
	Functional state	Vegetation index - NDVI	index (-1 to 1)	0.65	0.63	-1	1	0.83	0.82	-0.01
Landscape/seascape characteristics		Forest area density	%	74	59	0	100	0.74	0.59	-0.15

Variable account

Table 5.2: Ecosystem condition variable account

SEEA Ecosystem Condition Typology Class	Variables		Ecosystem type		
	Descriptor	Measurement unit	Opening value	Closing value	Change
Physical state	Variable 1				
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Chemical state	Variable 3				
Compositional state	Variable 4				
	Variable 5				
Structural state	Variable 6				
Functional state	Variable 7				
Landscape/seascape characteristics	Variable 8				

Indicator account

Table 5.3: Ecosystem condition indicator account

SEEA Ecosystem Condition Typology Class	Indicators	Measurement unit	Ecosystem type						
			Variable values		Reference level values		Indicator values (rescaled)		
	Descriptor		Opening value	Closing value	Upper level (e.g., natural)	Lower level (e.g., collapse)	Opening value	Closing value	Change in indicator
Physical state	Indicator 1								
	Indicator 2								
Chemical state	Indicator 3								
Compositional state	Indicator 4								
	Indicator 5								
Structural state	Indicator 6								
Functional state	Indicator 7								
Landscape/seascape characteristics	Indicator 8								

Condition index

- Composed of composite indicators that are aggregated from individual ecosystem condition indicators
- Aggregation process is underpinned using comparable reference levels from a common reference condition.
  - > Component indicators are scaled according to reference levels, normalized to a common scale and direction of change and combined to form a composite index.
- Aggregation can be done in multiple ways
  - > Thematically: across ECT class, across classes of characteristics in the ECT
  - > Spatial: across ecosystem types
- Pros and cons of indices→ index account is optional!

Condition index

Table 5.4: Ecosystem condition indices reported using rescaled indicator values ('mean values' approach)

SEEA Ecosystem Condition Typology Class	Indicators	Ecosystem type				
		Indicator value			Index value	
	Descriptor	Opening value	Closing value	Indicator weight	Opening value	Closing value
Physical state	Indicator 1	0.5	0.25	0.05	0.025	0.013
	Indicator 2	0.9	0.7	0.05	0.045	0.035
	Sub-index				*0.07*	*0.048*
Chemical state	Indicator 3	0.625	0.5	0.1	0.063	0.05
Total Abiotic characteristics					0.133	0.098
Compositional state	Indicator 4	0.94	0.89	0.067	0.063	0.062
	Indicator 5	0.75	0.50	0.033	0.025	0.017
	Sub-index				*0.088*	*0.079*
Structural state	Indicator 6	0.5	0.25	0.12	0.06	0.03
Functional state	Indicator 7	1	0.66	0.08	0.08	0.053
Total Biotic characteristics					0.228	0.162
Landscape and seascape characteristics	Indicator 8	0.5	0.2	0.5	0.25	0.1
Ecosystem condition index	**Index**			**1.0**	**0.611**	**0.360**

SEEA

Multiple ecosystem types

Table 5.6: Ecosystem condition account (condition indices) for multiple ecosystem types

Accounting entries	Stylized ecosystem types					
	Forests	Lakes	Cropland	Urban areas	Wetlands	Seagrass
Opening condition value						
Change in abiotic ecosystem characteristics (physical and chemical state)						
Change in biotic ecosystem characteristics (composition, structure and function)						
Change in landscape/seascape characteristics						
Net change in condition						
Closing condition value						

Table 5.7: Examples of ecosystem condition variables for selected ecosystem types[52]

