Ecosystem Services

Presentation of the concept and current challenges

PhD Shool Ecosystem Services assessment in agricultural and peri-urban areas – April 11 2023

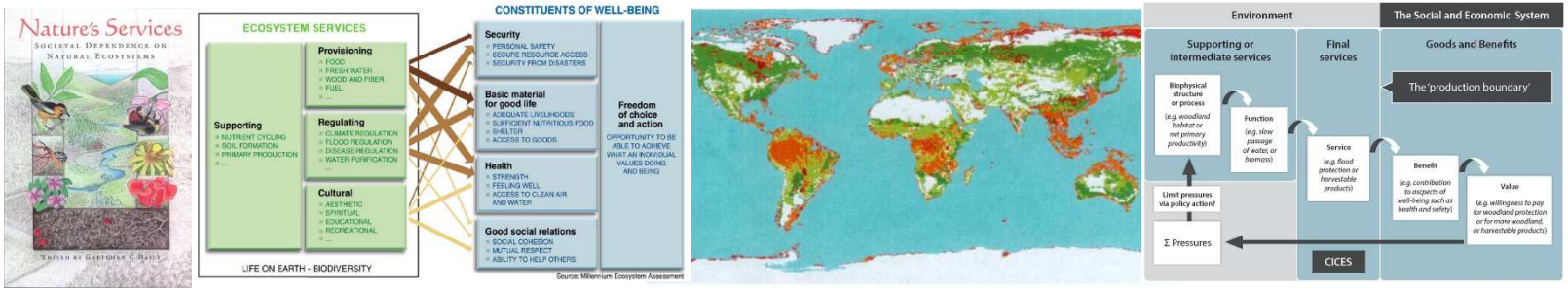
Ecosystem Services: a « magic » concept

- to recognize and value the dependency of human well-being on ecosystems
- for natural, managed, or strongly artificialized terrestrial or aquatic ecosystems
- from global to local levels
- To raise awareness, monitor and manage ecosystems or design and assess public policies

⇒ A “magic” concept used in numerous sciences including ecology, agronomy, forestry, water and marine sciences, land planning and management, economics, political sciences,…

⇒ What practical reality behind a (new) concept with such great ambitions ?

Outline



1- A brief history of ecosystem services

2- Definition of Ecosystem Services

3. Classification of Ecosystems Services

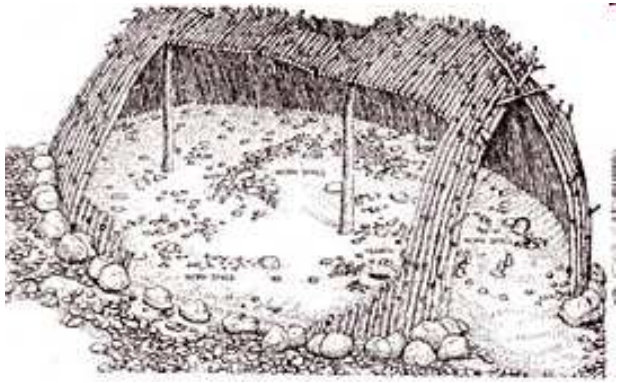
4. The three components of the delivery process

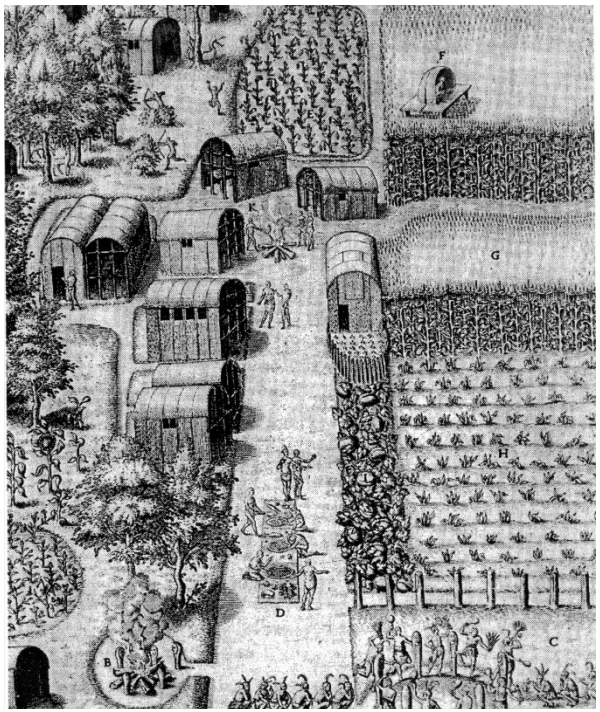
5. From theory to practice: ES metrics

6. Concluding remarks

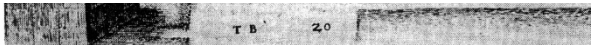
Ecosystem Services: An old concept

- The dependency of human well-being on ecosystems …
- … an idea as old as humanity itself, which depends on ecosystems for food, shelters or tools

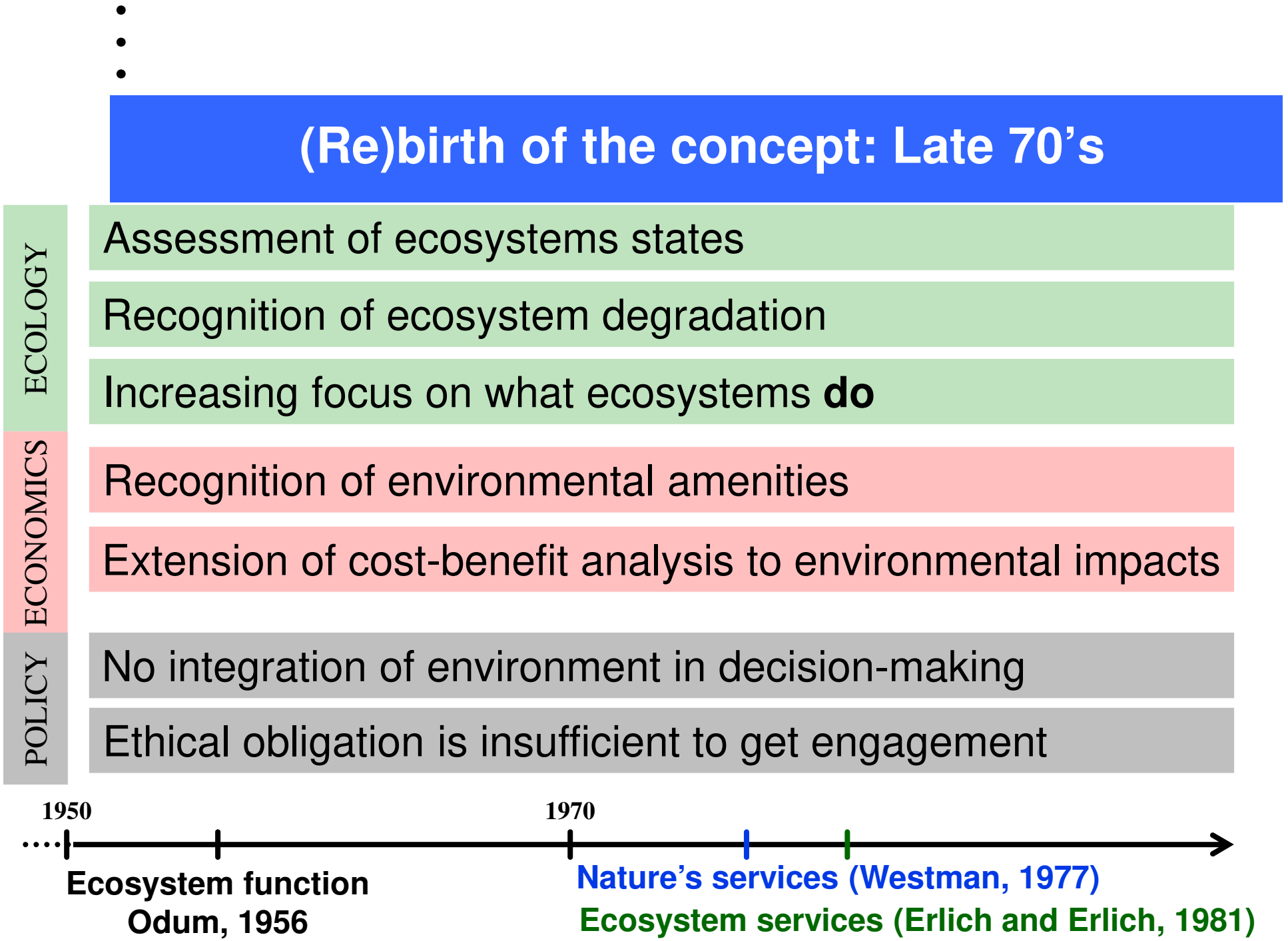




- Not an issue as long as natural resources are not limited



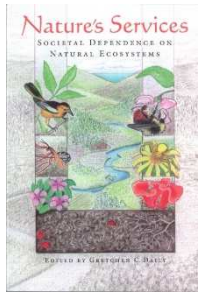
Gomez-Baggethun *et al.,* 2010; Baveye et al., 2016


(Re)birth of the concept: Late 70's
ECOLOGY
Assessment of ecosystems states
Recognition of ecosystem degradation
Increasing focus on what ecosystems do
ECONOMICS
Recognition of environmental amenities
Extension of cost-benefit analysis to environmental impacts
POLICY
No integration of environment in decision-making
Ethical obligation is insufficient to get engagement
1950
1970
Ecosystem function
Odum, 1956
Nature's services (Westman, 1977)
Ecosystem services (Erlich and Erlich, 1981)

Gestation: 1980 - 1997

The ecological economics gambles :

- Integrate ecology and economics
- Use dominant political and economic views to influence decision-making on ecosystem conservation
  - Develop an utilitarian framing of ecological functions
  - Develop the monetary valuation of ecosystems



Daily, 1997. Nature's services
A consistent description of the links between nature and society

1980 — 1997

Costanza et al, 1997
A first valuation of the world's ecosystem services

Gomez-Baggethun *et al.*, 2010; Chaudhary *et al.*, 2015

Mainstreaming and institutionnalisation: 2000s

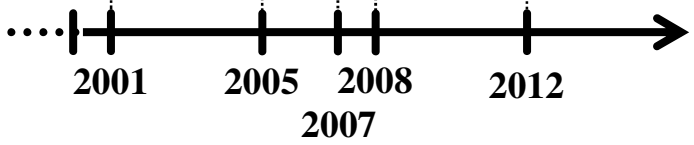
Launch of the Millenium Ecosystem Assessment (MEA - multilateral)

Publication of the MEA report

The Economics of Ecosystem and Biodiversity (TEEB) – G8 + 5

Ecosystem Services Partnership (ESP) – a worldwide network to enhance the science, policy and practice of ES

Intergovernmental Science-Policy Platform on biodiversity and Ecosystem Services (IPBES)



Gomez-Baggethun *et al.*, 2010; Chaudhary *et al.*, 2015

A Success story

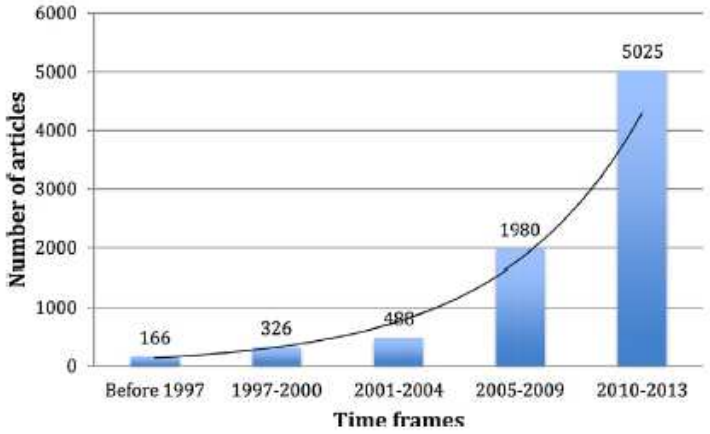


Fig. 2. An indicative figure showing growth of articles, identified analyzing 7985 articles in *Scopus*.

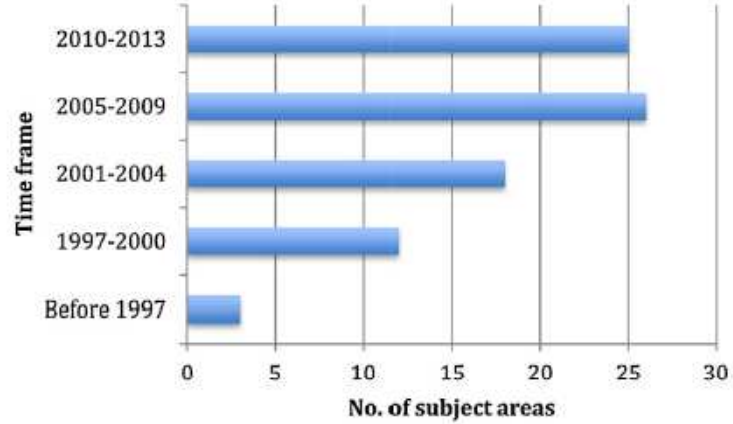


Fig. 3. An indicative figure showing broadening of subject areas, identified analyzing 519 articles through *Google Scholar*.

