System of Environmental Economic Accounting

Key Concepts

(Level 0)

October 2017

United Nations

Overview

- SEEA-EEA Training (Level 0)
  - > Overview of training modules
  - > Basic concepts:
    - Ecosystems as “Assets”
    - Ecosystem Services Cascade
    - Accounting Principles
    - Ecosystem Accounting is Spatial
  - > Accounts
  - > Tools

SEEA-EEA Training

- Concepts, Accounts and Tools
- Flexible and modular (don't need all Accounts and Tools)
- Three levels:
  - Level 0 (All participants)
  - Level 1 (Compiling)
  - Level 2 (Providing data, country examples)
- Links to related training materials:
  - Secretariat for the Convention on Biological Diversity (SCBD)
    - Quick Start Package (QSP): includes GIS exercises
  - World Bank WAVES

SEEA EEA Training Level 0

- **Learning objectives**
  - Understand the basic concepts in ecosystem accounting
  - Understand the structure, data requirements and uses of the SEEA-EEA accounts
  - Understand the basic tools used to compile the SEEA-EEA accounts
- For **technical and scientific experts**, this is:
  - Preparation for Levels 1 & 2
- For **policy experts and supporters** you will:
  - Understand how to use the accounts and who to engage in the discussion

SEEA EEA Training Level 0

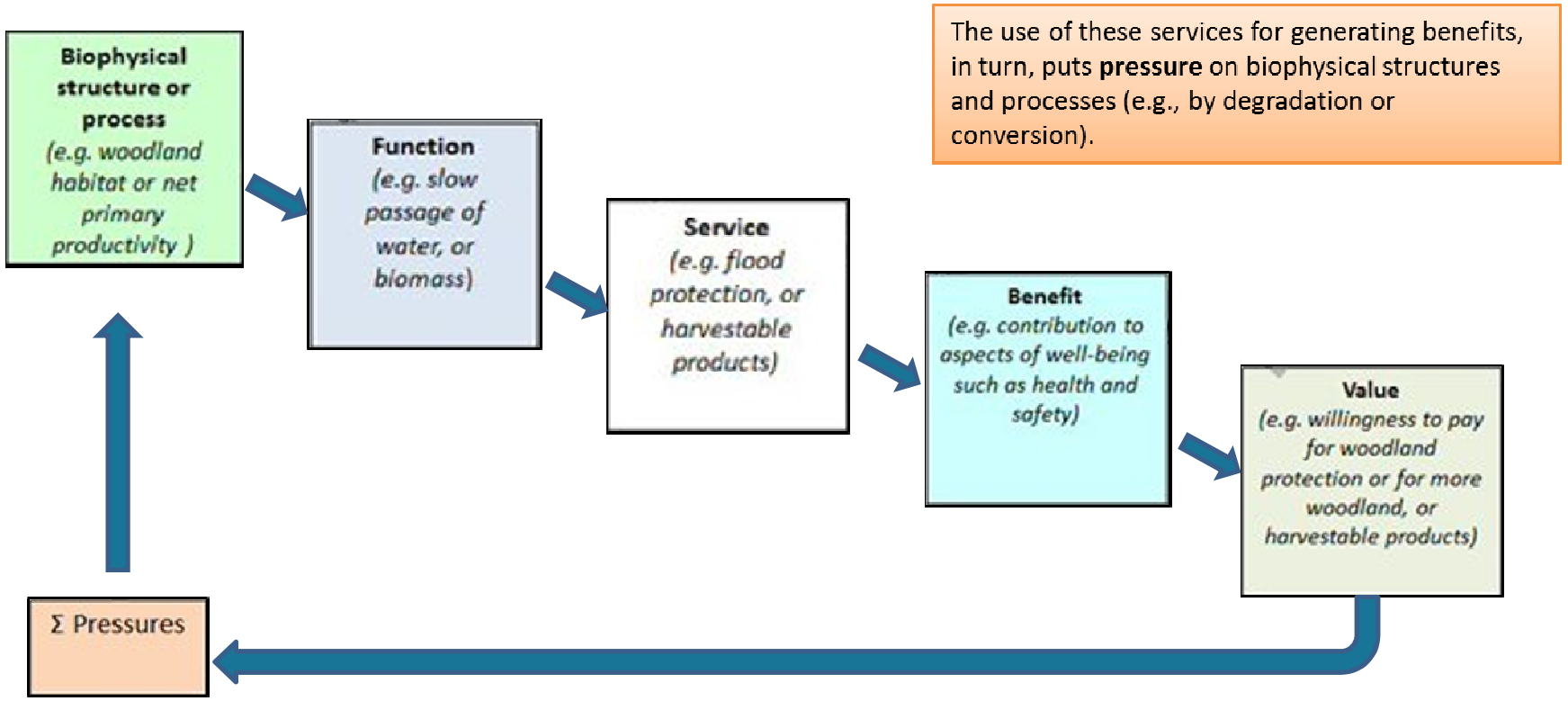
- **Basic concepts and definitions**
  - Ecosystems as "Assets"
  - The Ecosystem Services "Cascade"
    - Ecosystem structure and processes, function, services, benefits and values
  - Accounting (not just "counting") Principles
    - Assets, stocks and flows
    - Balancing the books
  - Ecosystem Accounting is Spatial
    - Geographic information systems (GIS)

Ecosystem assets: a definition

- ***Ecosystem assets*** *are spatial areas containing a combination of biotic and abiotic components and other characteristics that function together* (SEEA-EEA Sections 2.31, 4.1)
- A **forest** is an area that:
  - > Can be located on a map (spatial)
  - > Contains trees, shrubs, grasses, soil biota, birds, mammals, insects… functioning together with
  - > The soil, water, geology (rocks), sunlight, wind…

The Ecosystem Services Cascade

Ecosystem services are the contribution of ecosystems to benefits for people…

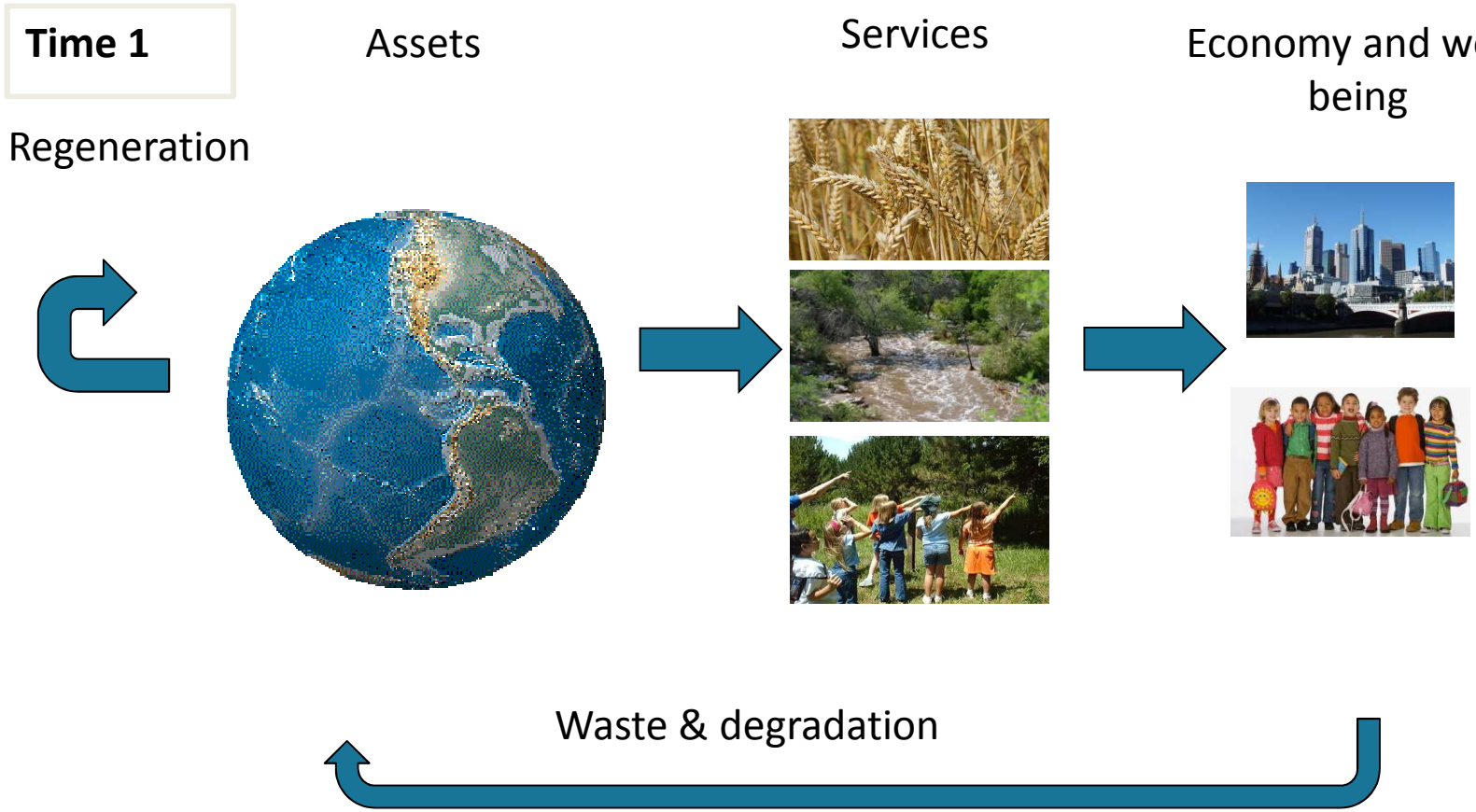


Source: Nottingham School of Geography

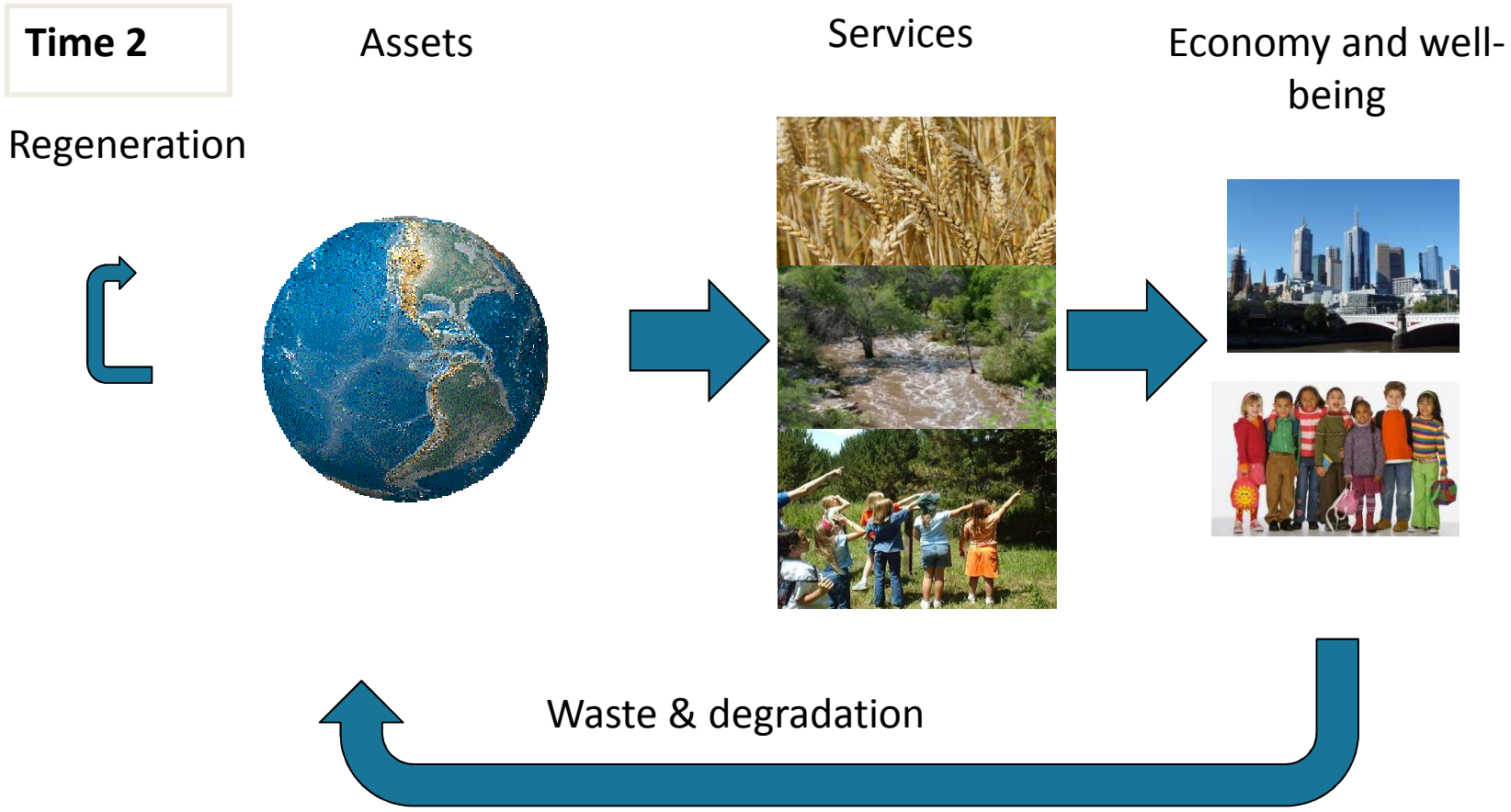
Accounting principles…

- **Apply to environmental data, too…**
  - **Double entry accounting**:
    - Beginning & end of time period → reconcile changes
    - Compare two sources → reconcile and find errors
  - **Time of recording**:
    - Referring to same time period (accounting period)
  - **Unit of measurement**:
    - Same units (physical or monetary)
    - Reconciliation and aggregation
  - **Consistent valuation rules**:
    - Market price: Basic, producer, purchaser
  - **Consistent concepts and classifications**
  - **Stock → Flow (Asset → Service)**