		A1 Physical state	A2 Chemical state	B1 Compositional state	B2 Structural state	B3 Functional state	C1 Landscape / seascape
T1	**Tropical-subtropical forests**	Soil water availability in the driest quarter; Wetness	Soil organic carbon content; Leaf and litter nitrogen concentration	Tree species richness; Bird species richness	Tree cover density; Dominant tree height; Number of canopy layers; Deadwood volume; Forest age class distribution; Density of epiphytes	Dry matter productivity; Presence of seed dispersing species (capacity for regeneration); Water stress index	Forest area density; Landscape diversity; Forest connectivity; Ratio of edge distance to interior area of forest patches
T2	**Temperate-boreal forests & woodlands biome**	Vegetation water content (NDWI)	Soil organic carbon content; Air pollutant concentration; Foliar and litter nitrogen concentration	Tree species richness; Lichen species richness; Bird species richness	Forest floor depth (soil layer thickness); Tree cover density; Deadwood volume; Forest age class distribution	Dry matter productivity; Density of trees with hollows for nesting; Presence of top predator species (food web functionality); Vegetation index (NDVI); Water stress index	Forest area density; Landscape diversity; Forest connectivity;
T3	**Shrublands & shrubby woodlands**	% Burnt area; Soil layer thickness	Soil organic carbon content; Soil phosphorus concentration	Bird species richness	Tree cover density	Dry matter productivity; Proportion of re-sprouting species after fire (capacity for regeneration)	Landscape diversity; Shrubland/forest connectivity
T4	**Savannas and grasslands**	% Bare ground	Soil organic carbon content; Soil pH	Bird species richness; Butterfly species richness; Proportion of non-native species	The presence/density of trees/shrubs	Dry matter productivity Abundance of termite mounds (organic matter turnover)	Connectivity of trees; Grassland connectivity
T5	**Deserts and semi- deserts**	Water availability; Degree of surface crusting	Soil pH	Reptile species diversity or abundance	Vegetation cover	Density of viable seeds in soil (capacity for regeneration)	Spatial distribution of waterholes
T6	**Polar-alpine (cryogenic)**	% Bare ground; Snow depth; Extent of sea ice	Pollutant concentrations	Lichen species richness	Vegetation cover; Lichen cover or abundance on rocks		Diversity of habitat types; Connectivity of routes for migratory species
T7.1	**Annual croplands**	Water holding capacity; Soil bulk density; Vegetation water content (NDWI)	Soil organic carbon content; Soil nutrient availability	Bird species richness	Share of organic farming; Crop diversity; Share of time or area as fallow land	Soil respiration rate (decomposition); Gross primary production	The presence/ share of semi-natural vegetation fragments (small woody features); Landscape diversity (mosaic)
T7.4	**Urban and**	Imperviousness	NO_2 concentration	Bird species richness	Share of urban green		Average distance of residents to

Examples ecosystem condition

EU: Forest condition variable account

Table 2: Forest condition variable account for EU28 (spatially averaged values)

Condition group	Condition class	Descriptor	Units	Opening stock (2010)	Closing stock (2020 - projected)	Change (% per decade)	Confidence
Abiotic characteristics	**Physical state**	Soil moisture content	%	13.50	13.45	-0.4	medium
	Chemical state	Effective rainfall	mm/year	-32	-44	-38	high
		Exceedances of critical loads for eutrophication	equivalent/ha/ year	251.8	173.7	-31	medium
		Tropospheric ozone concentration	ppb hours	19 265	13 293	-31	high
Biotic characteristics	**Composition**	Common forest birds index (1)	Index (1990 = 100)	93.23	104.86	17.8	medium
	Structure	Biomass volume	m³/ha	200	220	10	medium
		Dead wood	tonne/ha	4.1	4.5	10.3	medium
		Defoliation	%	20	22	10	high
	Function	Evapotranspiration	mm/year	482.0	490.2	1.7	high
		Dry matter productivity	tonne/ha/year	11.8	13.1	11.1	high
Landscape characteristics		Forest area density	%	72.0	72.1	0.1	high