Chaudhary et al., 2015

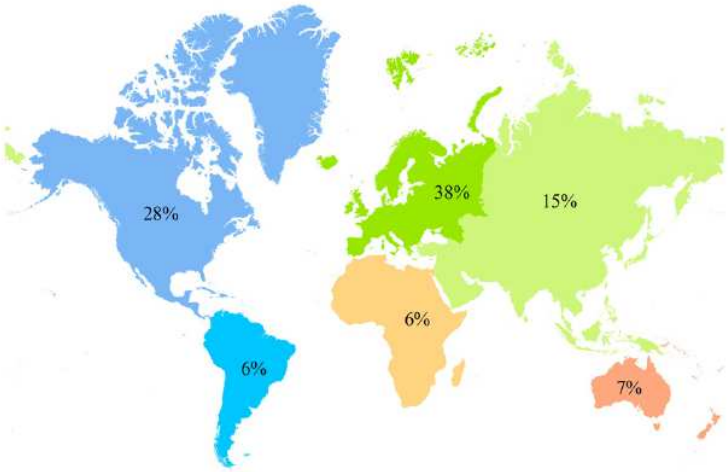


Fig. 4. Studies on ecosystem services by continents (based on papers published from 1990 to 2014).

Adhikari and Hartemink, 2016

- From confidential to common topic
- Interest largely beyond ecology and economics
- Embrace all parts of the world
- Still dominated by most advanced countries and economic and ecological originators

From an educational to a political use of the ES concept

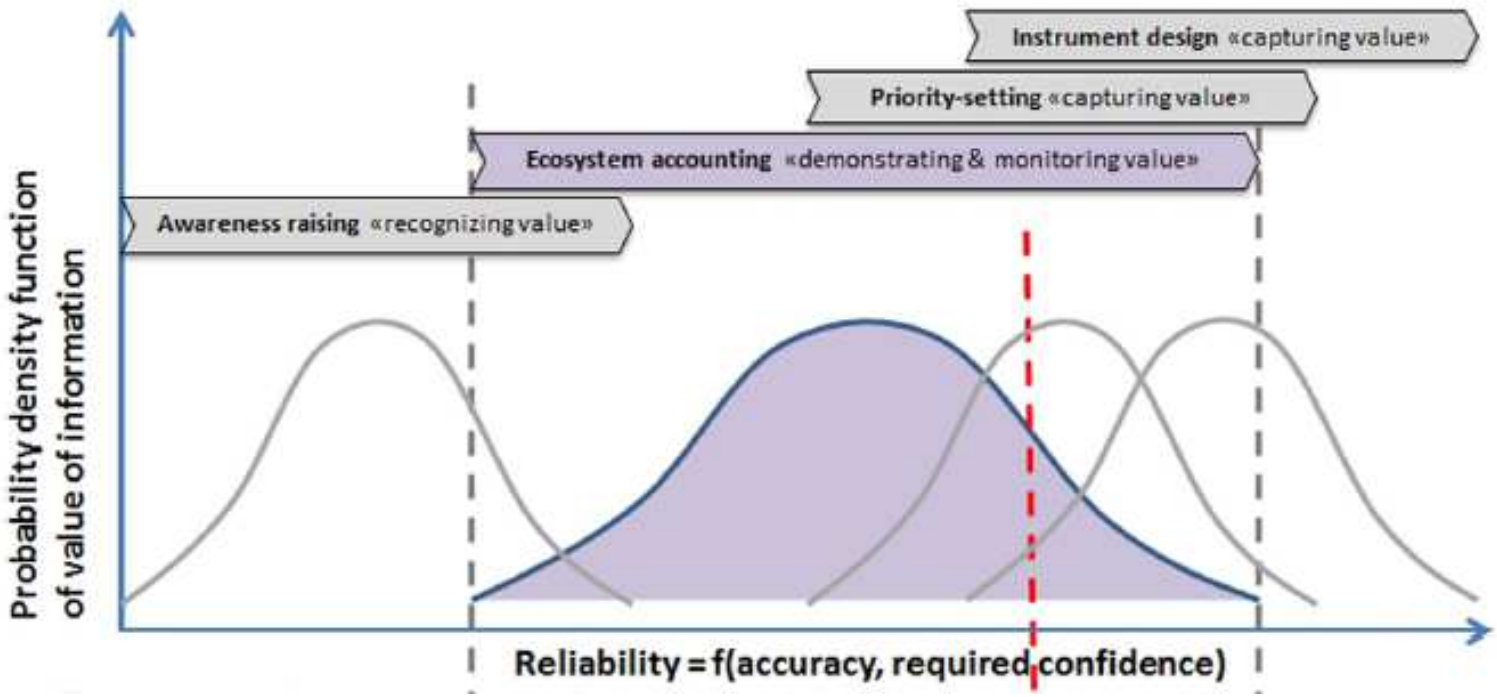
The explosion of interest in the ES concept resulted in an increasing diversity of uses

- Educational ⇒ raising awareness on the dependency of society on ecosystems conditions
- Heuristic ⇒ better understanding of the link between eco- and socio-systems

  ⇒ monitoring changes in ecosystems
- Political ⇒ helping decision-making

  ⇒ designing and assessing policies and their impacts

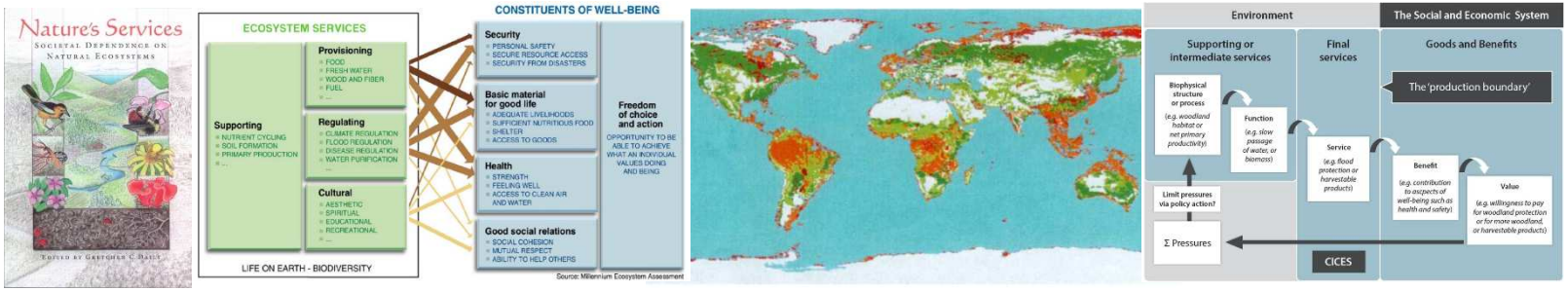
Various uses for various needs



Various uses of the ES concept and increasing demand for reliability. Adapted from (Schröter *et al.*, 2015).

- A concept that has demonstrated its effectiveness in raising awareness
- Is it mature enough for more complex uses ?

Outline



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Definition of ecosystem services

Definition of ecosystem services
..."the benefits human populations derive, directly or indirectly, from ecosystem functions."
..."the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life."
..."the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly."
..."the set of ecosystem functions that is useful to humans."
..."the benefits people obtain from ecosystems."
..."components of nature, directly enjoyed, consumed, or used to yield human well-being."
..."the aspects of ecosystems utilized (actively or passively) to produce human well-being."
..."a range of goods and services generated by ecosystems that are important for human well-being."
..."Benefits that humans recognize as obtained from ecosystems that support, directly or indirectly, their survival and quality of life."
..."a collective term for the goods and services produced by ecosystems that benefit humankind."

- Numerous definitions of the ES concept based on a large diversity of terms

Nahlik *et al.*, 2012

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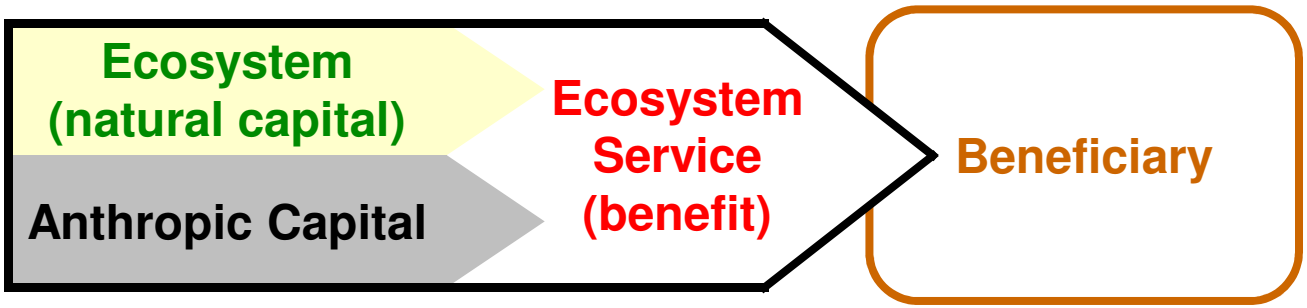
- Numerous definitions of the ES concept based on a large diversity of terms
- Two main philosophies

Nahlik *et al.*, 2012

Definition of ecosystem services

- First family of definition

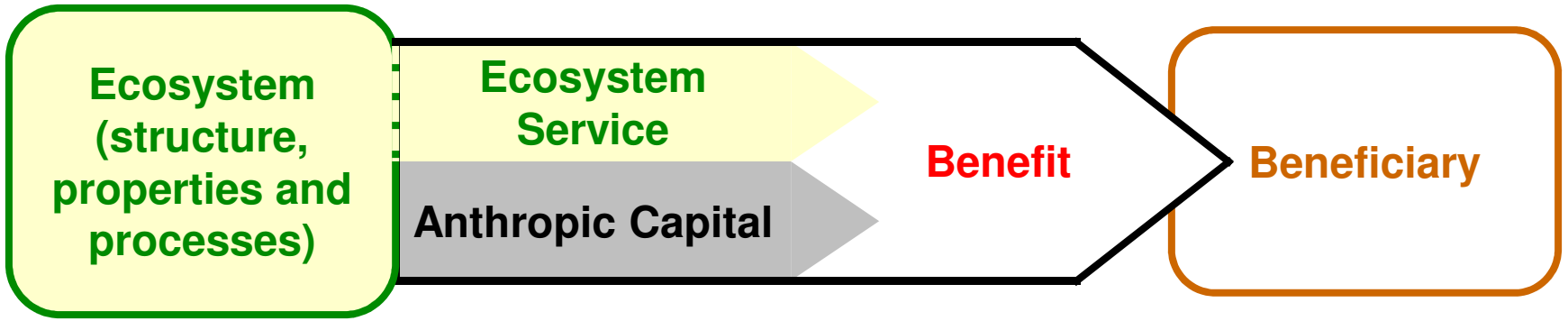


⇒ ES are part of the **socio-ecological domain** and are the **co-product** of the natural and the built, human and social capitals

Adapted from Remme *et al.*, 2014 and Therond *et al.*, 2018

Definition of ecosystem services

- Second family of definition

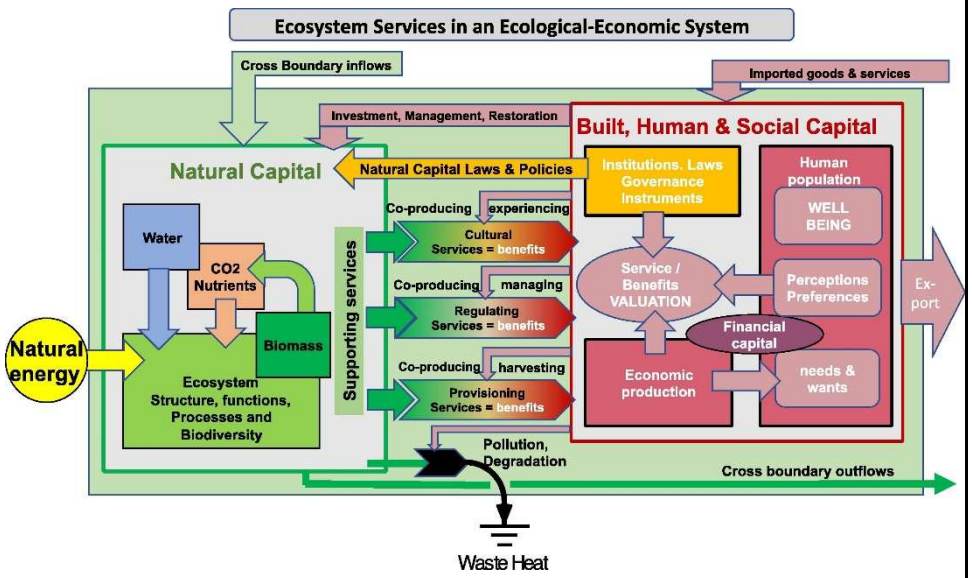


⇒ ES are part of the **ecological domain** and **produced** benefits in combination with the built, human and social capitals