Balancing the books of environmental assets



Balancing the books of environmental assets



Ecosystem accounting is spatial

- Ecosystems are different and function differently depending on **where** they are
- Their capacity to supply services depends on their **location**
- The benefits of many services depends on whether or not the ecosystems are **accessible**
- Therefore…Ecosystem accounting needs to integrate **spatial** and **non-spatial** data
- For example, wetlands in northern Canada may have the **capacity** to purify water, but there is no population there to benefit from it.

Ecosystem accounting is spatial

- Geographic information systems (GIS)
  - > Manage spatial information as layers
  - > Have tools to integrate spatial information:
    - Overlay different data where space is the common denominator
    - Aggregate point information (e.g., water sampling station) to larger areas (polygons)
    - Attribute information from larger areas to smaller ones (downsampling)
    - Geospatial statistics (interpolation, modelling)
  - > Generate tables based on common properties (e.g., land cover and land cover change)

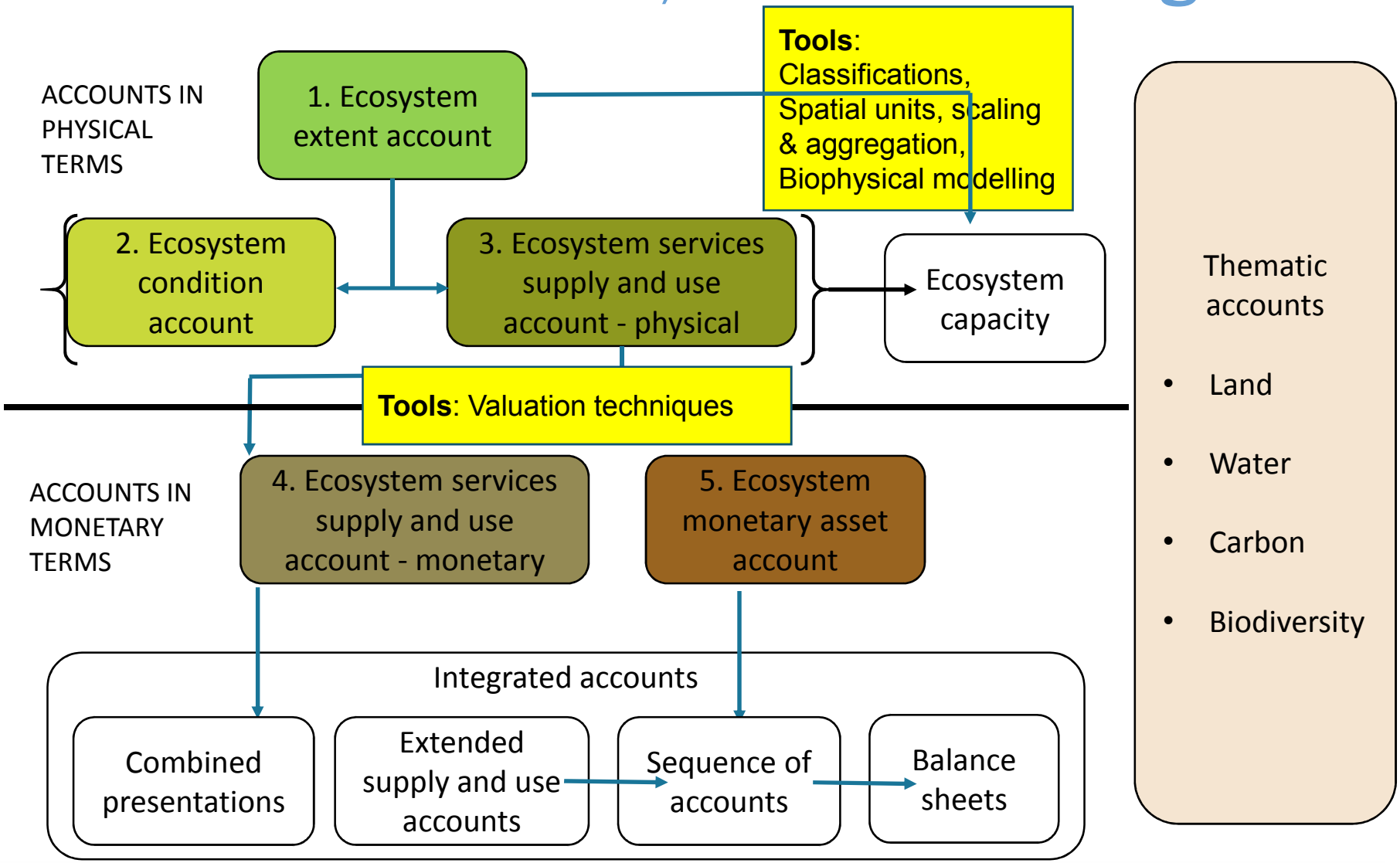
Pop quiz!

- What is an important ecosystem type in your country and what services does it provide?

- What are examples of spatial data that you may wish to integrate into ecosystem accounting?

- Why is GIS a useful tool for ecosystem accounting?

SEEA-EEA accounts, tools and linkages



SEEA-EEA Accounts and Tools

Today's session presents 2-4 slides on each topic:

Ecosystem Accounts
- Ecosystem Extent Account
- Ecosystem Condition Account
- Ecosystem Services Supply and Use Account – physical terms
- Ecosystem Services Supply and Use Account – monetary terms
- Ecosystem monetary asset account – monetary terms

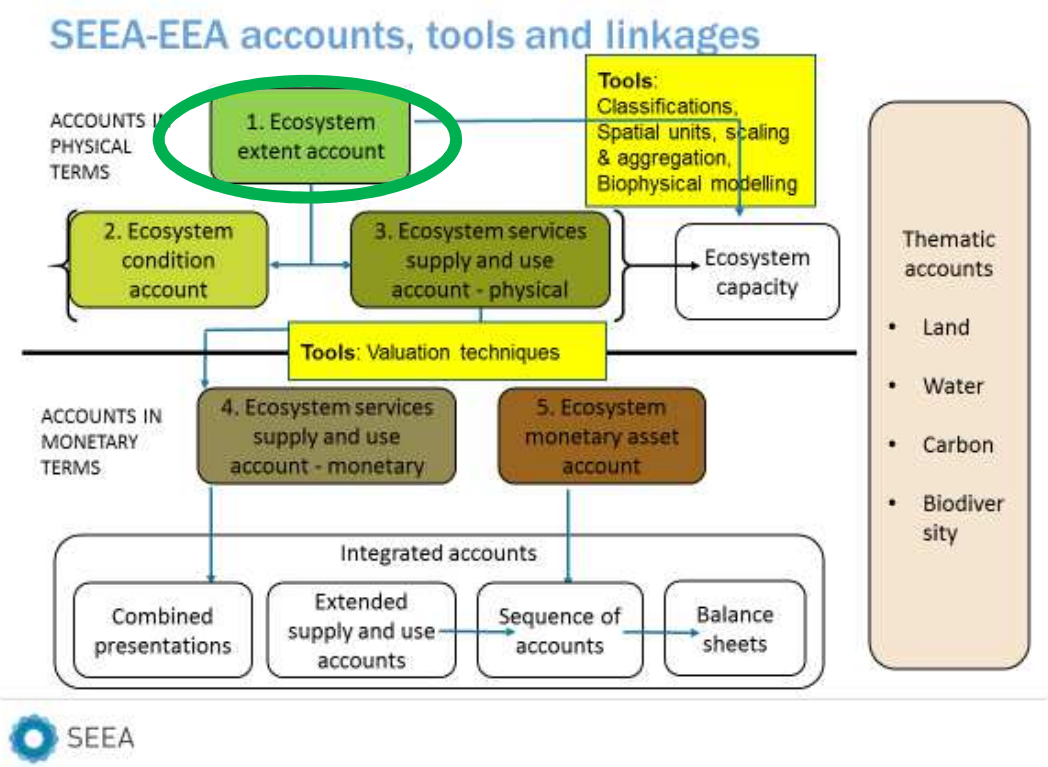
Thematic Accounts
- Land account
- Water Account
- Carbon Account
- Biodiversity Account

Integrated accounts
- Combined presentations
- Extended supply and use accounts
- Integrated Sector Accounts
- Balance Sheets

Tools
- Classifications
- Spatial units, scaling and aggregation
- Biophysical modelling
- Valuation

Level 0: Account 1: Extent

Account 1: Extent



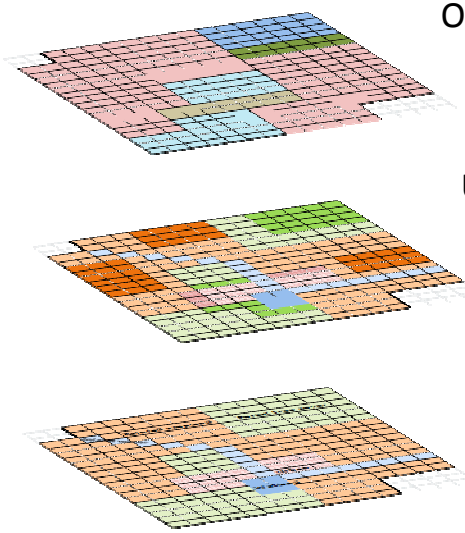
Level 0: Account 1: Extent

- **What?**
  - ***Ecosystem assets*** *are spatial areas containing a combination of biotic and abiotic components and other characteristics that function together* (SEEA-EEA Sections 2.31, 4.1)
  - **National** coverage of terrestrial, freshwater, coastal and marine areas
  - Mutually exclusive and exhaustive coverage
- **Why?**
  - Land management, conservation policies
  - Spatial foundation for other accounts
    → basis for allocating macro data to spatial units
  - Builds on SEEA-CF (land, forest, water)
  - Indicators:
    - Land cover change → where changes occurring
    - Land cover/use intensity → who owns it

Level 0: Account 1: Extent

What does an Extent Account look like?

Maps



Tables

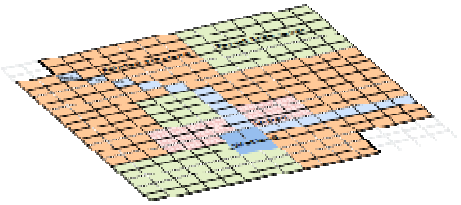
Cover	Urban and associated		Rainfed herbaceous cropland		Forest tree cover		Inland water bodies		Open wetlands	Total
Use	Infrastructure	Residential	Permananet crops	Maintenance	Forestry	Protected	Infrastructure	Aquaculture	Maintenance	
Ownership	Government	Private	Private	Private	Private	Government	Government	Private	Government	
Units	hectares									
Opening Stock										
Additions to Stock										
Managed expansion										
Natural expansion										
Reductions to stock										
Managed regression										
Natural regression										
Closing stock										

Spatial units
Classifications

Level 0: Account 1: Extent

What does an Extent Account look like?