Source: sdg_15_60, EU Ecosystem Assessment

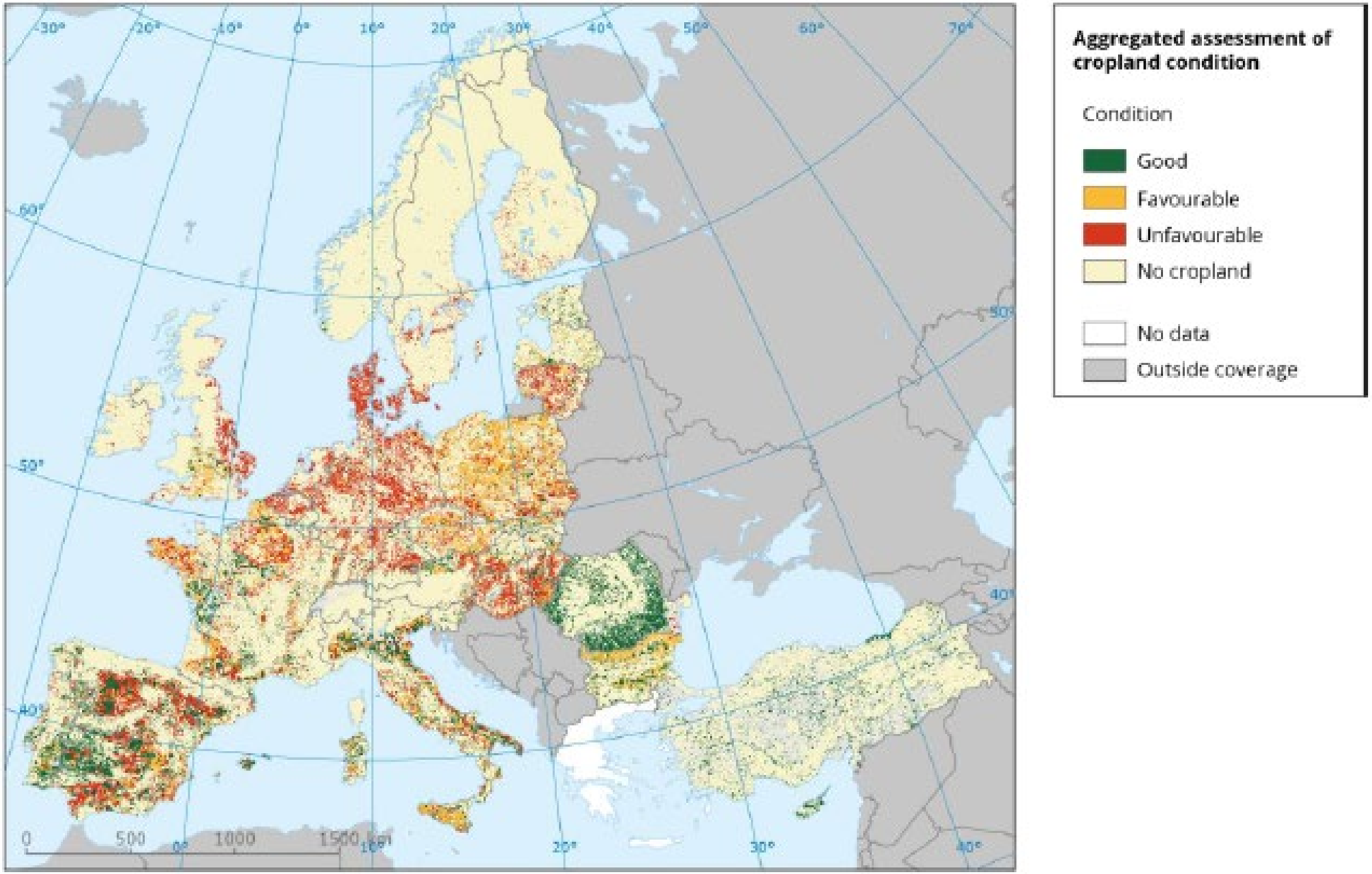
(1) Closing stock for the common forest bird index uses year 2017

- Some findings:
  - > Forest pollution levels are declining across the EU28 but absolute levels of still very high
  - > Forest productivity increased.
  - > Pressures from climate change are increasing (evapotranspiration up; effective rainfall down
  - > Concerning trend is defoliation
  - > Fragmentation remained virtually constant since 2010.