Adapted from Remme *et al.*, 2014 and Therond *et al.*, 2018

Definition, conceptualisation and measure

ES as co-product of natural and anthropic capitals

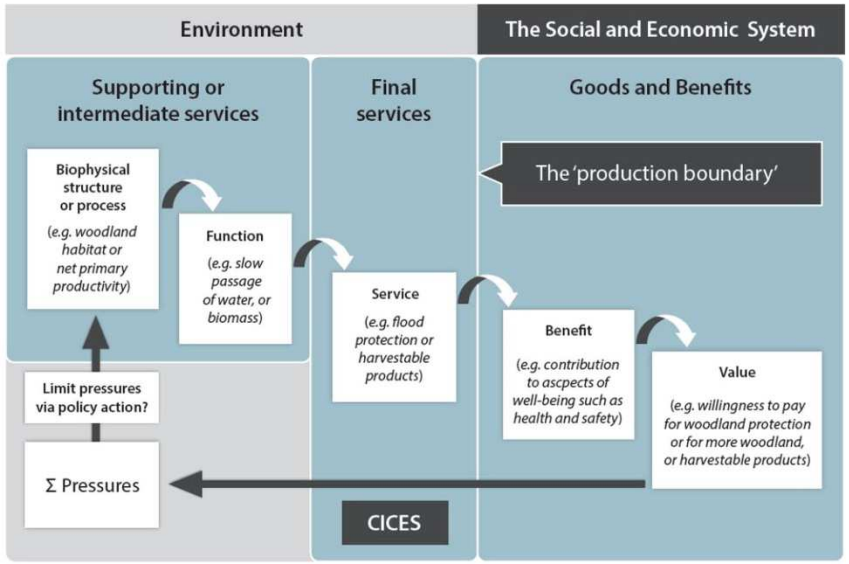


Biomass prod. Yields

Cultivated lands High

Costanza *et al.*, 2017

ES as product of natural capital

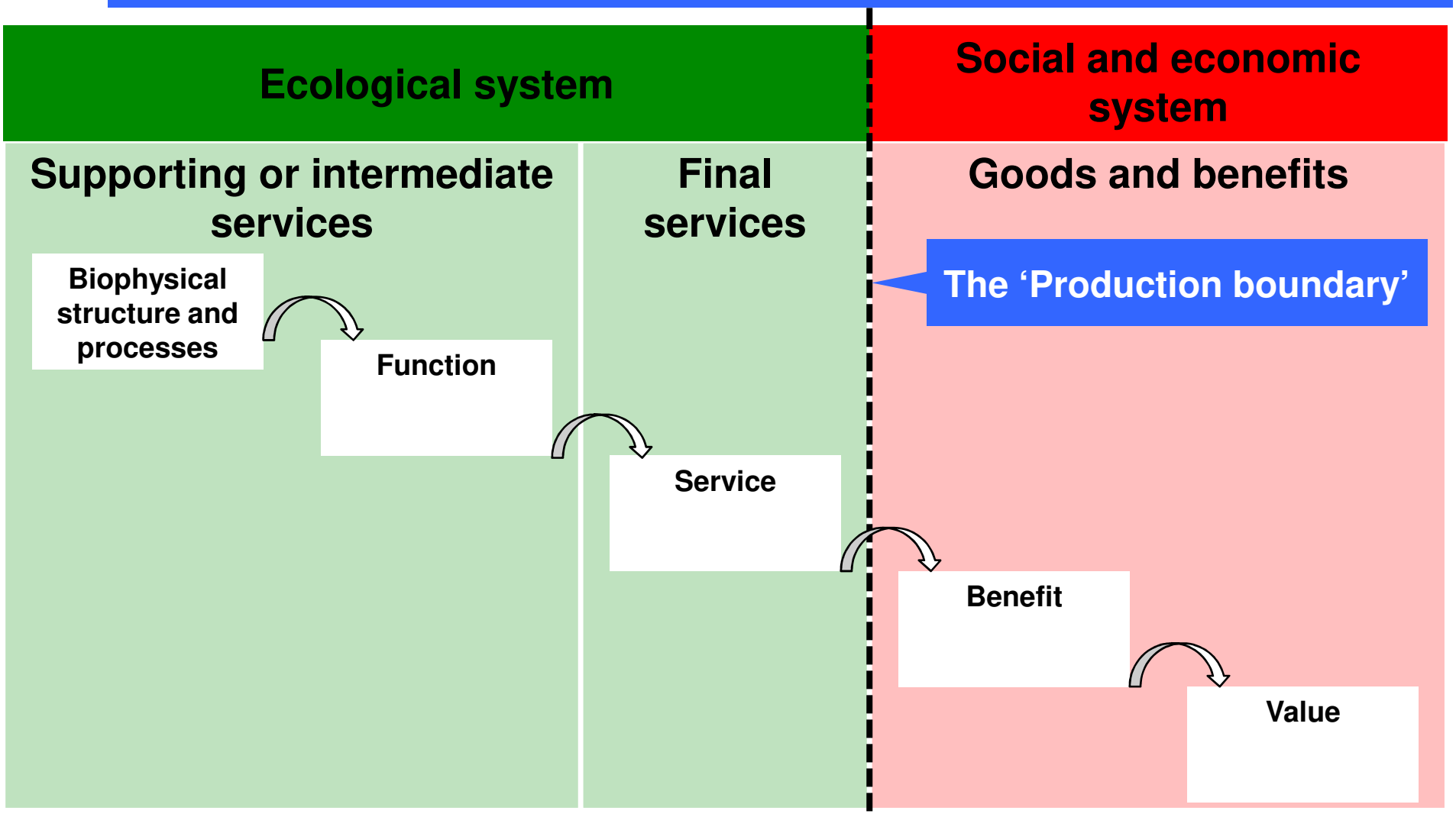


Contribution of natural capital and processes to yields

Variable

Potschin-Young *et al.*, 2018

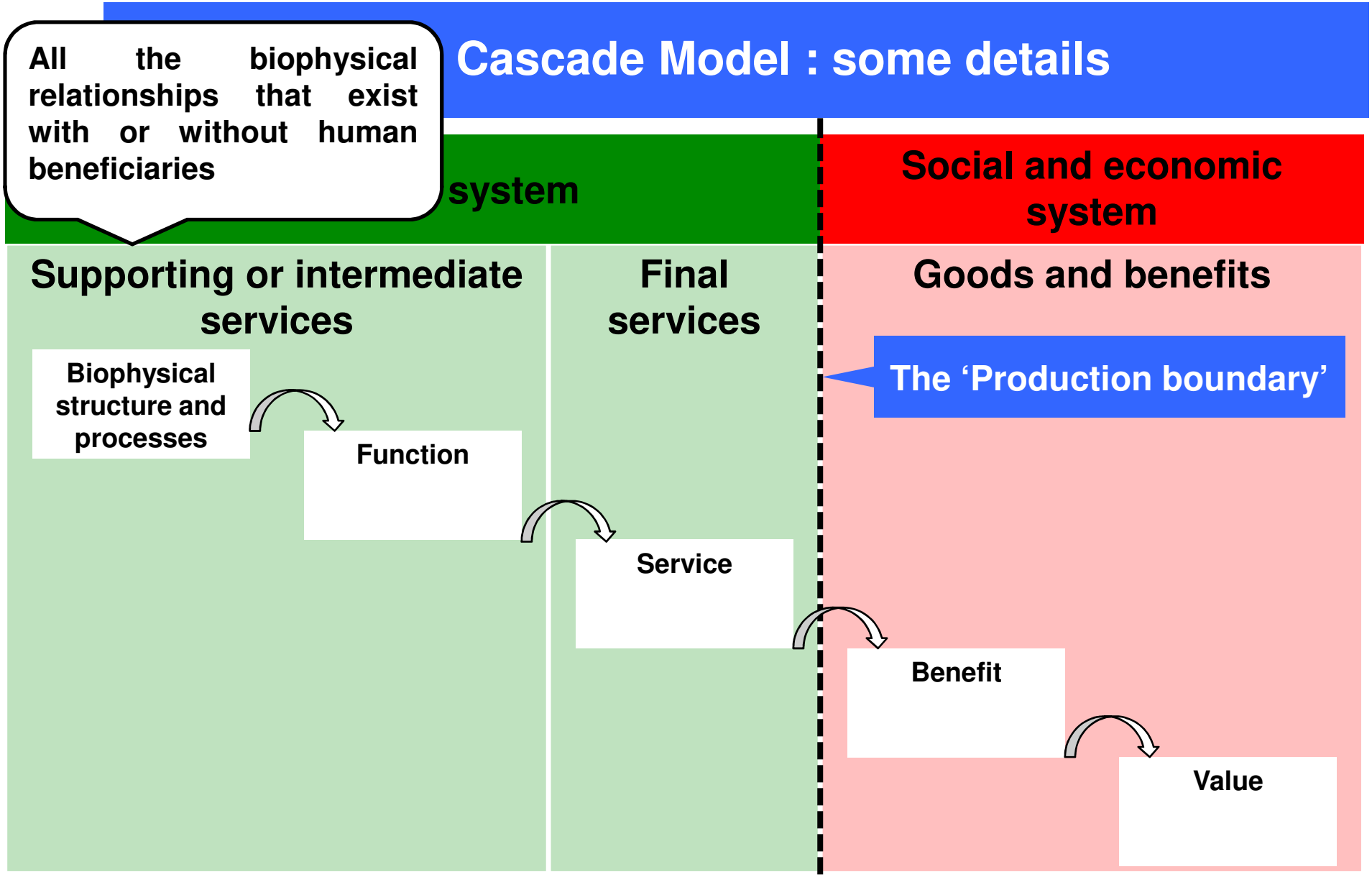
The Cascade Model : First look



Adapted from Haines-Young and Potschin 2010; de Groot *et al.*, 2010; Potschin-Young *et al.*, 2018

Cascade Model : some details

All the biophysical relationships that exist with or without human beneficiaries



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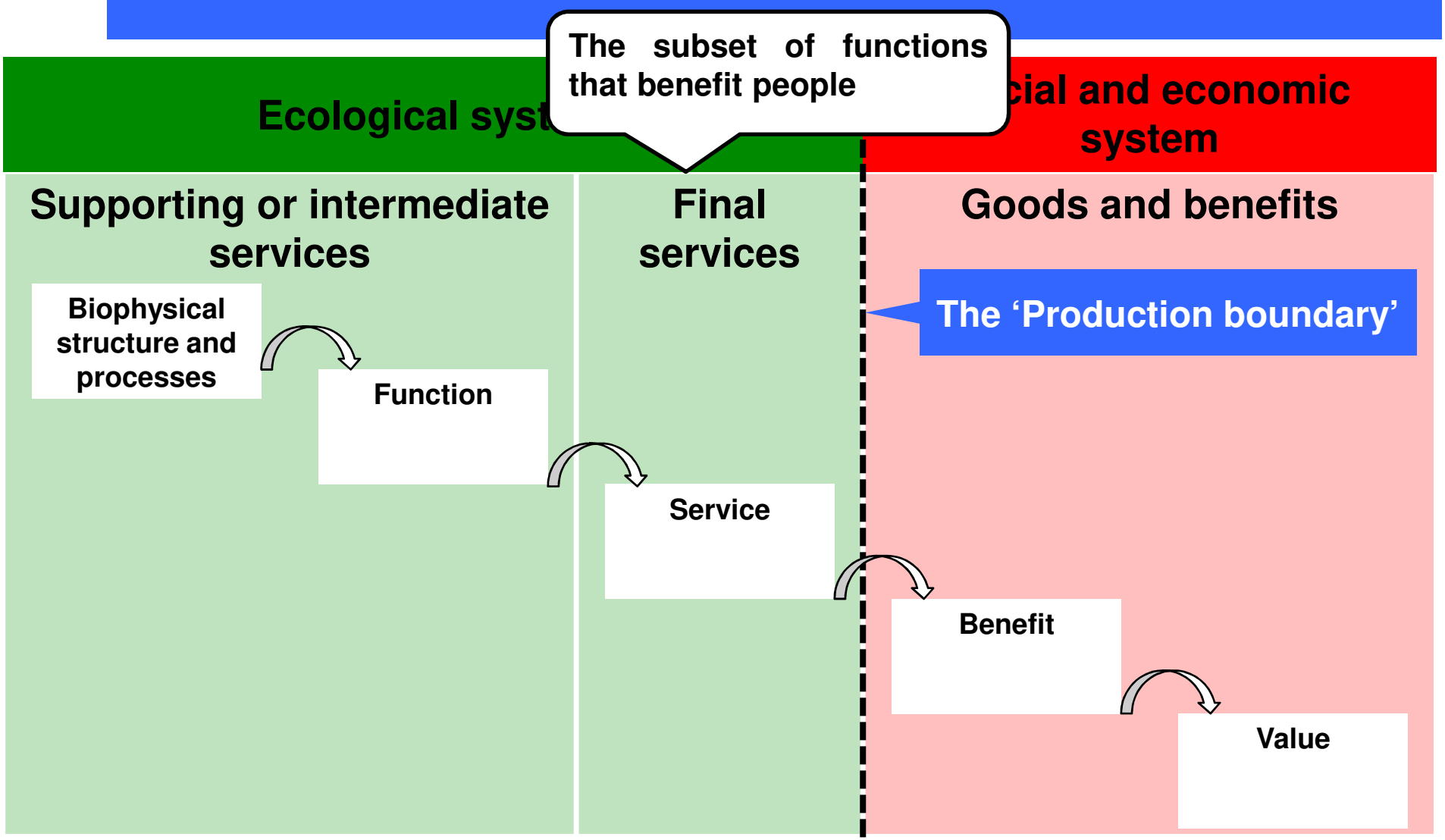
The Cascade Model: some details