Maps



Ecosystem type

Spatial units
Classifications

	Proxy ecosystem type (based on land cover)															
	Artificial surfaces	Herbaceous crops	Woody crops	Multiple or layered crops	Grassland	Tree-covered areas	Mangroves	Shrub-covered areas	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow and glaciers	Inland water bodies	Coastal water and inter-tidal areas	Sea and marine areas	TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Opening extent																
Additions to extent																
Managed expansion																
Natural expansion																
Upward reappraisals																
Reductions in extent																
Managed regression																
Natural regression																
Downward reappraisals																
Net change in extent																
Closing extent																

Level 0: Account 1: Extent

- **What does an Extent Account look like?**

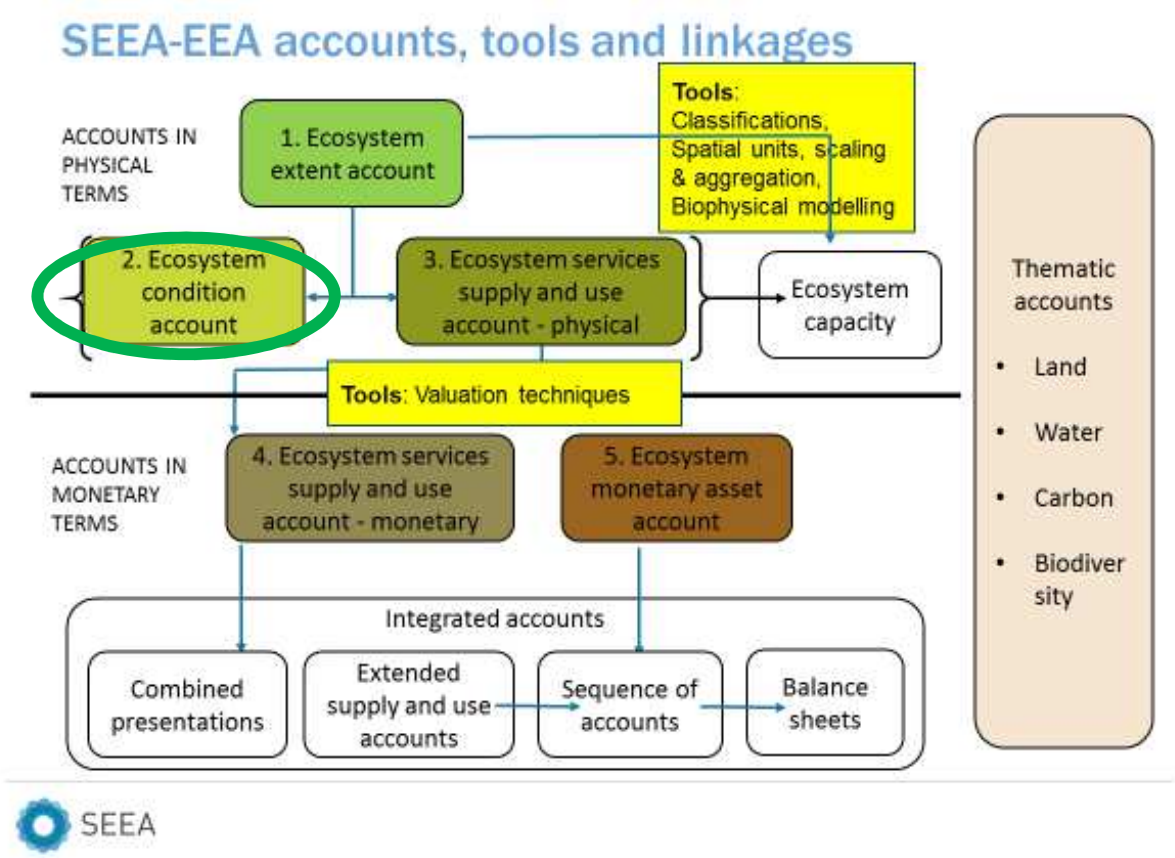
  An integrated spatial (GIS) database that overlays:
  - Land cover: forest, wetland, lake…
  - Use and intensity of use: agriculture, forestry, protected…
  - Ownership: business, private, government
- Classified into **Spatial Units**
- At high resolution (30m to 100m, maximum 500m) with national coverage
- For two or more periods (change over time)
- Based on comparable **Classifications**, quality, methods and **Spatial Units**
- Units: hectares
- Records: opening stock, closing stock, additions, reductions

Level 0: Account 1: Extent

- **What do you need to compile an Extent Account?**
  - GIS platform: software, protocols, spatial units
  - Classifications: land cover, land use, ownership
  - National level data:
    - Existing land account would be useful
    - Satellite: land cover, aerial photography
    - Census: agriculture, population, settlements
    - Forest inventories
    - Hydrological, topographic (rivers, drainage areas, elevation, coastlines)
    - Cadastral (ownership, tax)
  - Expertise:
    - Land managers, ecologists, geographers (GIS, satellite imagery, integration)

Level 0: Account 2: Condition

Account 2: Condition



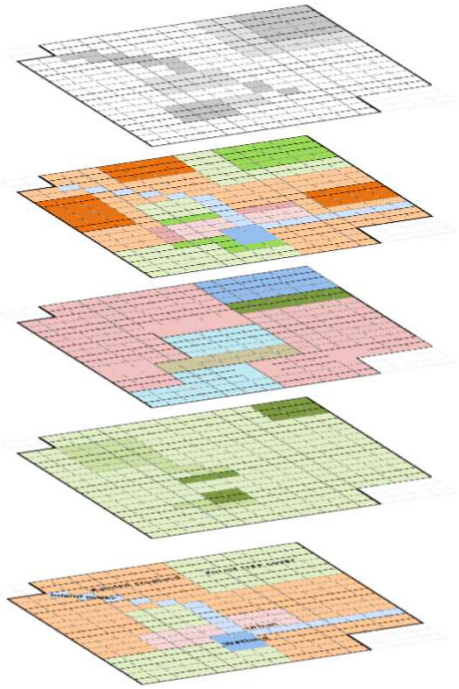
Level 0: Account 2: Condition

- What?
  - > ***Ecosystem condition*** *reflects the overall quality of an ecosystem asset, in terms of its characteristics. (SEEA EEA paragraph 2.34)*
- Why?
  - > Policies to limit degradation of natural heritage, rehabilitation of degraded ecosystems
  - > Links to capacity to produce services (Services Supply)
  - > Indicators:
    - Indices of condition ➔ change over time ➔ where changes
    - Good/bad condition (exceeding "safe" levels) ➔ where

Level 0: Account 2: Condition

- **What does a Condition Account look like**

Maps



Carbon

Water

Soil

Biodiversity

Vegetation

Tables

Ecosystem type	Ecosystem extent (ha)	Ecosystem condition					
		Vegetation biomass (tonnes)	Biodiversity Index	Soil Organic matter	Water Quality Index	Carbon Carbon Balance	Index
Urban and associated							
Rainfed herbaceous cropland							
Forest tree cover							
Inland water bodies							
Open wetlands							

Scaling & aggregation

Level 0: Account 2: Condition

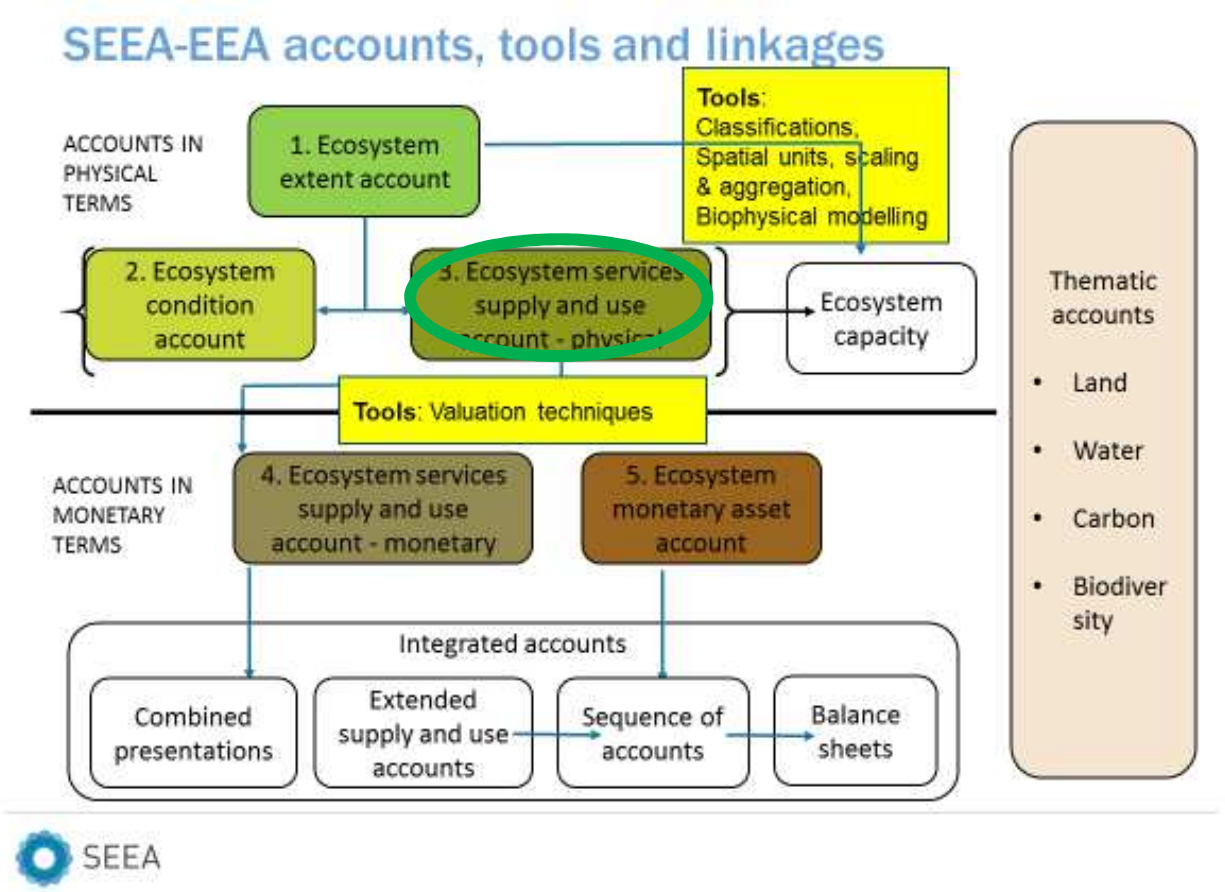
- **What does a Condition Account look like?**
  - Spatially-detailed condition measures (quality or biophysical) for each characteristic:
  - Vegetation
  - Biodiversity (species abundance, diversity indices)
  - Soil
  - Water
  - Carbon
  - Air
  - Overall measures (e.g., heterogeneity)
- **Selected** to reflect an area's capacity to generate services
- Summarized in terms of an **index**
- Accounts for changes over time (accounting period)
- Attributes changes to **drivers** (natural and human)

Level 0: Account 2: Condition

- **What do you need to compile a Condition Account?**
  - Ecosystem Extent Account
  - Common spatial database (Spatial units)
  - **Data:**
    - Condition measures from satellite imagery and field studies over two periods of time
    - Environmental monitoring data (water, air, soil, species)
  - **Expertise:**
    - Ecologists (vegetation, soil, water)
    - Statisticians (methodologists to create indices, **Scaling, Aggregation**)
    - Environmental policy analysts (focus on relevant indices)
    - Geographers (GIS, remote sensing, integration)