SEEA

Source: Accounting for ecosystems and their services in the European Union INCA Final Report; Vysna et al 2021

Ecosystem condition account - EU



Experimental System of Ecosystem Accounts in Spain

MAIA
Mapping and Assessment for Integrated ecosystem Accounting

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

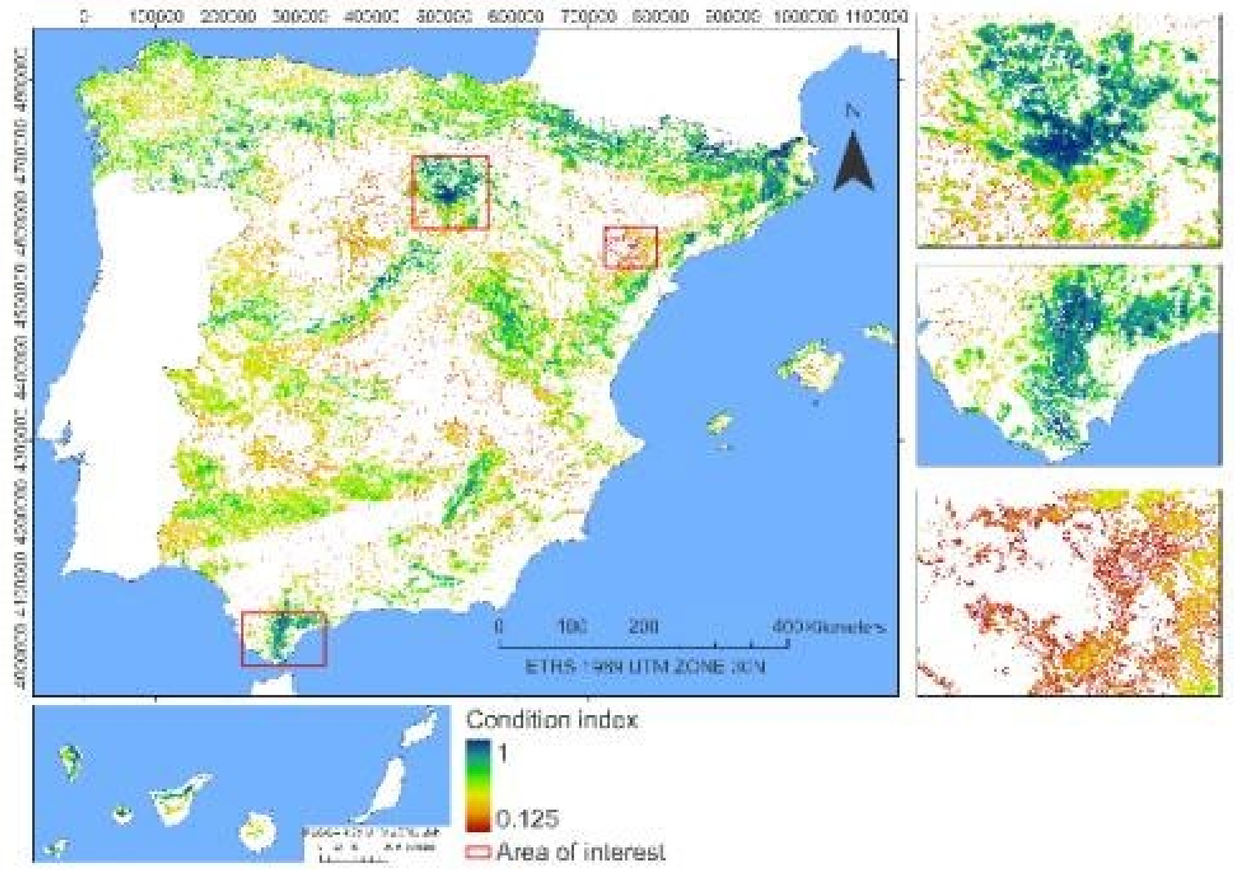
Group	Class	Weigth	Indicator	Source	Resolution (m)
Abiotic characteristics	Physical state	0,07	NDWI	Landsat	30
		0,07	Soil organic carbon	Lucas	1000
	Chemical state	0,07	Ozone (AOT40f)	EEA	2000
		0,07	Nitrogen Deposition (Critical Loads)	EEA	5000
Biotic characteristics	Composition state	0,1	Forest bird 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