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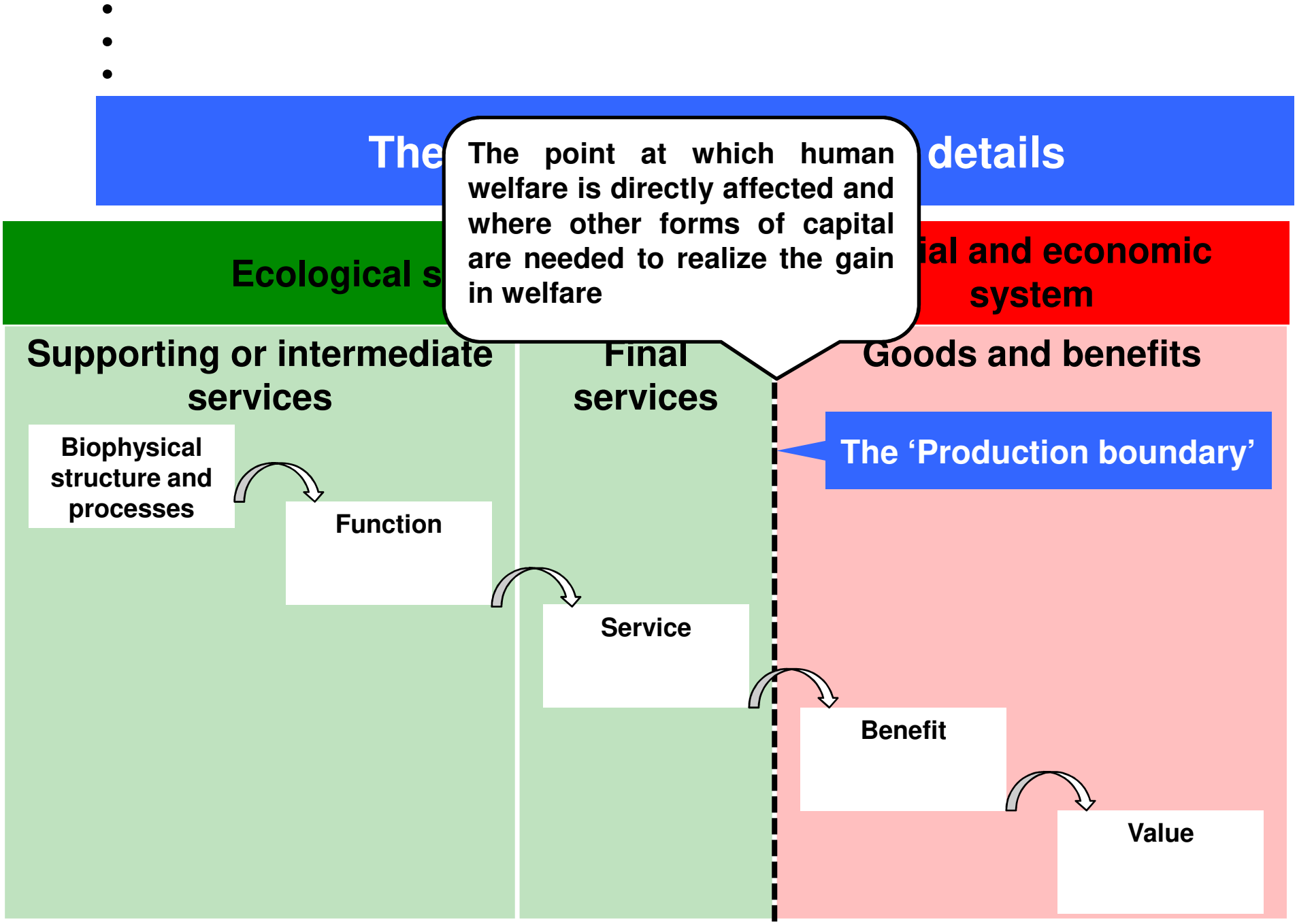

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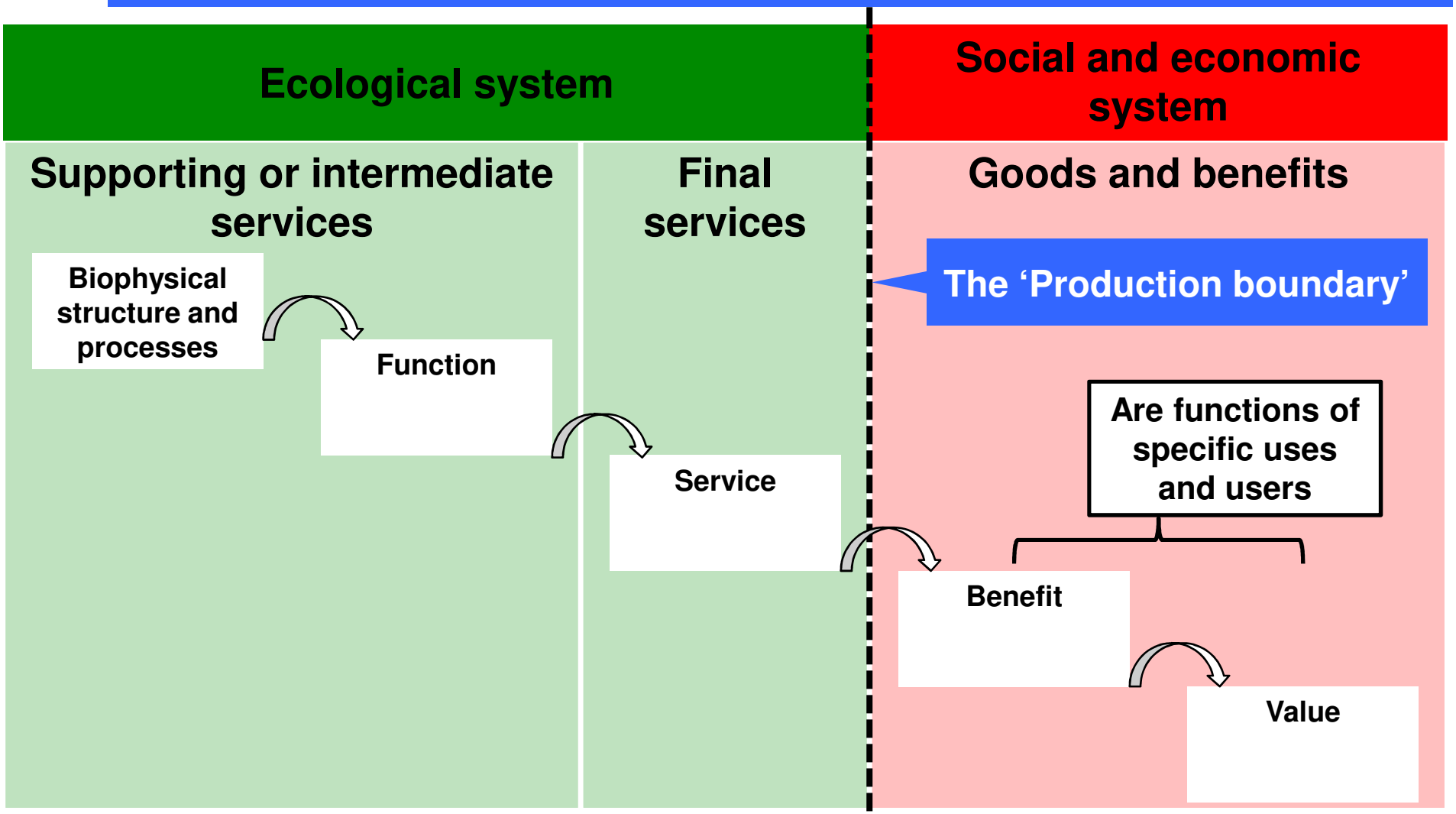
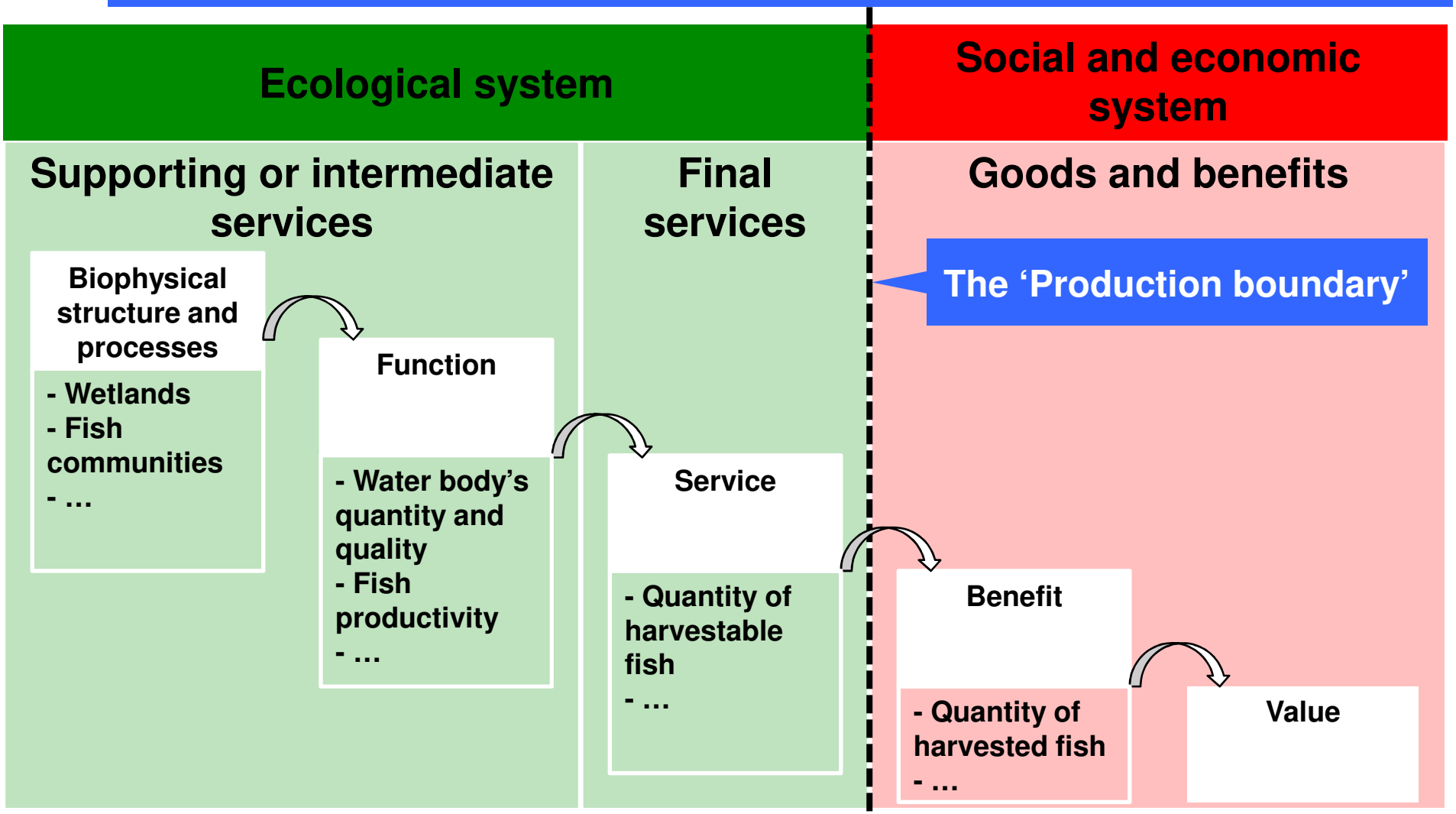