Level 0: Account 3: Services supply and use- physical

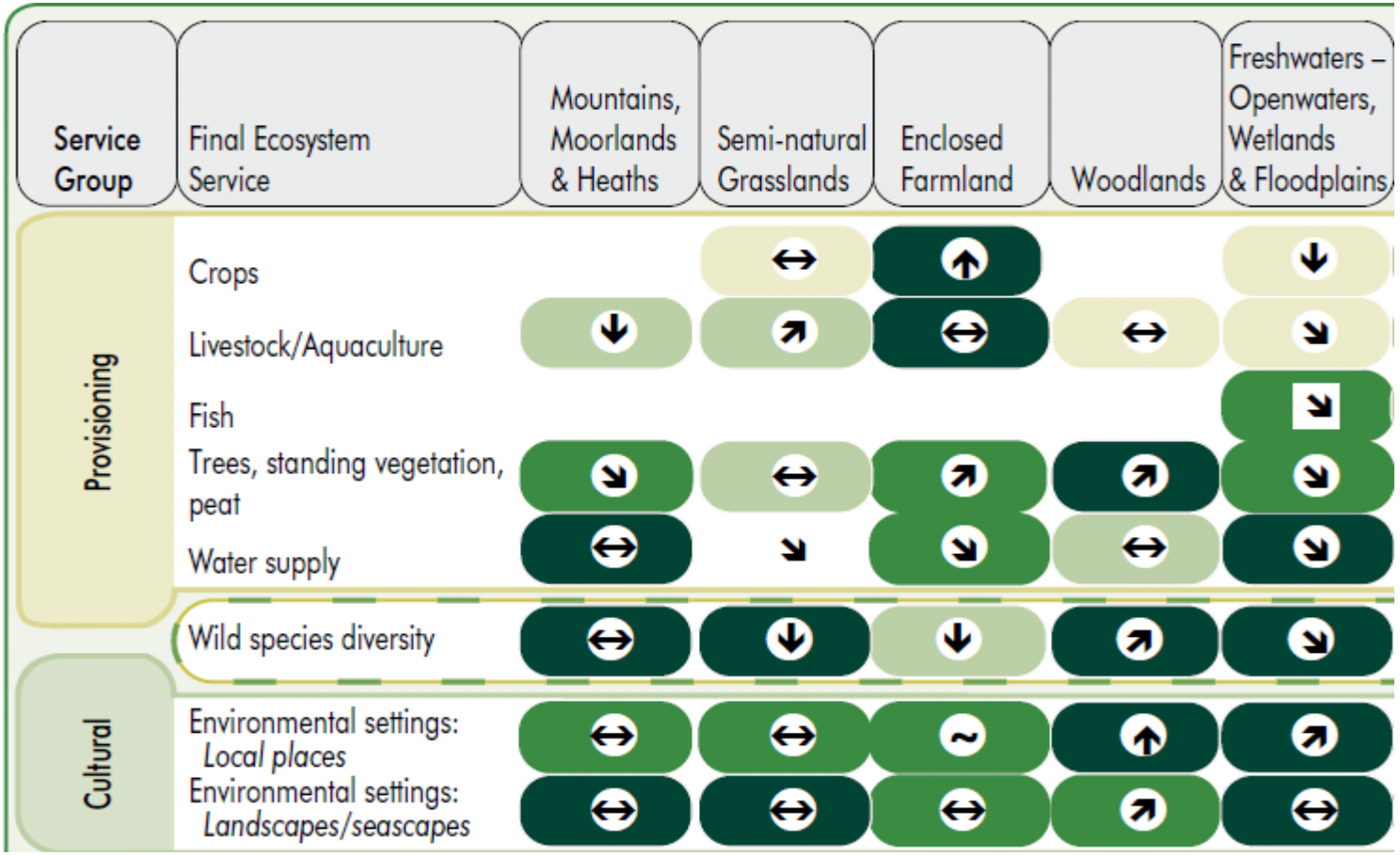
Account 3: Services supply and use - physical



Level 0: Account 3: Services Supply

- **What?**
  - Physical flows of "final" ecosystem **services** from ecosystems to beneficiaries
  - Directly used by (or affect) people
- **Why?**
  - Inform policies of contribution of ecosystems to human well-being
  - Assess trade-offs between development and conservation
  - Link to standard economic production measures in SNA
  - Link to other SEEA-EEA accounts (**Condition, Services Use, Monetary Ecosystem Services; Ecosystem Monetary Asset** valuation)
  - Indicators:
    - Flows of individual services (physical and monetary) ➔ change
    - Indices of aggregated services by ecosystem type ➔ change

Level 0: Account 3: Services Supply

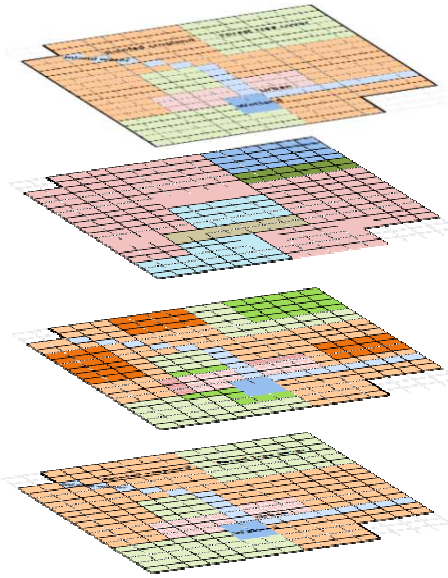


Source: UK National Ecosystem Assessment (2011)

Level 0: Account 1: Services supply

What does an Ecosystem Service Supply Account look like?

Maps



Ecosystem extent

Provisioning

Regulating

Cultural

Tables

Type of service	Ecosystem type			
	Urban and associated	Forest tree cover	Agricultural land	Open wetlands
Provisioning		e.g., tonnes of timber	e.g., tonnes of wheat	
Regulating	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of P absorbed
Cultural	e.g., hectares of parkland	e.g., number of visitors / hikers		e.g., hectares of duck habitat

Look up tables
Biophysical modelling

Valuation

Monetary Services Supply

Level 0: Account 3: Services Supply

- **Example (Services Supply in physical units)**

Ecosystem service		Units	Land cover type								
			Urban	Pasture	Cropland	Forest	Heath	Peat	Surface Water	Other nature	**Provincial total**
Provisioning	Hunting	kg meat	-	9,100	14,732	8,100	678	70		1,513	**34,193**
	Drinking water extraction	10^3 m^3 water	4,071	7,026	11,227	3,117	214	-	478	862	**26,995**
	Crop production	10^6 kg produce	-	-	1,868	-	-	-	-	-	**1,868**
	Fodder production	10^6 kg dry matter		533	251						**784**
Regulation	Air quality regulation	10^3 kg PM_{10}	272	404	717	700	45	7	40	69	**2,254**
	Carbon sequestration	10^6 kg carbon	875	8,019	273	50,664	393	149	-	1,056	**61,429**
Cultural	Recreational cycling	10^3 trips	2,690	1,863	2,611	1,565	30	3	139	220	**9,121**

Source: Remme et al., 2014 (Limburg, the Netherlands)

Level 0: Account 3: Services Supply

- **What does a Services Supply Account look like?**
  - Spatially-detailed physical measures of "final" services according to a common **Classification**:
    - Provisioning
    - Regulating
    - Cultural
  - Physical measures (crops, flood control, clean drinking water, carbon sequestration, recreation, …)
  - Services supply account in physical terms forms the basis for **Valuation** where appropriate and available

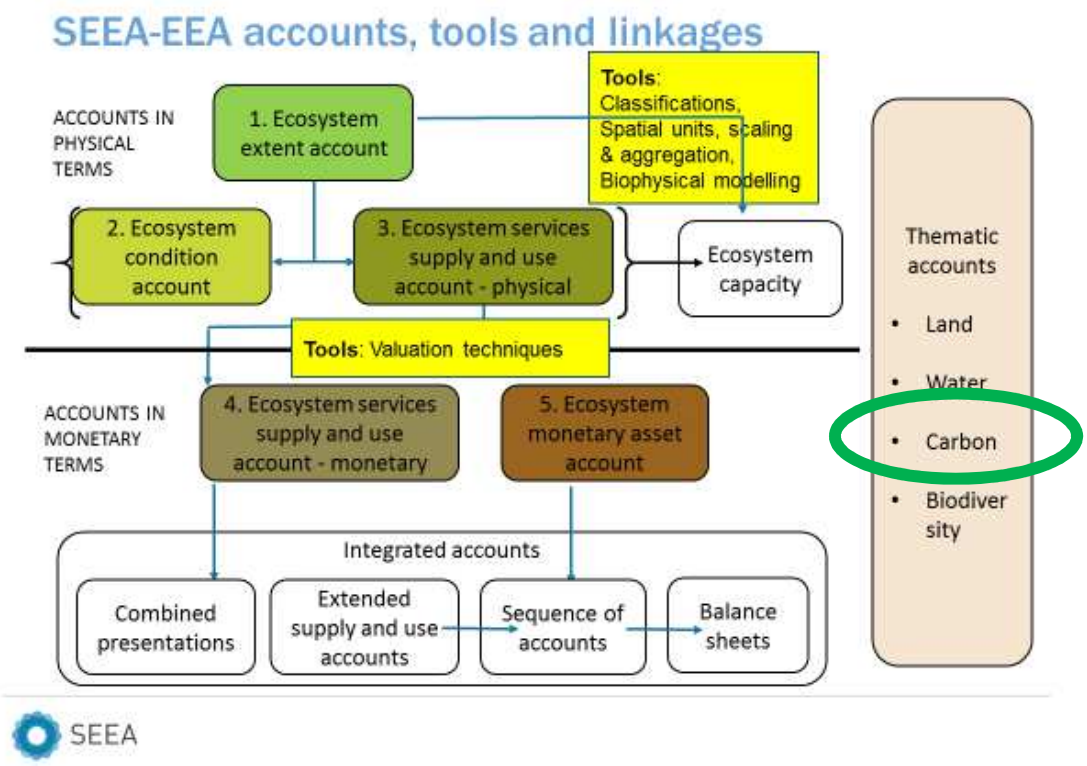
    → **Monetary Services Supply**

Level 0: Account 3: Services Supply

- **What do you need to create a Services Supply Account?**
  - **Ecosystem Extent**
  - Common spatial infrastructure (**Spatial Units**)
  - Common **Classification** of services
  - **Data**:
    - Field studies
    - Economic production (agriculture, forestry, fisheries, water)
    - **Biophysical modelling** of individual ecosystem services
  - **Expertise**: ecologists, geographers (GIS), economists, policy analysts, statisticians

Level 0: Thematic accounts

Thematic Account : Carbon

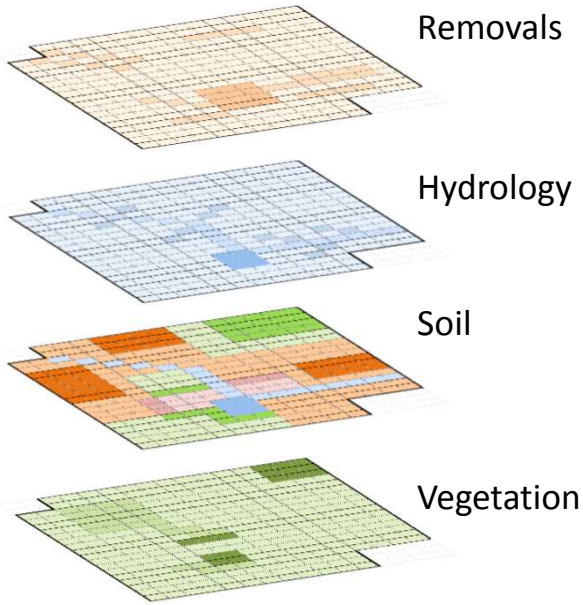


Carbon account: What and Why?

- **What?**
  - Measurement of carbon stocks and flows for all parts of the carbon cycle and all carbon pools
    - Focus of carbon accounting at this stage is on biocarbon and geocarbon
  - Carbon-related services (sequestration and storage)
  - Carbon as a characteristic of ecosystem condition (productivity)
- **Why?**
  - Policies on climate change, low-carbon economy
  - Assess changes in land cover and land use on carbon stocks and sequestration
  - Links to other SEEA accounts (**Condition**, **Services Supply**)
  - Links to SEEA CF (timber, soil, materials)
  - Links to international guidelines (IPCC and REDD+)
  - Indicators:
    - Natural and human additions to carbon stock → where
    - Natural and human removals from carbon stock → where

What does a carbon stock account look like?