Experimental System of Ecosystem Accounts in Spain

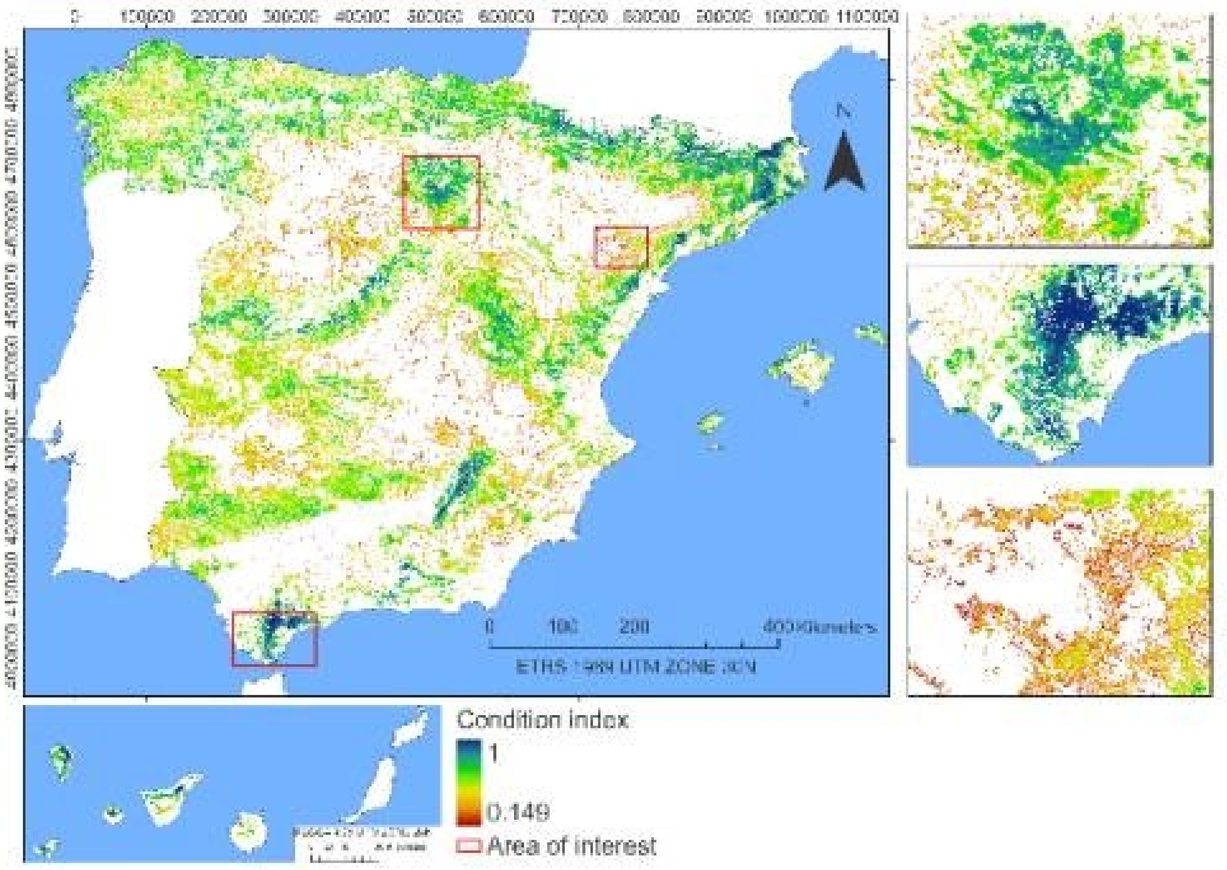
MAIA
Mapping and Assessment for Integrated ecosystem Accounting

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

2000



2015



Experimental System of Ecosystem Accounts in Spain

MAIA
Mapping and Assessment for Integrated ecosystem Accounting

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
Broad. Sclerophyllous Med.	0.536	0.561	0.025	Con. Atlantic	0.601	0.630	0.029
Broad. Continental Med.	0.556	0.565	0.009	Con. Alpine	0.735	0.730	-0.005
Broad. Mountain Med.	0.607	0.598	-0.009	Con. Insular	0.585	0.660	0.075
Broad. Atlantic	0.568	0.602	0.033	Mixed Sclerophyllous Med.	0.571	0.601	0.030
Broad. Alpine	0.661	0.693	0.032	Mixed Continental Med.	0.602	0.606	0.005
Broad. Insular	0.661	0.712	0.050	Mixed Mountain Med.	0.591	0.601	0.009
Con. Sclerophyllous Med.	0.546	0.573	0.027	Mixed Atlantic	0.580	0.616	0.036
Con. Continental Med.	0.593	0.596	0.003	Mixed Alpine	0.758	0.775	0.017
Con. Mountain Med.	0.609	0.606	-0.003	Mixed Insular	0.654	0.716	0.063