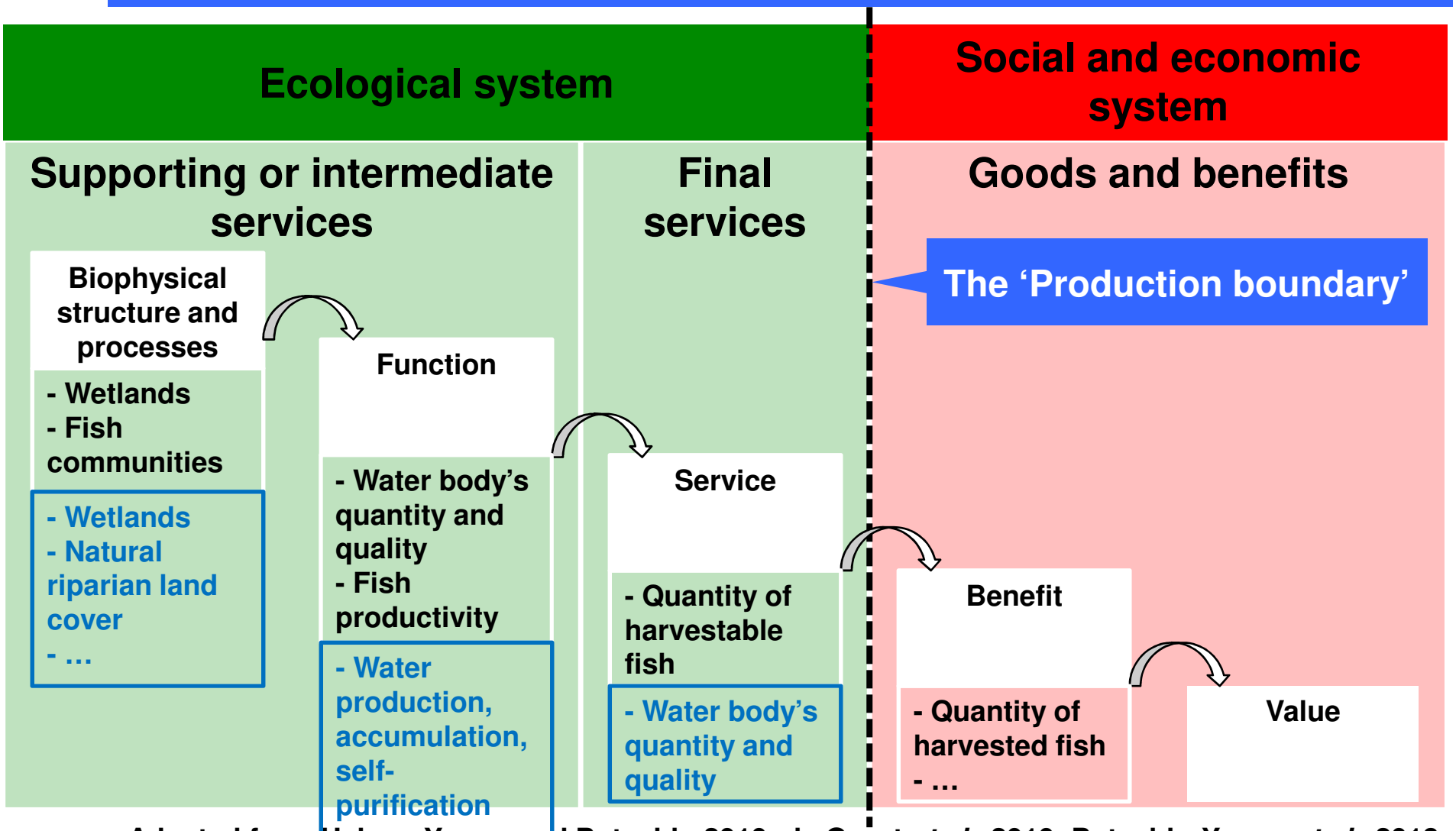
Adapted from Haines-Young and Potschin 2010; de Groot *et al.*, 2010; Potschin-Young *et al.*, 2018

The Cascade Model: Angling



Adapted from Haines-Young and Potschin 2010; de Groot *et al.*, 2010; Potschin-Young *et al.*, 2018

The Cascade Model: Water provisioning



Adapted from Haines-Young and Potschin 2010; de Groot *et al.*, 2010; Potschin-Young *et al.*, 2018

The cascade model : advantages and drawbacks

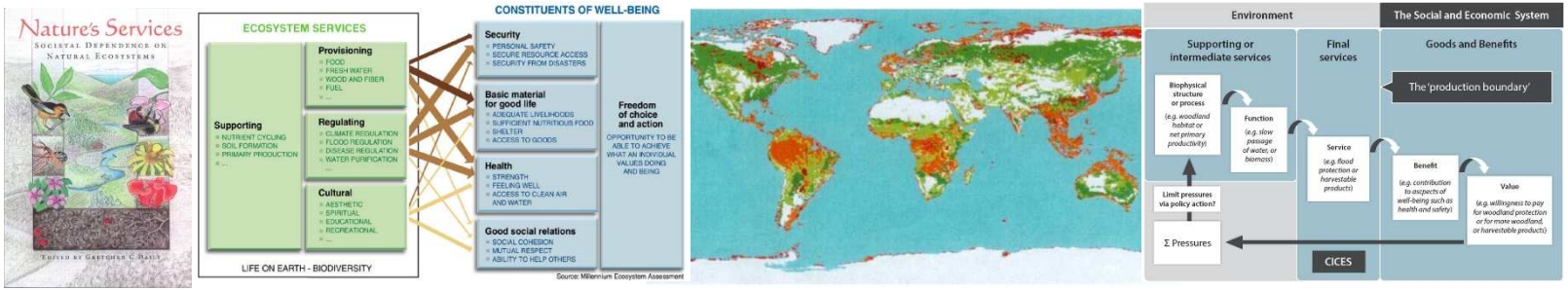
ADVANTAGES

- Illustrate the production chain linking ecological and biophysical conditions to elements of well-being
- Disentangle the natural capital contribution to human welfare
- With the use of final services, limit double-counting

DRAWBACKS

- Maintain a separation between ecology that deals with the environment and economics that deals with the valuation of benefits
- Precise boundaries between “structure/processes”, “functions”, “services”, “benefits” and “goods” difficult to define and context-dependent

Outline

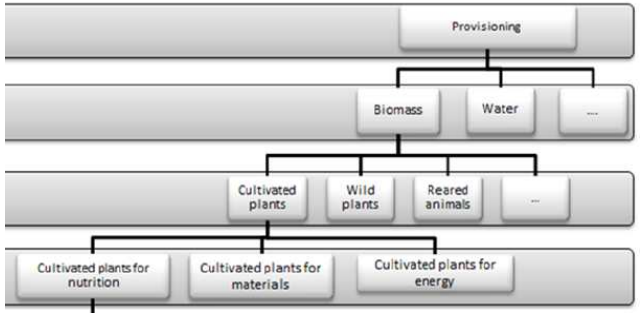


Classifying ES: From the first attempts to CICES

Broad categories to be adapted to local case studies

ES number

Number	Ecosystem service*
1	Gas regulation
2	Climate regulation
3	Disturbance regulation
4	Water regulation
5	Water supply
6	Erosion control and sediment retention
7	Soil formation
8	Nutrient cycling
9	Waste treatment
10	Pollination
11	Biological control
12	Refugia
13	Food production
14	Raw materials
15	Genetic resources
16	Recreation
17	Cultural



Detailed descriptions for systematic monitoring and reporting

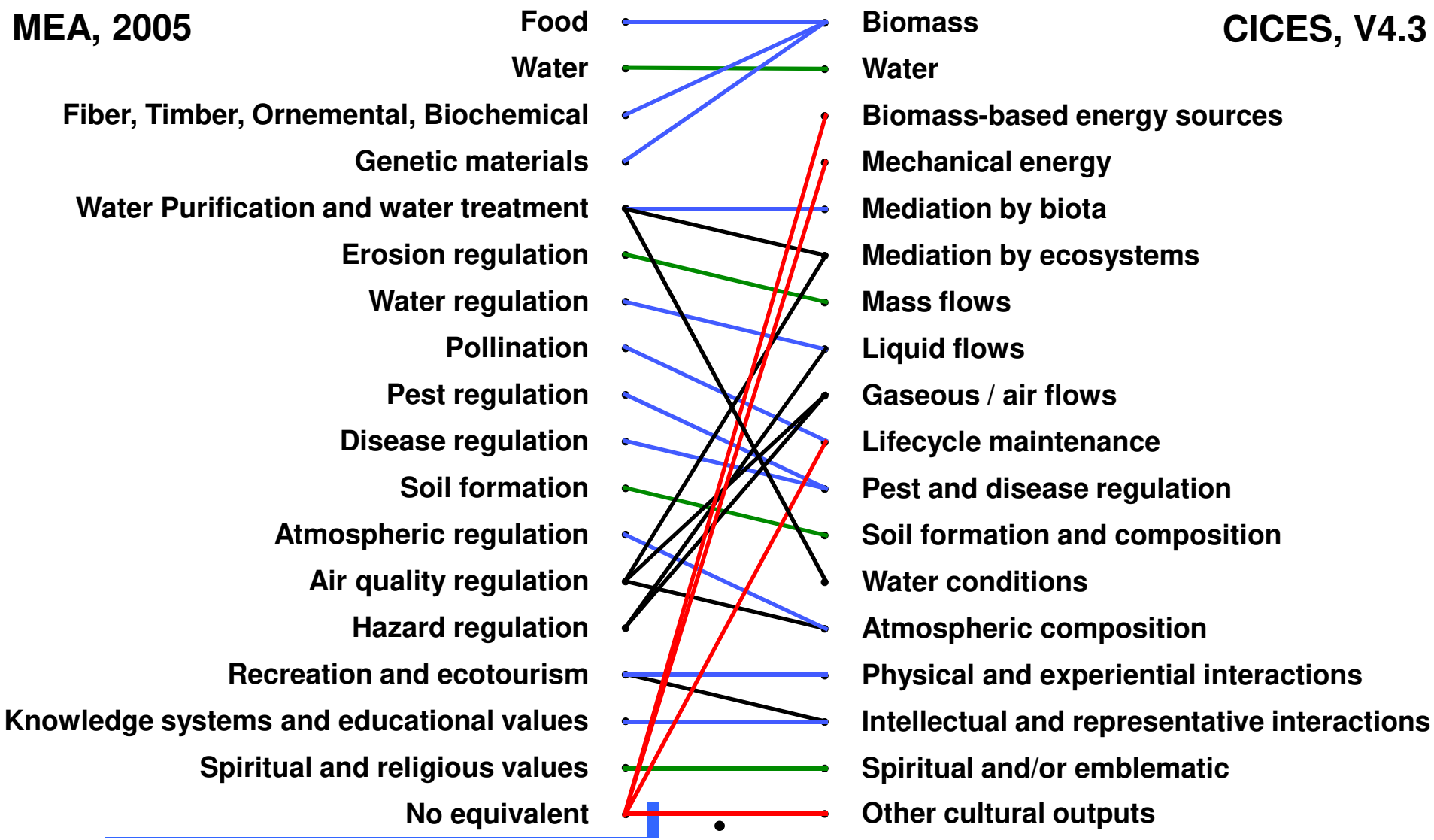
Refinement with time

Costanza *et al.*, 1997
No categories
17 ES

MEA, 2005
4 categories
19 ES

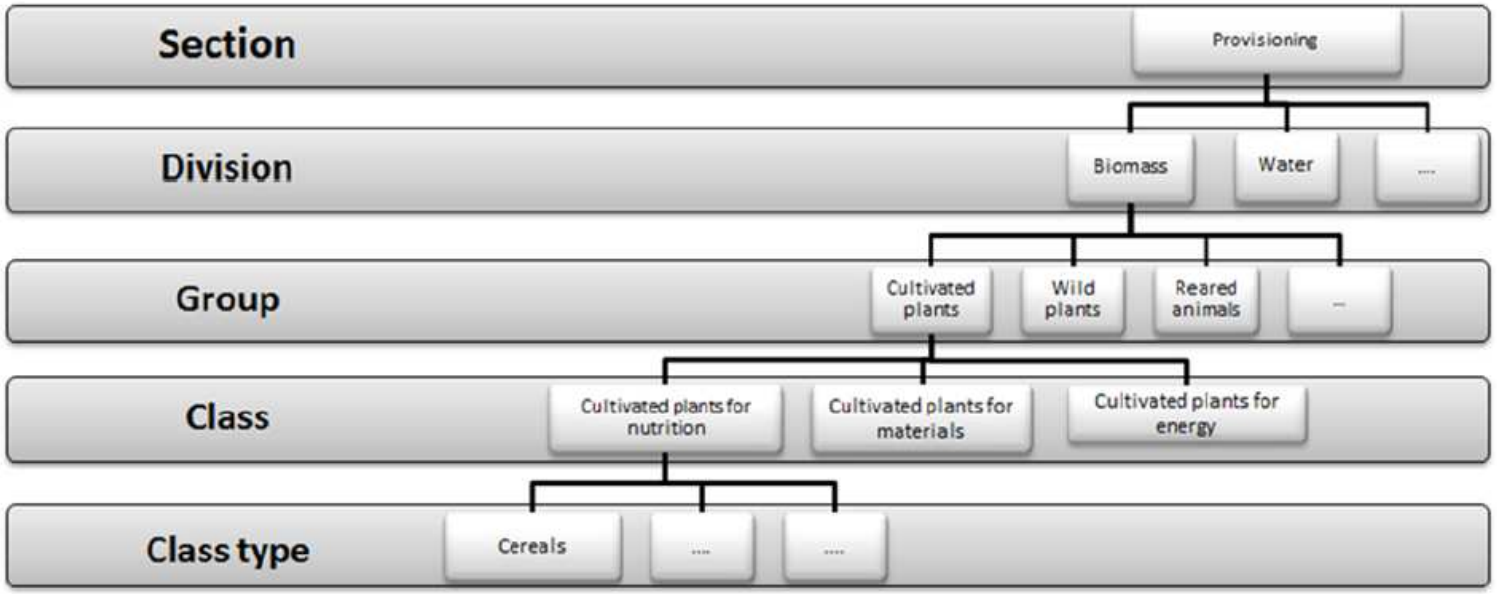
CICES v5.1, 2010
3 categories
89 classes of ES