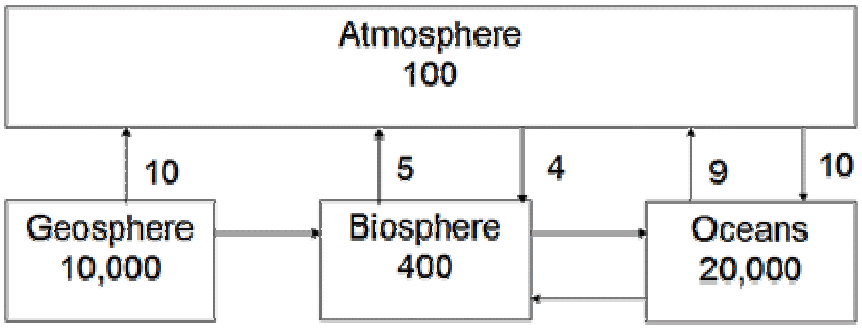
Maps



Tables

	Geocarbon	Biocarbon	Oceans	Atmosphere
	billion tonnes C			
Opening stock	10,000	400	20,000	100
Additions	-	4	10	24
Reductions	10	5	9	14
Closing stock	9,990	399	20,001	110

Scaling
Biophysical modelling



What does a carbon stock account look like?

- Spatially detailed in terms of:
  - Carbon stocks
  - Additions and reductions
- Natural & human additions and removals

Gigagrams Carbon (GgC)	Geocarbon					Biocarbon			Atmosphere	Water in oceans	Accumulation in economy				Total
	Limestone	Oil	Gas	Coal	Other	Terrestrial ecosystems	Aquatic ecosystems	Marine ecosystems			Inventories[a]	Fixed assets	Consumer durables	Waste	
Opening stock of carbon															
Additions to stock															
Natural expansion															
Managed expansion															
Discoveries															
Upward reappraisals															
Reclassifications															
Total additions to stock															
Reductions in stock															
Natural contraction															
Managed contraction															
Downward reappraisals															
Reclassifications															
Total reductions in stock															
Imports and exports															
Imports															
Exports															
Closing stock of carbon															

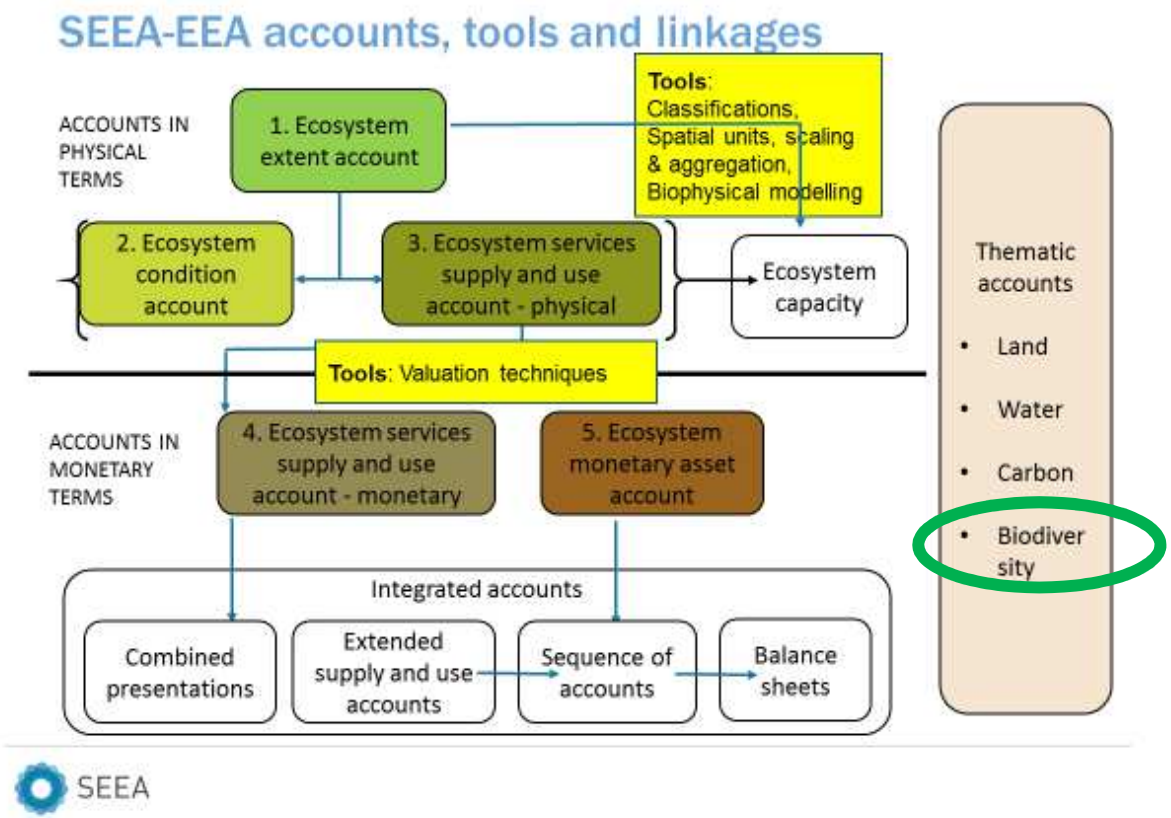
a Excluding inventories included in biocarbon (e.g., plantation forests, orchards, livestock, etc.).

Note: Dark grey cells are null by definition.

What do you need to compile a carbon account?

- **Ecosystem extent account**
- Common spatial infrastructure (**spatial units**)
- Lookup tables (sequestration and storage by land cover type)
- **Data:**
  - Biocarbon (above-ground biomass) from satellite data
  - Carbon sequestration and storage from vegetation cover
  - Soil carbon from soil inventories
  - Removals from agriculture, forestry data, fires
- **Expertise:**
  - Ecologists (biophysical modelling)
  - Agriculture, forestry experts
  - Geographers (GIS, remote sensing)

Thematic Account : Biodiversity



Biodiversity accounting: What?

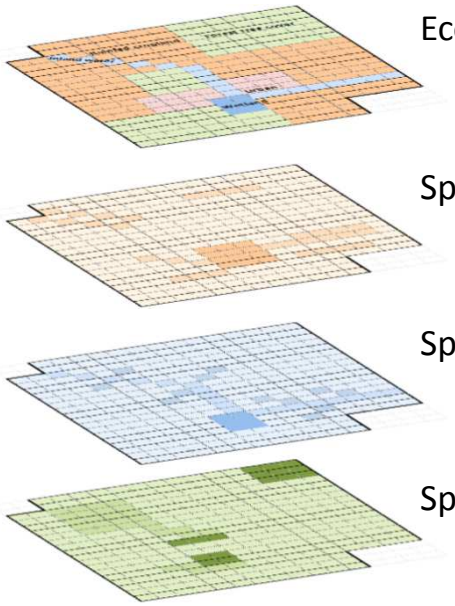
- **What do biodiversity accounts contain?**
  - Biodiversity information linked to areas of ecosystems (from extent account)
  - Spatially detailed information on key species:
    - Abundance
    - Richness
    - Conservation status
    - Other characteristics (e.g. health)
  - Spatially detailed summary statistics (index) on species diversity (used in condition account)

Biodiversity accounting: Why?

- **Why would you create biodiversity accounts?**
  - To compare trends in biodiversity with economic and social activity in a spatially explicit manner
  - To link biodiversity information with other SEEA accounts (condition, services supply)
  - To meet global commitments under the Convention on Biological Diversity's Strategic Plan for Biodiversity (2011-2020)
  - To support sustainable development

What does a biodiversity account look like?

Maps



Tables

	Priority species and ecosystems								Index
	Species 1		Species 2		Species 3		Species ...		
	Pop.	Ecosys. Area	Pop.	Ecosys. Area	Pop.	Ecosys. Area	Pop.	Ecosys. Area	
Reference									
Opening									
Closing									
Net change									

Species data:
- abundance
- richness
- classification
- conservation status
- characteristics
- health

Biodiversity account: requirements

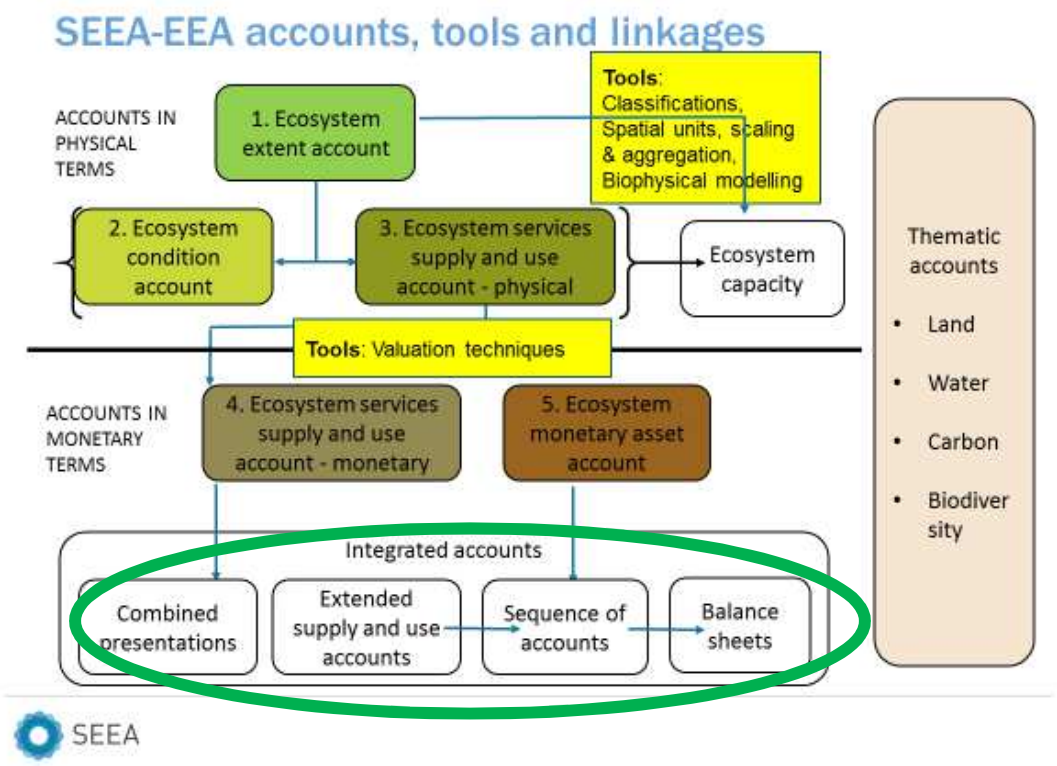
- **What do you need to produce a biodiversity account?**
  - The key policy questions & goal of the biodiversity account
  - List of key or priority species
  - List of data sources (e.g., national, global) supported by a dialogue with data providers to ascertain data availability.
  - Expertise to mobilise data and plug data gaps:
    - Species measurement
    - Biophysical modelling, GIS
    - Indicator development
    - Statistical analysis

Biodiversity account: requirements

- **What do you need to produce a biodiversity account?**
  - Information on key or priority species
    - Species classifications (family, genus)
    - Species measures (ranges, richness, population counts over time)
    - Characteristics (e.g., habitat, specialist/generalist, health)
    - Conservation status
  - **Extent account** or some form of spatial infrastructure for ecosystems (**spatial units**)

Level 0: Integrated accounts

Integrated accounts



Four broad types of integrated accounts :

- Combined presentations
- Extended supply and use accounts
- Sequence of accounts
- Balance sheets (extended measures of wealth)

Combined presentations

- Tables that support the presentation of information from a variety of sources in a manner that facilitates comparison between economic and environmental data.
  - > Possible because of common classifications and accounting principles.
  - > Well-known is decoupling graphs, indicators on resource productivity / intensity
- Two examples in ecosystem accounting:
  - > (i) combine changes in condition with expenditure on environmental protection on those assets; and
  - > (ii) information on flows of ecosystem services generated by an ecosystem asset combined with information on economic activity associated with that asset

Extended supply and use accounts

- Augmented SUA present information on the supply and use of ecosystem services as extensions to the standard SNA SUA.
  - > Ecosystem accounting -> extension to the production boundary
  - > Additional rows for ES (as set of products within scope of the SUA is broader and hence the size)
  - > Additional columns (as ecosystem assets considered additional producing units)
- Environmentally-extended input-output tables (EE-IOT).
  - > Requires information on environmental flows classified and structured as for the standard input-output data.
  - > Matrix algebra (Leontief inverse) -> consumption based indicators (e.g. Carbon or biodiversity footprints / embodied water)
- IO tables are regularly compiled (national and multi-regional)

Sequence of accounts

Sequence of accounts (SNA) provide a complete overview of all economic transactions:

- Current accounts (production, income, savings)
- Capital accounts
- Balance sheets

- Focus on the institutional sector level (i.e. corporations, governments, households)
- Full suite of indicators (income, saving, investment and wealth)
- **Integrated sequence of institutional sector accounts**
  - Environmentally adjusted aggregates (depletion or degradation adjusted NDP ("green GDP")

Balance sheets

Balance sheets: record all assets and liabilities of country (by institutional sector) and changes during accounting period

- The integration of ecosystem asset -> extended measures of wealth (wealth accounting)
- Issues:
  - avoid double counting with existing values for natural resources, such as timber and fish
  - in many countries value of land already recorded on the SNA balance sheet in terms of its market price (but may not capture all ecosystem services)
  - Ecosystems that provide intermediate (or supporting services)

End of Accounts...