India – condition index

- NCAVES project:
  - Uttrara Kanada district
- Integrates 20 different variables
  - multiple soil characteristics such as organic carbon, nitrogen, pH;
  - status of flora and fauna in terms of endangered species;
  - structural state variables such as above and belowground biomass;
  - net primary productivity as key measure for functional status;
  - land surface temperature and forest fragmentation
- Each of these variables were assessed using spatial data and models

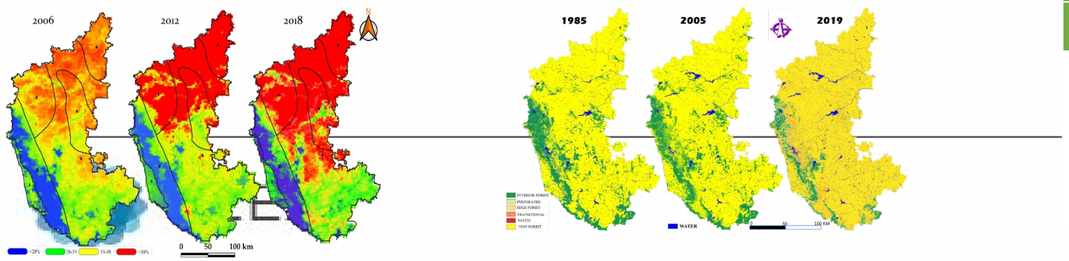


Table 1: Condition accounts of Uttara Kannada (2005-2020)

Districts	SEEA -EA Conditions	**Indicator**	**Parameter**	**Opening -2005 (%)**				**Closing - 2020 (%)**		
				Weight	High	Med.	Low	High	Med.	Low
Uttara Kannada	**Abiotic ecosystem**	Soil	K	0.017	0.0	84.4	15.6	0.0	99.3	0.7
		Soil	N	0.017	100.0	0.0	0.0	0.0	0.0	100.0
			P	0.017	0.0	0.0	100.0	37.6	62.4	0.0
			OC	0.017	0.0	72.4	27.6	0.0	100.0	0.0
			S	0.017	45.4	54.6	0.0	45.4	54.6	0.0
			Zn	0.017	0.0	85.8	14.2	0.0	100.0	0.0
			Fe	0.017	0.0	100.0	0.0	0.0	100.0	0.0
			B	0.017	0.0	0.0	100.0	0.0	0.0	100.0
			Cu	0.017	0.0	99.3	0.7	0.0	99.3	0.7
			Mn	0.017	0.0	100.0	0.0	0.0	100.0	0.0
			EC	0.017	100.0	0.0	0.0	100.0	0.0	0.0
			pH	0.017	94.4	5.6	0.0	100.0	0.0	0.0
	Biotic - Compositional State	Flora		0.05	87.8	5.5	6.7	73.1	5.5	21.4
		Fauna		0.05	56.3	11.0	32.7	46.9	11.0	42.1
	Biotic - Structural State	AGB		0.05	46.2	35.2	18.6	33.1	42.1	24.8
		BGB		0.05	46.2	35.2	18.6	33.1	42.1	24.8
	Biotic - Functional State	NPP		0.10	32.4	55.2	12.4	1.4	84.8	13.8
	Landscape Level	Fragmentation		0.25	55.0	10.8	34.2	45.8	13.5	40.8
		LST		0.25	20.6	53.2	26.2	0.6	69.9	29.6
Ecosystem condition Account			Index	1.00	39.6	35.9	24.5	25.8	46.3	28.0

Note: N: Nitrogen, P: Phosphorous, K: Potash, OC: Organic Carbon, Zn: Zinc, Fe: Iron, B: Boron, Cu: Copper, Mn: Manganese, S: Sulphur, EC: Electrical conductivity, AGB: Above ground biomass, BGB: Below ground Biomass, NPP: Net Primary Productivity, LST: Land Surface Temperature