Classifying ES: From the first attempts to CICES



A focus on The Common International Classification of Services (CICES v5.1)

- A contribution of the European Environment Agency to the revision of the System of Environmental-Economic Accounting (SEEA)
- A hierarchical list of 89 class of services to accommodate the fact that people work at different thematic and spatial scales



Haines-Youg and Potschin, 2018

A focus on The Common International Classification of Services (CICES v5.1)

- Systematically defines the different ES on the basis of :
  - An **"ecological clause"** to limit ES to the contribution of the **ecological system** to human welfare
  - A **"use clause"** to limit ES to goods and benefits **enjoyed** directly or indirectly

Service	Ecological clause	Use clause
Cultivated biomass grown for nutritional purposes	**The ecological contribution to the growth of cultivated, land-based crops…**	**…that can be harvested and used as raw materials for the production of food**
Control of erosion rates	**Reduction in the loss of material by virtue of the stabilising effects of the presence of plants and animals…**	**…that mitigates or prevents potential damage to human use of the environment or human health and safety**

Haines-Youg and Potschin, 2018

A focus on The Common International Classification of Services (CICES v5.1)

- Recognise and classify abiotic ecosystem outputs as water, mineral, or non-mineral substances (wind, heat,…)
- According to the close association of abiotic and biotic services, their classifications follow the same logic

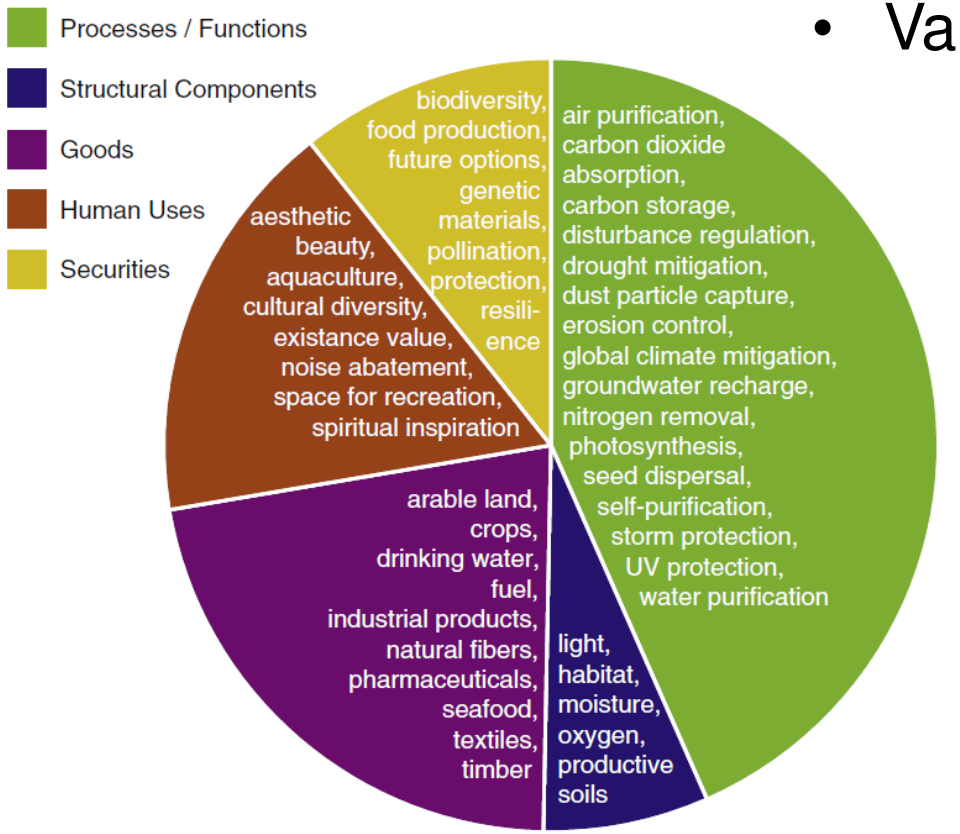
Provisioning (Biotic)	Biomass	Cultivated terrestrial plants for nutrition, materials or energy	Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes
Provisioning (Biotic)	Biomass	Cultivated terrestrial plants for nutrition, materials or energy	Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials)
Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy	Surface water for drinking
Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy	Surface water used as a material (non-drinking purposes)

Haines-Youg and Potschin, 2018

Classifying ES: In progress…

- A huge work, still in progress (CICES), to clarify the distinctions between “functions”, “services”, and “benefits” and improve the consistency of individual ES definitions
- A broad agreement on :
  - The association of ES with **human benefits** (following the utilitarian gamble)
  - The recognition of **three main categories** of services, the famous:
  - **Provisioning** ES: all the outputs from ecosystems directly consumed
  - **Regulating** ES: all the way in which ecosystems mediate the environment that affects human health, safety or comfort;
  - **Cultural** ES: all the non-material outputs of ecosystems that affect physical and mental state of people

Classifying ES: In progress…but



Assignment of "ecosystem services" cited in 25 publications to processes/functions, structural components, goods, human uses and securities. Nahlik *et al.*, 2012.

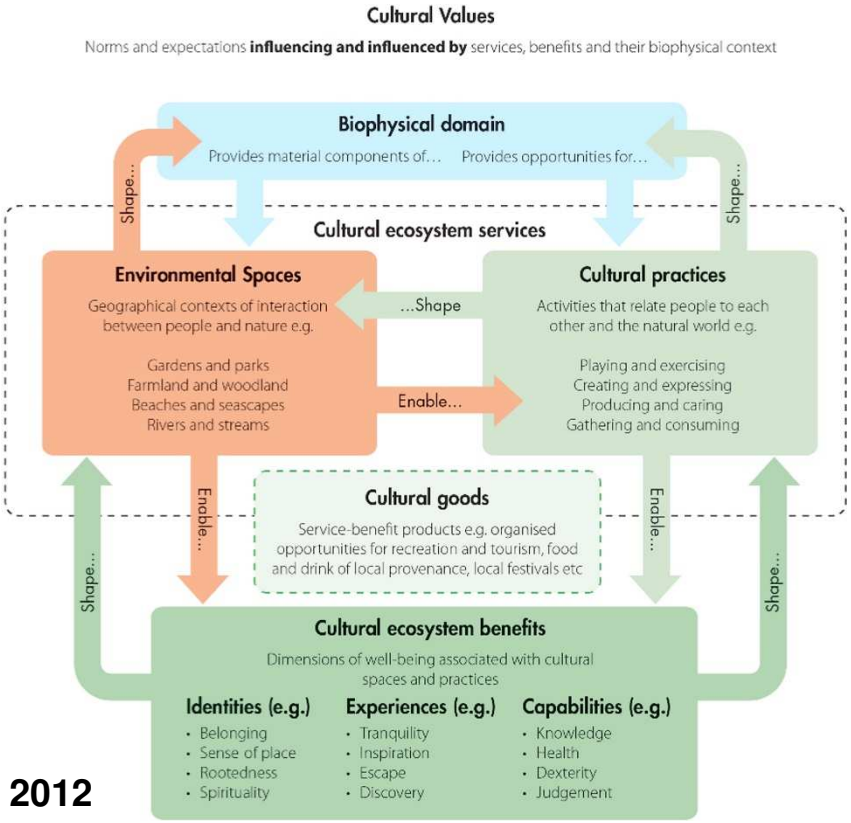
- Various things still called ES:
  - **Conditions** (chemical conditions)
  - **Functions** (carbon storage)
  - **Goods** (cultivated crops)
- Remaining **overlaps** with risk of double-counting between :
  - **Supporting** and other ES
  - **Individual ES** as between pollination and cultivated crop production

Classifying ES: in progress…but, the case of Cultural ES

- Cultural ES were poorly defined in the MEA definition and remain the least well defined in the CICES v5.1 classification
- Cultural ES are ontologically different from provisioning and regulating ES as they are :

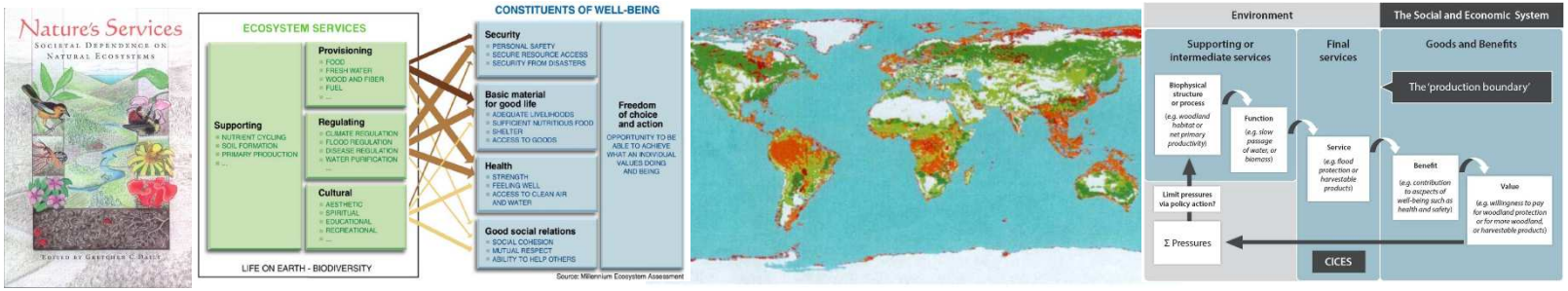
- Not **outputs** of ecosystems but **interactions** between ecosystems and people