Questions?

Discussion

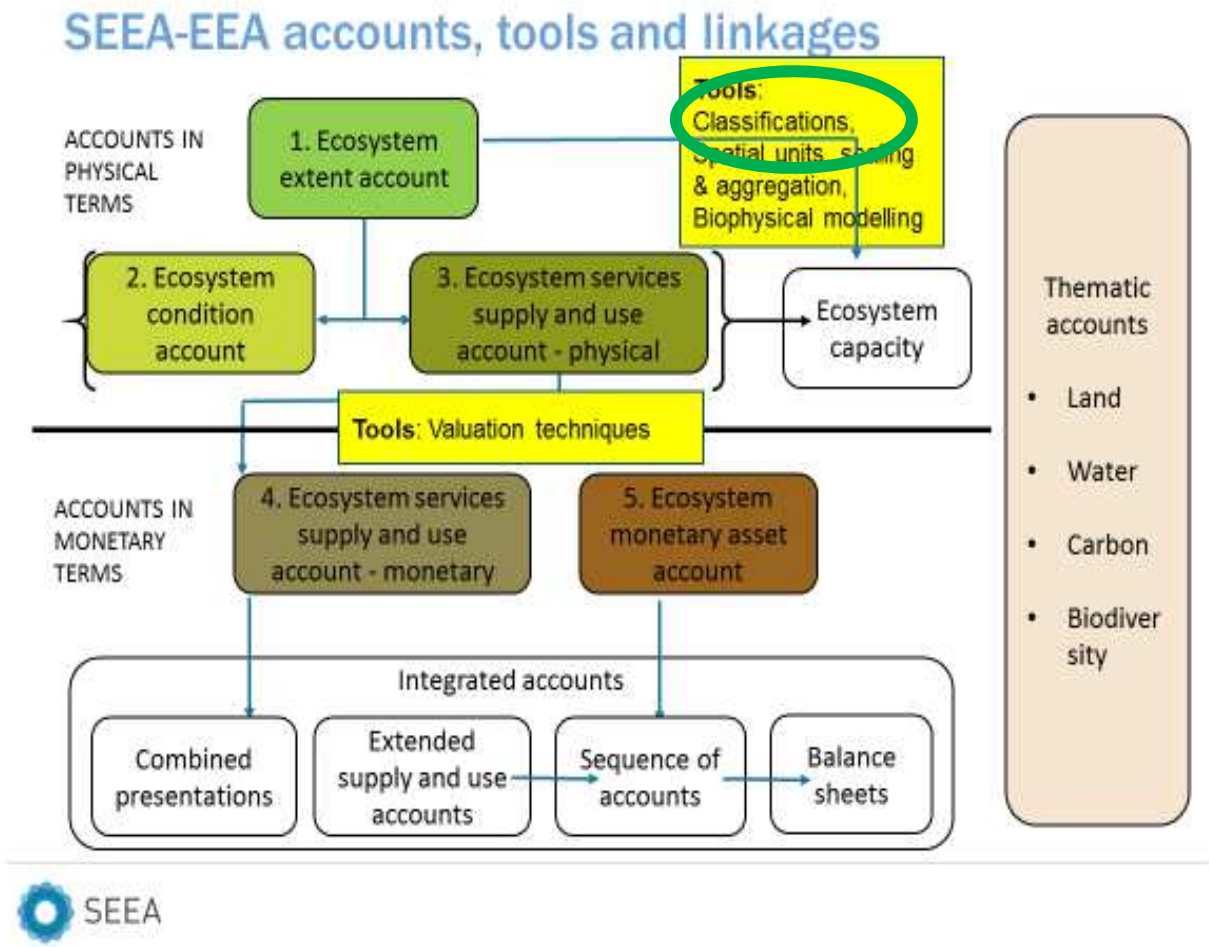
- Prepare for group exercise…think about:
  - What are your priority accounts?
  - What are the opportunities to produce them?
    - Stakeholders?
    - Institutional mechanisms?
    - Current activities?
  - What are the constraints?
    - Data?
    - Capacity?
- Next up: **Tools**

Level 0: Tools

Level 0: Tools

- Classifications
- Spatial units, scaling & aggregation
- Biophysical modelling
- Valuation
- Other tools:
  - > Statistical quality guidelines
  - > Interdisciplinary teams
  - > Case studies and surveys
- **Not discussed:** GIS (spatial analysis), data analysis, communications, engagement, data management, project planning and evaluation…

Tools 1: Classifications



Level 0: Tools 1: Classifications

- What?
  - From SEEA-CF:
    - Land cover, land use
    - Economic units, industry sectors
  - New:
    - Final ecosystem services
- Why:
  - Accounting needs **C**onsistent and **C**oherent and **C**omprehensive **C**lassifications
    - **C**onsistent: use same classification for same concept
    - **C**oherent: with other classification
    - **C**omprehensive: **C**lassifications **C**ertify **C**omplete **C**overage

Level 0: Tools 1: Classifications

Land Cover

- From SEEA-CF (p.276)
- Uses FAO LCCS 3 (Food and Agriculture Organization – Land Cover Classification System v3) definitions
- High-level aggregate
- May adapt to local situations
- Used as basis for ecosystem type

01 Artificial surfaces (including urban and associated areas)
02 Herbaceous crops
03 Woody crops
04 Multiple or layered crops
05 Grassland
06 Tree covered areas
07 Mangroves
08 Shrub covered areas
09 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

Level 0: Tools 1: Classifications

Land Use

- From SEEA-CF (p. 266)
- Detailed (4-digit level)

1.0 Land
- 1.1 Agriculture
- 1.2 Forestry
- 1.3 Aquaculture
- 1.4 Built up and related areas
- 1.5 Maintenance and restoration of environmental functions
- 1.6 Other uses of land
- 1.7 Land not in use

2.0 Inland waters
- 2.1 Aquaculture and holding facilities
- 2.2 Maintenance and restoration of environmental functions
- 2.3 Other uses of inland waters
- 2.4 Inland waters not in use

3.0 Coastal waters
- 3.1 Aquaculture and holding facilities
- 3.2 Maintenance and restoration of environmental functions
- 3.3 Other uses of coastal waters
- 3.4 Coastal waters not in use

4.0 Exclusive Economic Zone (EEZ)
- 4.1 Aquaculture and holding facilities
- 4.2 Maintenance and restoration of environmental functions
- 4.3 Other uses of coastal waters
- 4.4 Coastal waters not in use

Level 0: Tools 1: Classifications

Services

- Based on Common International Classification of Ecosystem Services (CICES)
- Not mutually exclusive
- A list of "final" services
- More detail (4-digit)
- Does not include "supporting services" (= ecosystem functions)

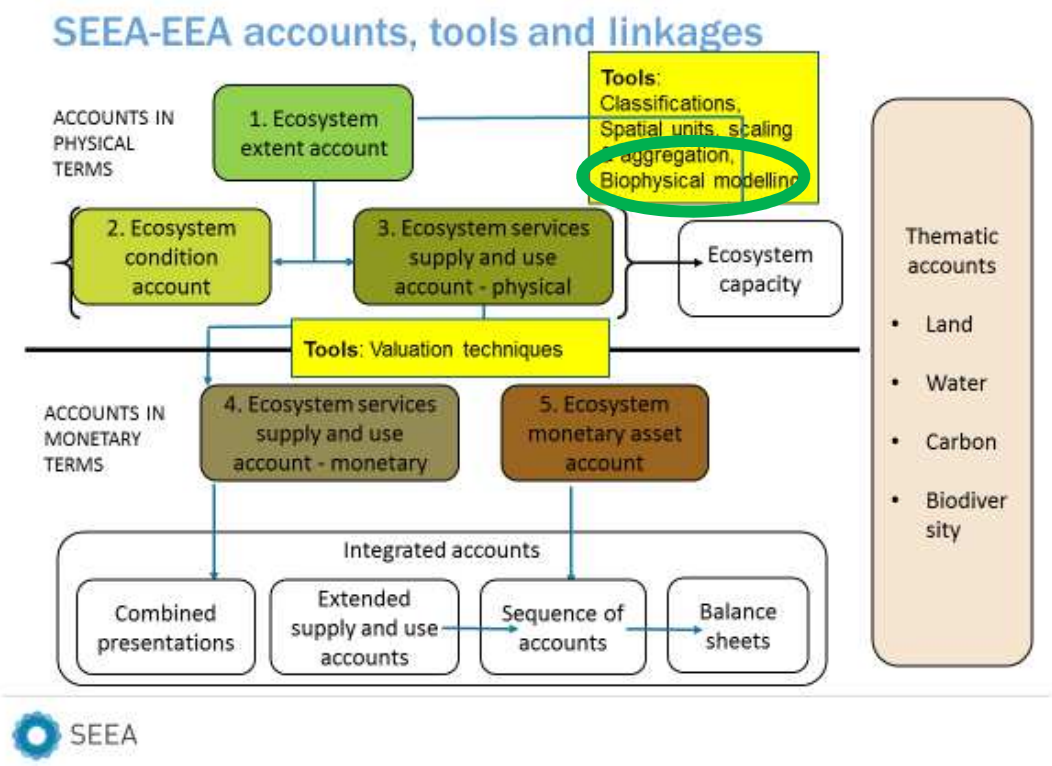
Section	Division	Group
01. Provisioning	01.01 Nutrition	01.01.01 Biomass
		01.01.02 Water
	01.02 Materials	01.02.01 Biomass
		01.02.02 Water
	01.03 Energy	01.03.01 Biomass-based energy sources
		01.03.02 Mechanical energy
02. Regulation & Maintenance	02.01 Mediation of waste, toxics and other nuisances	02.01.01 Mediation by biota
		02.01.02 Mediation by ecosystems
	02.02 Mediation of flows	02.02.01 Mass flows
		02.02.02 Liquid flows
		02.02.03 Gaseous / air flows
	02.03 Maintenance of physical, chemical, biological conditions	02.03.01 Lifecycle maintenance, habitat and gene pool protection
		02.03.02 Pest and disease control
		02.03.03 Soil formation and composition
		02.03.04 Water conditions
		02.03.05 Atmospheric composition and climate regulation
03. Cultural	03.01 Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	03.01.01 Physical and experiential interactions
		03.01.02 Intellectual and representative interactions
	03.02 Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	03.02.01 Spiritual and/or emblematic
		03.02.02 Other cultural outputs

Level 0: Tools 1: Classifications

- From SEEA-CF: Economic Units
  - Enterprises (business ◎ industry)
  - Households (people and non-corporate business)
  - Government
  - Rest of the world

- SEEA-EEA adds a spatial dimension:
  - Local
  - Regional
  - National
  - Global

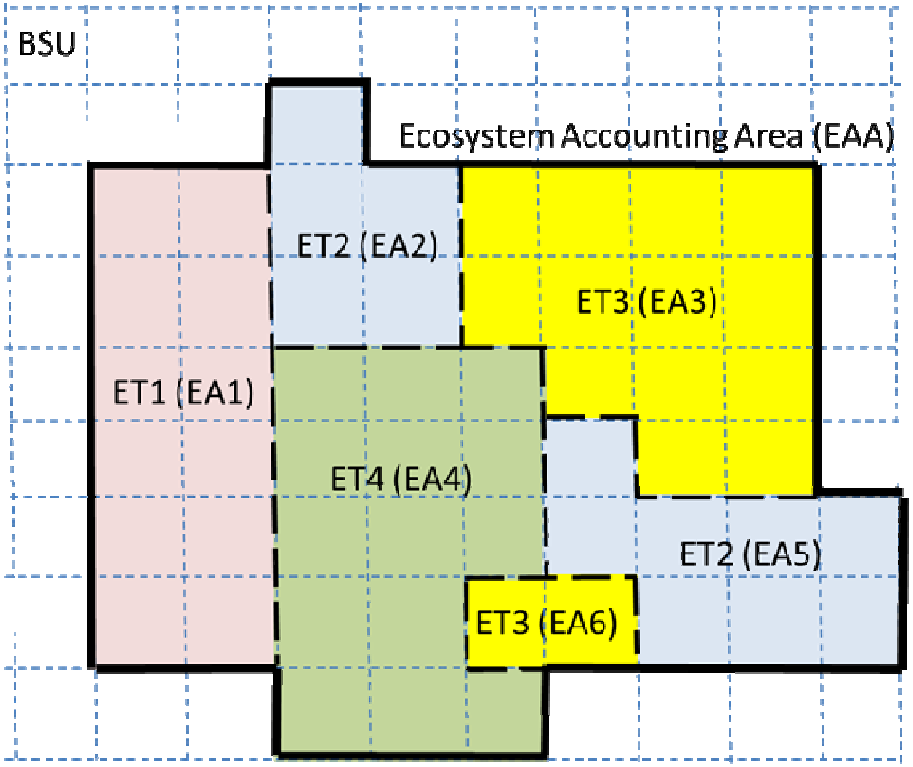
Tools 2 : Spatial Units



Level 0: Tools 2: Spatial units

- **What?**
  - A common definition of Spatial Units for all accounts
- **Why?**
  - Accounting needs **statistical units** about which information is compiled, derived, reported and compared
    - e.g., business statistics are built on locations, establishments, companies and enterprises
  - Information is collected on many **spatial levels**
    - Needs to be consolidated within a GIS or spatial model
  - First step in **tabulating & aggregating** more detailed data
    - Not everybody is a GIS expert
  - Links accounts together:
    - (**Extent, Condition, Services Supply…**)

Level 0: Tools 2: Spatial units



4 types of units

-Basic spatial units (BSU)

-Ecosystem asset (EA)

-Ecosystem type (ET)

-Ecosystem Accounting Area (EAA)

Level 0: Tools 2: Scaling

- **What?**
  - Converting information from one scale to another (spatial, temporal, thematic)
- **Why?**
  - Information exists in various types:
    - Point (water quality monitoring, "study sites", etc.)
    - Area (land cover, protected area, species range, etc.)
    - Network (roads, streams, corridors, etc.)
  - Need to understand how and when to attribute information from one scale to another

Level 0: Tools 2: Scaling

- **Main approaches**
  - > **Downscaling**
    - Attributing information from larger areas to smaller areas contained within them
    - **Caution**: Data need to be evenly distributed
  - > **Upscaling**
    - Attributing information from smaller areas to larger areas
    - **Caution**: Data need to be representative
  - > **Transfer**
    - Transferring information measured in one location to another
    - Often used in terms of **Benefits Transfer**
    - **Caution**: Locations need to be very similar

Level 0: Tools 2: Aggregation

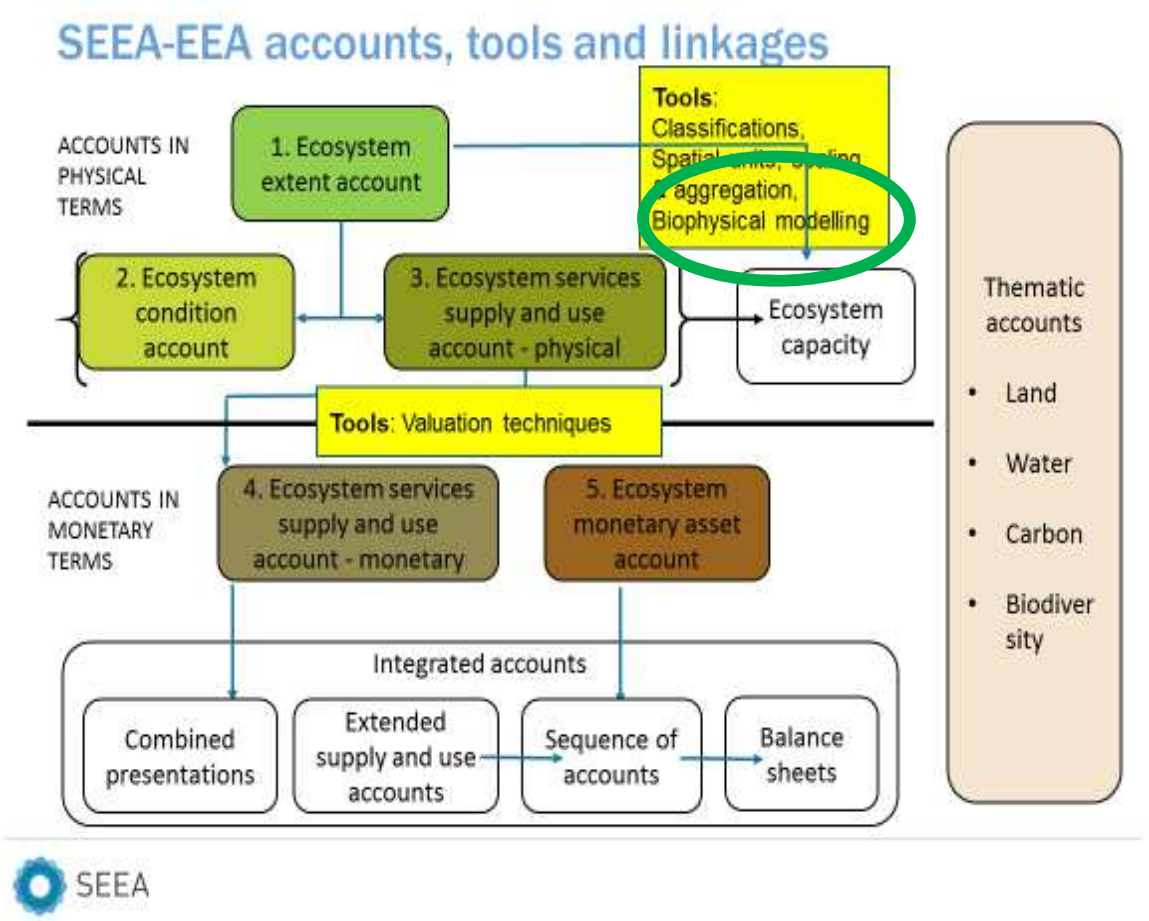
- **What?**
  - Combining many measures into simpler ones
  - Dissimilar measures may be aggregated using:
    - Indices (e.g., water quality index)
    - Conversion to common units (e.g., CO_2 equivalents)
- **Why?**
  - Accounting requires **aggregates** (of dollars, business types, sub-populations, regional summaries, national indicators…)
  - Summary indicators for dashboards, linking to economic accounts

Level 0: Tools 2: Aggregation

- **Aggregating dissimilar biophysical measures:**
  - > Requires indexing (comparison with reference)
  - > Example: ecosystem condition measures, service measures
  - > **Caution**: Requires understanding of relative importance of component measures (weighting)
- **Final aggregates**
  - > e.g., total value of ecosystem services, total asset value
  - > Require many assumptions (relative importance, methods…)
  - > Services can be competing, complementary or independent
  - > **Caution**: Monetary valuation is often applied inappropriately

  → **Valuation** results can be misleading

Tools 3: Biophysical modelling



Level 0: Tools 3: Biophysical modelling

- **What?**
  - > Four main approaches:

1. Look-up tables
2. Statistical approaches
3. Geostatistical interpolation
4. Process-based modelling

- **Why?**
  - > Estimate **Ecosystem Services** across spatial units and time
  - > Estimate **Ecosystem Capacity** from **Ecosystem Condition**
  - > Combine data from various sources and scales (e.g., point field data and satellite data)
  - > Estimate unknown data values
  - > GIS-based spatial modelling approaches have methods built-in

Level 0: Tools 3: Biophysical modelling

- **Approaches**:
  1. **Look-up tables**
  2. Statistical approaches
  3. Geostatistical interpolation
  4. Process-based modeling

Attribute values for an ecosystem service (or other measure) to every **Spatial Unit** in the same class (e.g., a land cover class).

- Example: **Benefits Transfer**
- *one ha of forest = $5000 → attribute to each ha of forest*
- error rate: 60-70%

Level 0: Tools 3: Biophysical modelling

- **Approaches**:
  1. Look-up tables
  2. **Statistical approaches** →
  3. Geostatistical interpolation
  4. Process-based modeling

Estimate ecosystem services, asset or condition based on known explanatory variables such as soils, land cover, climate, distance from a road, etc., using a statistical relation.

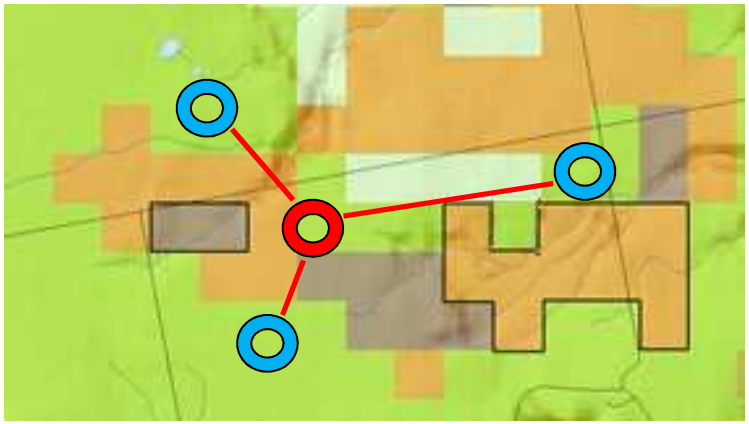
- Example: **Function Transfer**
- *Value = f(land cover, population, roads, climate)*
- Error rate = 40-50%

Level 0: Tools 3: Biophysical modelling

- **Approaches**:
  1. Look-up tables
  2. Statistical approaches
  3. **Geostatistical interpolation**
  4. Process-based modeling

Use algorithms to predict the measure of unknown locations on the basis of measures of nearby known measures:

- Example: **Kriging**
- Error rate = ?