- particularly **subjective**, being less linked to physiological needs

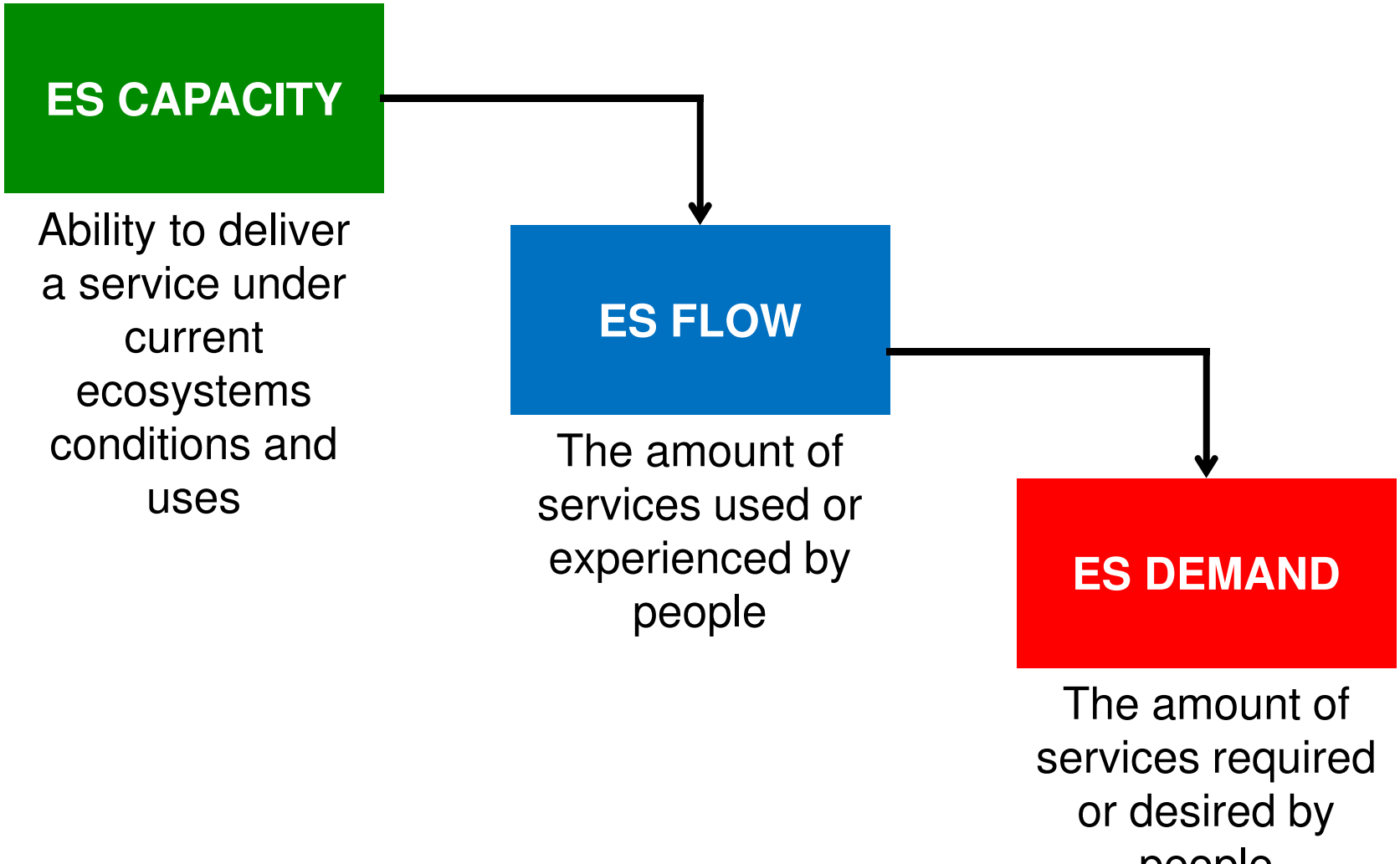


Fish *et al.*, 2012

Outline



The three components of the ES delivery process



Adapted from Villamagna *et al.*, 2013; Baro *et al.*, 2016

A case study

AIR PURIFICATION

ES CAPACITY

NO_2 dry deposition velocity on vegetation

ES FLOW

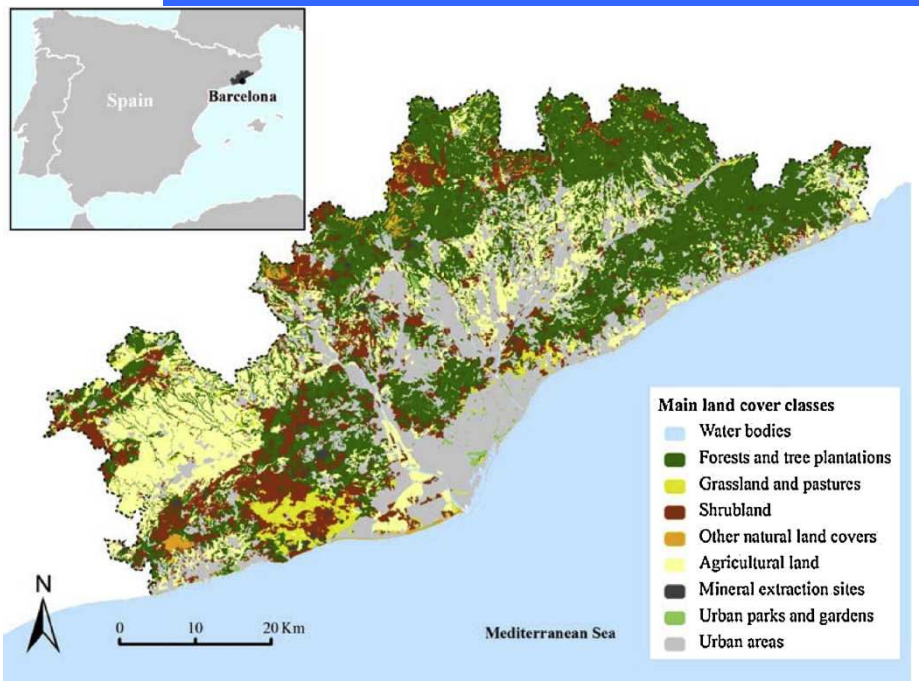
Modelled NO_2 removal flux by vegetation

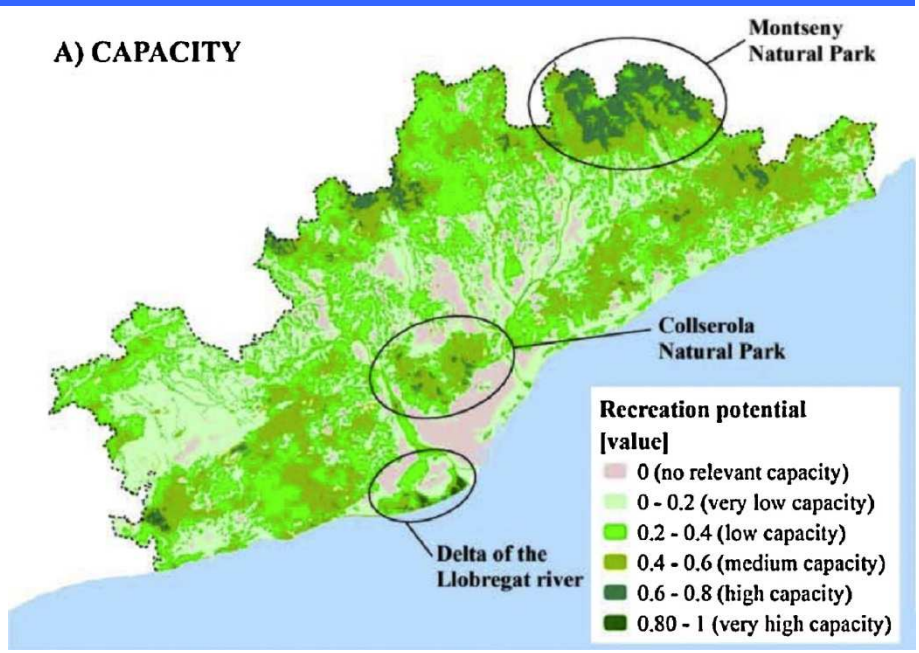
ES DEMAND

Index based on populations and exposure to NO_2 concentrations

Adapted from Villamagna *et al.*, 2013; Baro *et al.*, 2016

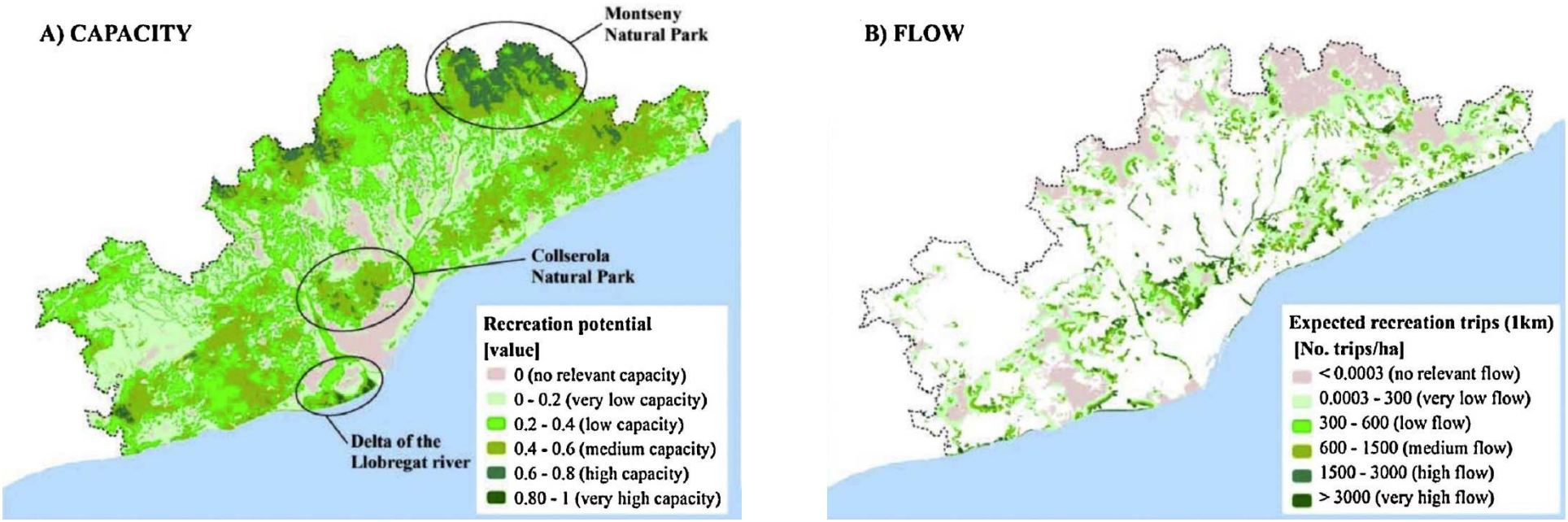
Capacity





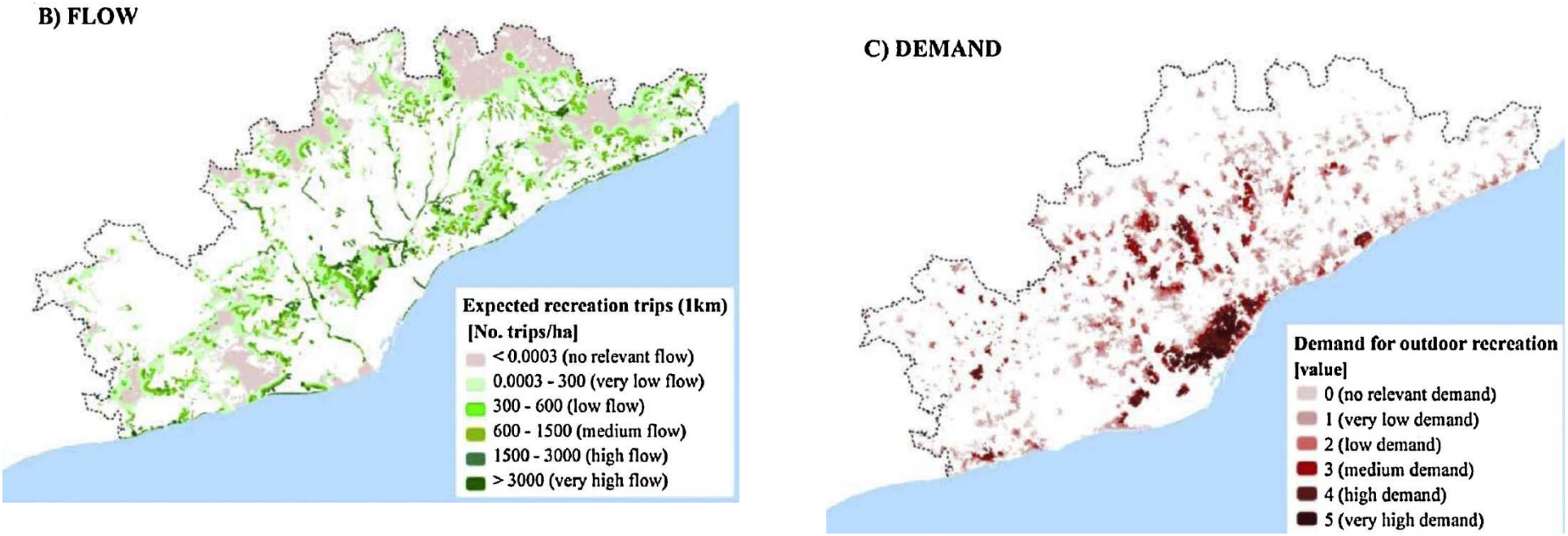
- High capacity values observed in hinterland (Montseny natural park) or coastal mountain range (Collserola natural park) forested areas
- Low capacity values in urban areas (grey) but also in agricultural lands (pale yellow)

Flow



- High flow values in periurban forest areas (Collserola) or along the main roads due to the combination of forest vegetation and high traffic emissions
- Lower flow values in forested areas located in the hinterland (Montseny Natural park)