Unknown

Known

Level 0: Tools 3: Biophysical modelling

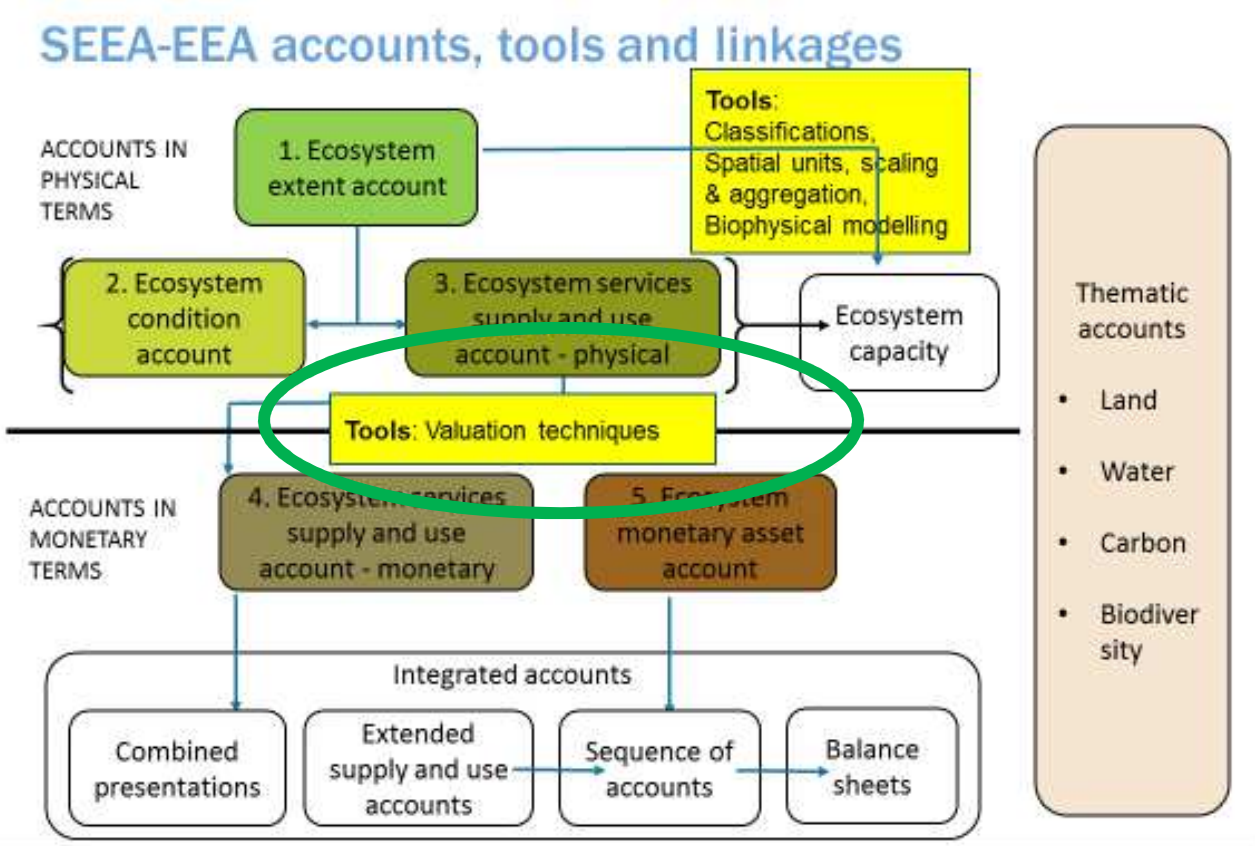
- **Approaches**:
  1. Look-up tables
  2. Statistical approaches
  3. Geostatistical interpolation
  4. **Process-based modeling**

Predict ecosystem services based on a set of future condition or management scenarios:

- Example: Scenario for future services based on expected changes in land cover, demand and management
- Error rate = 100%

Level 0: Valuation

Tools 4: Valuation



Level 0: Tools 4: Valuation

- **Why value?**
  - > To integrate environmental issues in economic decision making and development planning
- **Valuation is fit for purpose:**
  - > Different contexts require different value concepts
- Assessment of welfare:
  - > E.g. cost benefit analysis, focus on utility
- Assessment of economic activity:
  - > E.g. National accounts, focus on exchange value
- Other notions of value:
  - > Intrinsic value
  - > Critical value / strong sustainability

LETTERS

edited by Jennifer Sills

Ecosystem Services: Accounting Standards

IN THEIR RESEARCH ARTICLE "BRINGING ECOSYSTEM SERVICES INTO ECONOMIC DECISION making: Land use in the United Kingdom" (5 July, p. 45), I. J. Bateman *et al.* demonstrate the importance of considering nonmarket ecosystem services in economic decision-making. It is an excellent example of the potential for national-level spatial analysis of economic and environmental information to inform policy choices.

The drive to connect economic and environmental information mirrors the ongoing developments in environmental-economic accounting. Over the past 6 years, the international statistics community has led work to finalize an international standard—the UN System of Environmental-Economic Accounting (SEEA) (*1*)—and to place the measurement of ecosystem services and ecosystem condition into a national accounting context (*2*). The development of these statistical frameworks provides the basis for compiling internationally comparable data sets at a national level on the relationship between the environment and economic activity.

Despite their common motivations, the approaches of Bateman *et al.* and the SEEA differ in the ways that they assign value to ecosystem services. Bateman *et al.* ground their analysis in welfare changes as a consequence of specific policy scenarios. The SEEA approach aims to record the "output" generated by ecosystems, given current uses of ecosystem capital; thus, monetary values represent exchange values consistent with the principles of national accounting.

The SEEA approach provides a way to place welfare-based estimates in a broader context. According to Bateman *et al.*, the maximization of all monetary values leads to an increase of £19,606 million per year with a loss of £448 million in agricultural output [Table 3 in (*3*)]. This loss equates to just over 2% of current UK agricultural output, and the overall impact of including nonmarket services as a proportion of GDP is an additional 1.3% (*3*).

However, there are some important differences between the definitions of economic activity used by Bateman *et al.* and standard national accounting, which may limit the interpretation of such comparisons. By integrating estimates of ecosystem services within the framework of accepted economic data, the SEEA approach can provide additional impetus to mainstream these types of studies.

Therefore, in addition to the calls by Bateman *et al.* to ensure the use of additional information on ecosystem services within standard decision-making, we call for investment to improve the quality of the underlying data within a widely accepted and integrated measurement framework such as the SEEA. The availability of quality data is an important precondition to analysis that should not be overlooked.

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Level 0: Tools 4: Valuation

Object of valuation, what do we value?

Stocks and flows: natural capital conceived as asset (stock) that provides a basket of services (flows)

- Ecosystem services
  - > Flows: during the year
- Ecosystem capital
  - > Assets: value at beginning/end of year and changes therein
- Degradation of ecosystems
  - > The decline in the condition of ecosystem assets as a result of economic and other human activity.

Level 0: Tools 4: Valuation

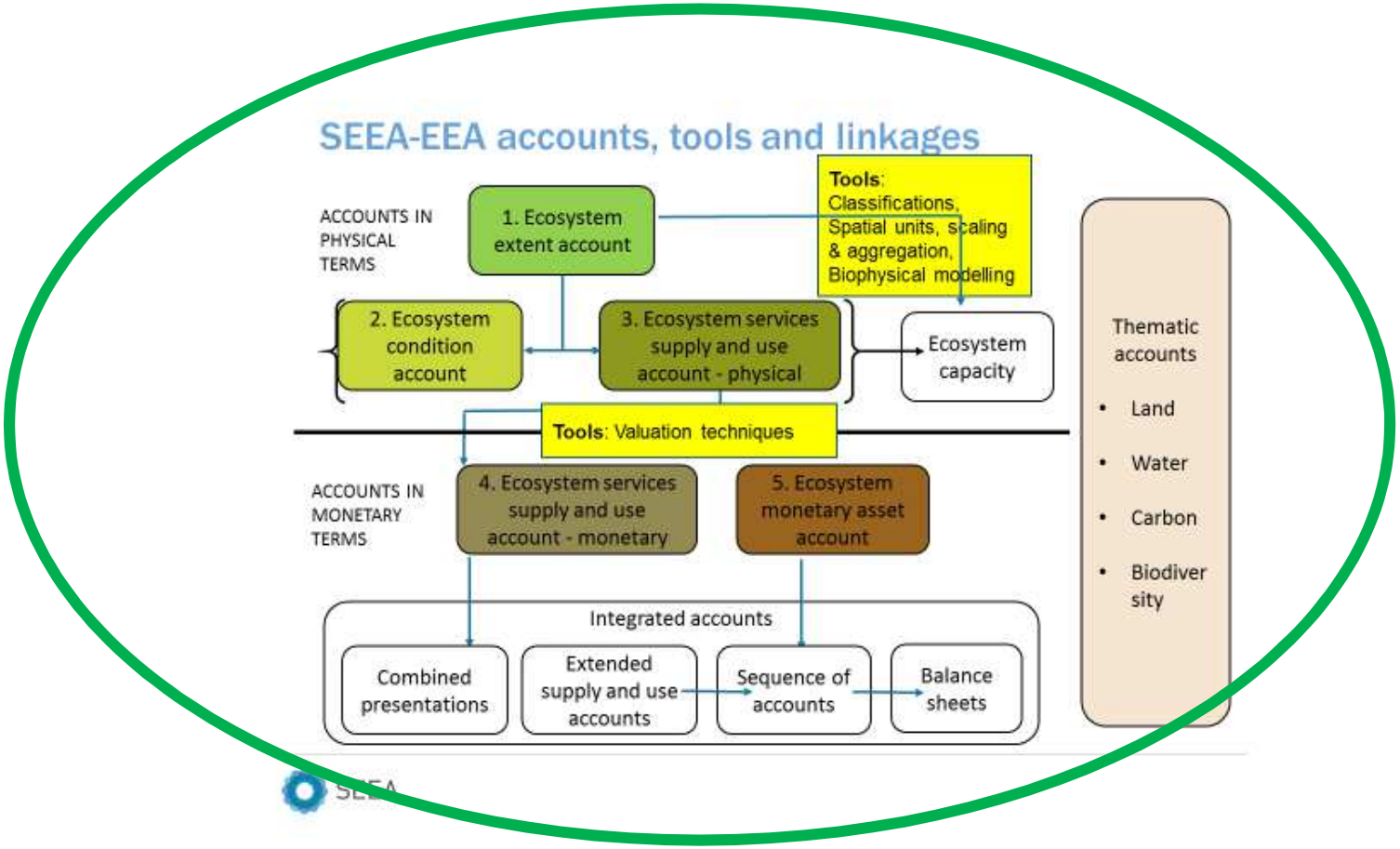
How do we value?

- Range of valuation techniques exist
- SEEA EEA is multipurpose system that does not rule out a priori any techniques, BUT advocates consistency when integrating with existing values
- National accounts is a transaction based system:
  - > SUPPLY = USE
  - > Rules out consumer surplus and externalities
- When integrating into national accounts -> estimating exchange values

Level 0: Tools 4: Valuation

- **Measurement challenges**
  - > More challenging for Regulating and Cultural Services
  - > How to measure monetary value of regulating services?
    - Spatial dependencies (downstream, species/habitat)
    - Multiple beneficiaries
    - Risks (e.g., flood control, climate regulation)
  - > Non-linear responses
    - Thresholds/resilience, climate change, refuge areas
  - > Aggregating values of different services
    - Services can be competing, complementary or independent
  - > Transferring measured values from one site to another
    - (Discussed under **Biophysical Modelling** & **Scaling**)

Tools 5: Other tools



Level 0: Tools 5: Other tools

- **What?**
  - > Statistical **quality guidelines**
- **Why?**
  - > Need a common concept of quality, uncertainty and "fitness for use"
- **How?**
  - > Apply national or international guidelines
    - UN National Quality Assurance Framework (NQAF)
    - International Monetary Fund – Data Quality Assessment Framework (IMF-DQAF)
    - Disciplinary "accepted methods" are less-well documented
  - > Build a culture of quality:
    - Metadata, process documentation, strategic planning…
  - > Work within accepted statistical processes (e.g., Generic Statistical Business Processing Model – GSBPM)

Level 0: Tools 5: Other tools

- **What?**
  - > **Interdisciplinary teams** (ecology, economic, geography, policy, sociology, statistics…)
- **Why?**
  - > **No single** discipline can do it alone
    - → Need a shared "language"
    - → Need to become **transdisciplinary**
- **How?**
  - > Agree on common objectives and approaches
  - > Work together to avoid disciplinary "stovepipes"
  - > Engage experts, data providers, users and supporters

Level 0: Tools 5: Other tools

- **What?**
  - **Case studies & surveys** linking services with benefits
- **Why?**
  - In some countries, there is a close relationship between ecosystem services and poverty, water security, food security, employment…
  - Link ecosystem condition, services with socio-economic priorities (well-being, health, income, employment…)
- **How?**
  - Local surveys for priority stakeholders (e.g., dependent on ecosystem services)
  - National sample surveys (e.g., water use, importance of nature, expenditures on environmental protection…)

References

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