Demand

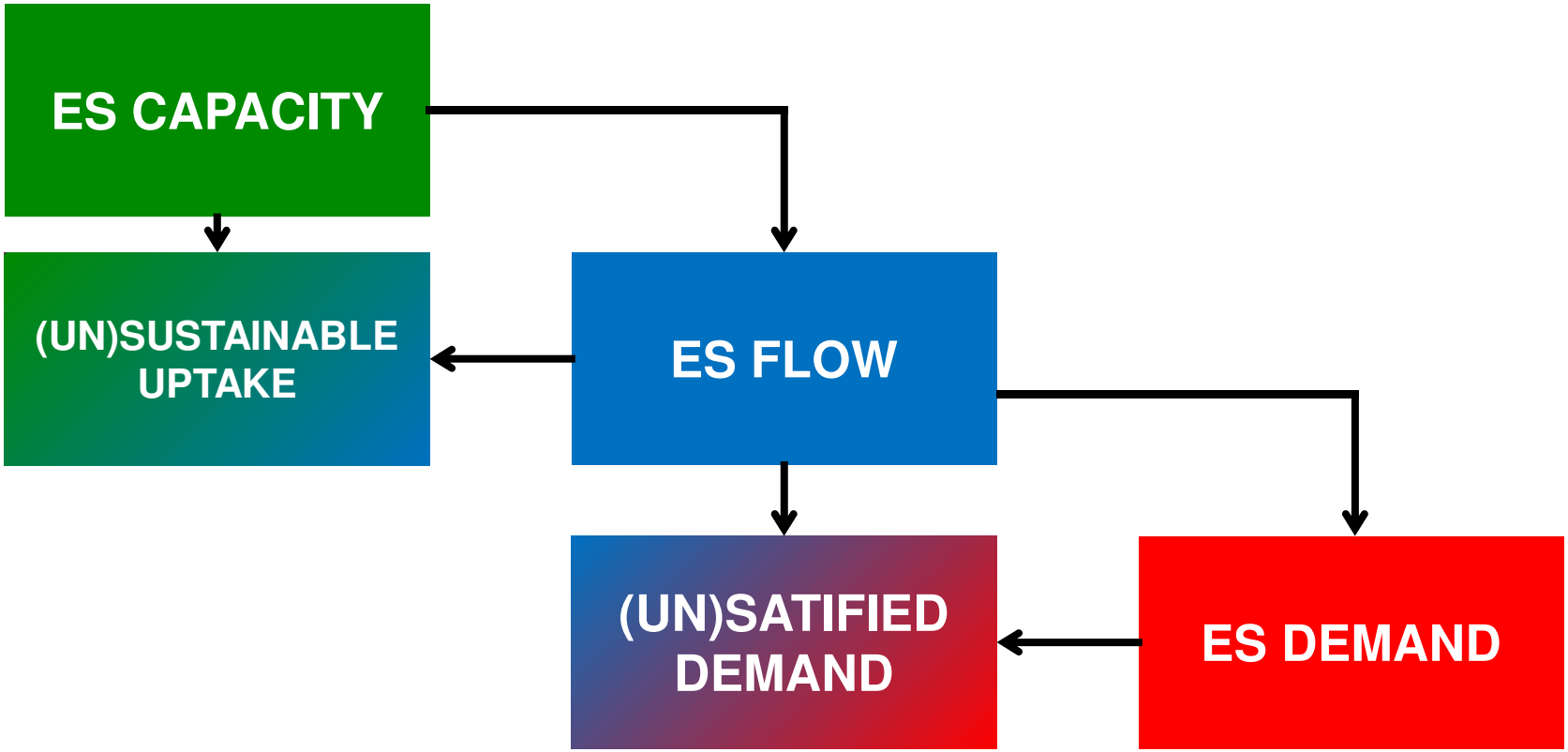


- High demand values in urban are (municipality of Barcelone and adjacent middle-sized cities)

⇒ Very different levels and spatial patterns of ES capacity, flow and demand

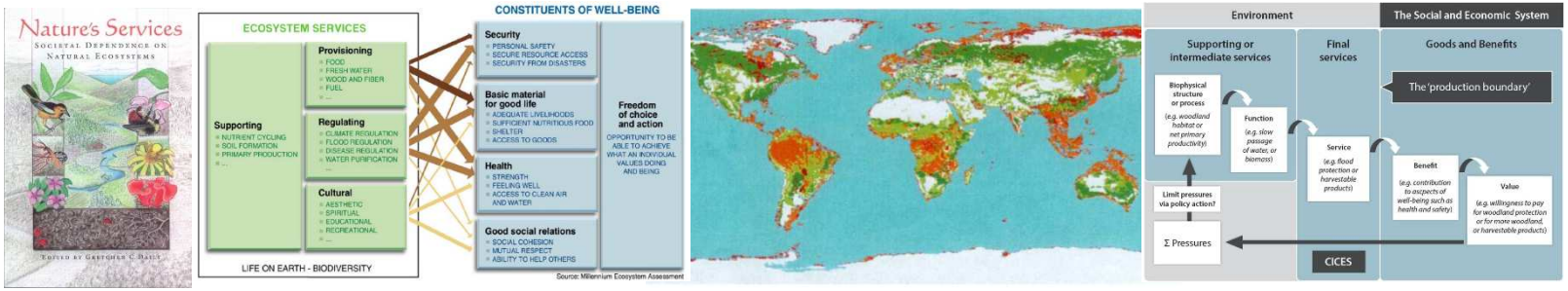
Baro *et al.*, 2016

The three components of the ES delivery process : Conclusion



- No ideal component but an opportunity to identify potential mismatches
- Most studies focus on the assessment of ES Capacity

Outline



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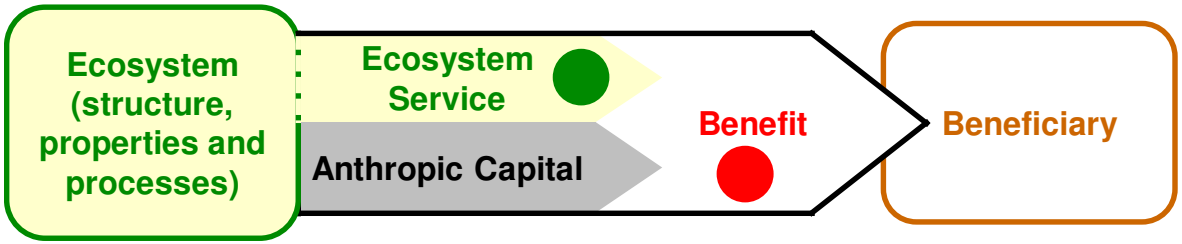
5. **From theory to practice: ES metrics**
6. Concluding remarks

From optimal to realistic metrics

ES metric choice

Optimal

Realistic



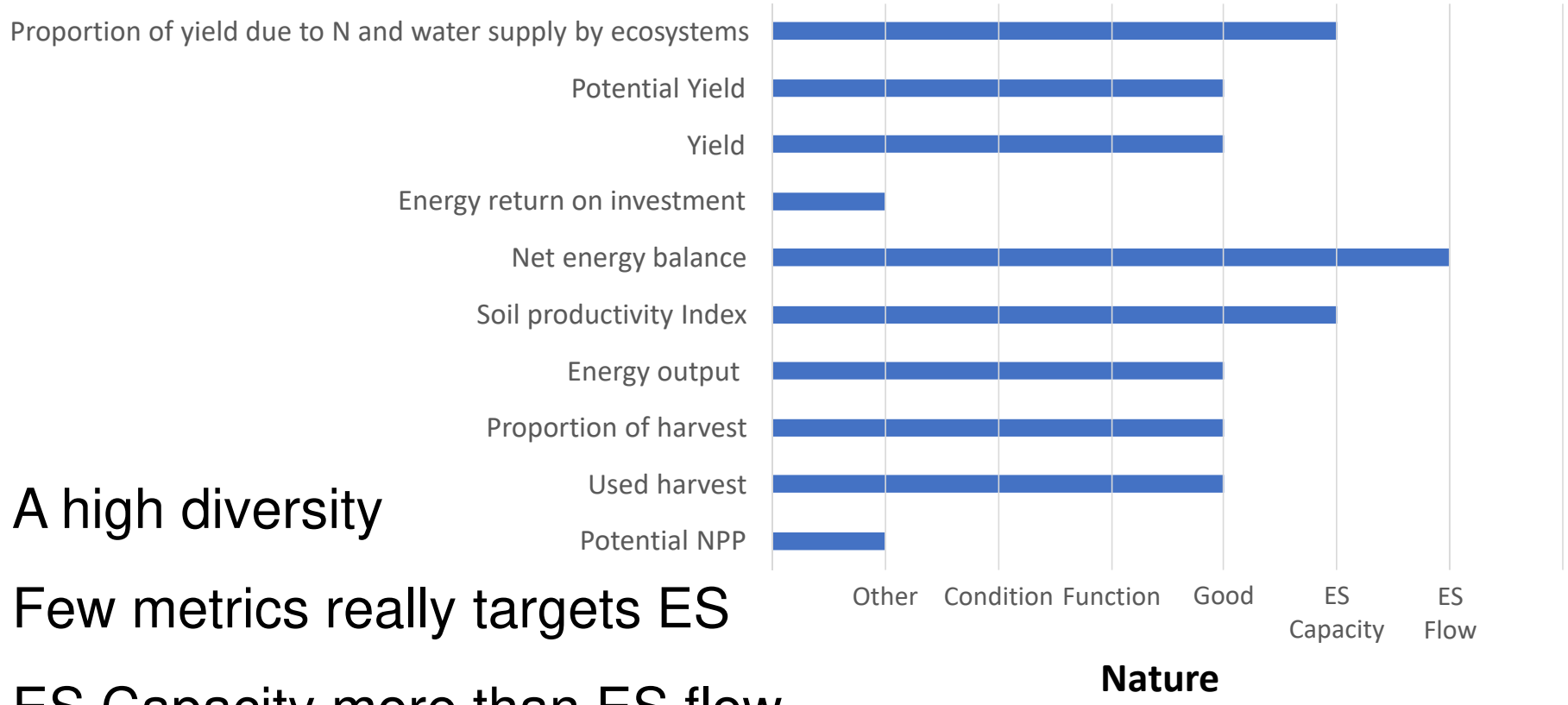
⇒ Realistic metrics often reflects the benefits instead of the contribution of ecosystems to this benefits

Ecosystem service name	Examples of human management of ecosystem	Ecosystem service	Benefit as used by humans	Ecosystem service indicator
Hunting	National parks, ecological corridors	Animals that are shot	Game meat	Game meat
Drinking water extraction	Groundwater protection zones, extraction zones	Extracted groundwater	Drinking water	Extracted groundwater
Crop production	Crop choice, fertilizer application, drainage and irrigation	Standing crop (at the time of harvest)	Harvested crop	Harvested crop
Fodder Production	Fertilizer application, drainage and irrigation	Standing grass (consumed by animals)	Milk, meat	Harvested or grazed fodder
Air quality regulation	Tree planting	PM_{10} capture	Health benefits	Captured PM_{10}
Carbon sequestration	Tree planting	Carbon sequestration	Reduced climate change	Carbon sequestered
Recreational cycling	Cycling paths	Scenic beauty along cycling paths	Cycling trips	Number of cycling trips

Remme *et al.*, 2014

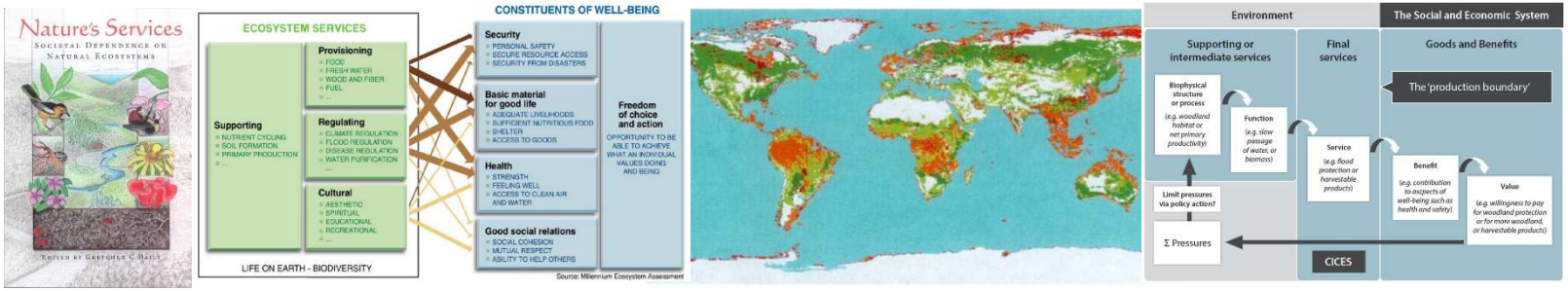
The case of “biomass production” in Europe (In progress)

Metrics used in Europe to assess biomass production at the European or national levels



- A high diversity
- Few metrics really targets ES
- ES Capacity more than ES flow
- Other things such as “capability” or “efficiency”

Outline



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Concluding remarks

- Over the past decades, an **unbelievable amount** of work has been done to define, frame, classify, (assess and map) ES
- It has led to a **functional**, **multidimensional** but **utilitarian** conceptualisation of the relationships between ecosystems and human well-being which can **change the game**
- It has already raised **the awareness** of the dependency of human well-being on ecosystems conditions and functioning
- No full **implementation** in major policies
- The **diversity** in ES definitions, frameworks, or classifications seems **confusing** rather than **attractive**
- **Harmonisation**, to enable accumulation of knowledge and cross-case comparisons appears as key future challenge

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