



Wealth Accounting and Valuation of Ecosystem Services (WAVES) Partnership Meeting

The World Bank, Washington DC  
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## Physical accounts for ecosystems in Europe

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## Recurrent demands for improved macro-economic indicators and aggregates

- Historical pioneer projects...
- Reminders:
  - Beyond GDP Conference, Brussels 2007 and Communication 2010
  - Potsdam 2007 G8+5 initiative & TEEB 2008, 2010
  - Stiglitz/ Sen/ Fitoussi report on the measurement of economic performance, Paris 2009
  - **Simplified Ecosystem Capital Accounts fast track project in Europe (2009-2012): the EEA (the ecosystems side) & Eurostat (the economic sectors side)**
  - CBD revised Nagoya Strategy 2010
  - SEEA revision for 2012/13: includes now a special volume on ecosystem accounts and valuation
  - WB's Global Partnership...



## Fast Track Implementation of Simplified Ecosystem Capital Accounts in Europe (2009-2012)

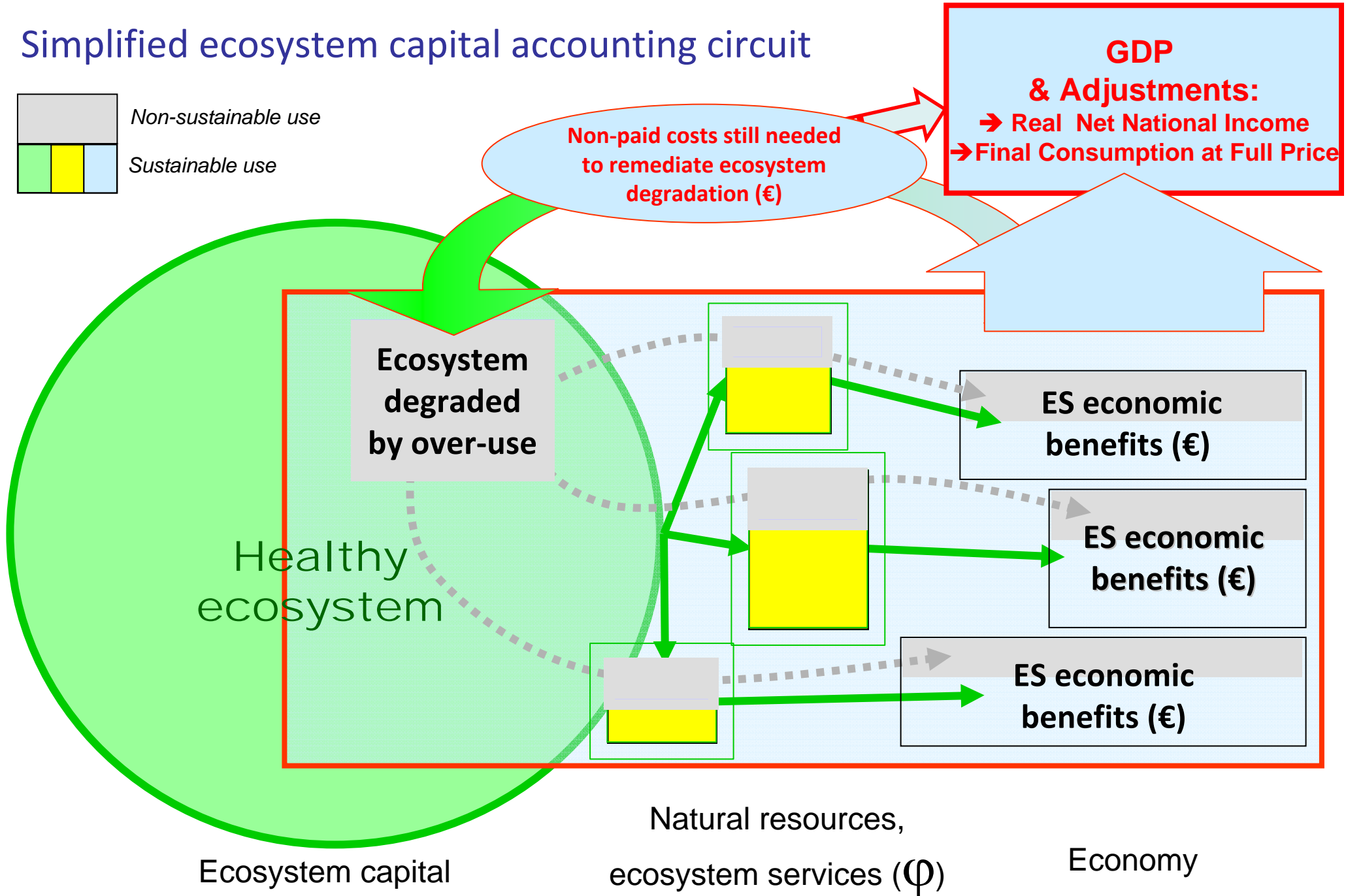
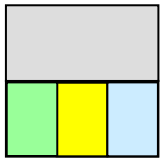
- Need of a minimum common reference for multiple national initiatives in 35 EEA member countries (and further on, Eastern and Southern European neighborhoods)
- Feasible with existing data and statistics
- Responding main policy questions:
  - “resource efficiency”: sustainable use of ecosystem (agriculture, forestry, fishery...) – Europe’s 2020 horizon
  - Benefits from ecosystem services: starting with the sustainable benefits supported by ES in agriculture, forestry, fishery, tourism... and their distribution between all beneficiary sectors (not only the primary producers...); continuing with selected regulating services, broader human well-being...
  - “Beyond GDP”, the macro-economic dashboard: the true price of final consumption (including consumption of ecosystem capital - CEC), the real net national income (net of CEC), genuine saving including ecosystems
  - Ecosystem capital restoration costs as a measure of depreciation (CEC)
  - Europe’s global responsibility: ECD embedded into international trade
- Central indicator: ecosystem capital degradation



# Characteristics of ecosystem capital accounts

- Meet the policy demand:
  - Measure resource efficiency: maximize benefits while maintaining capital
  - Indicators to supplement and/or adjust sector and macro-economic aggregates
  - Policy agenda: continuity, annual updates for year  $t - 1$  are needed
  - National statements, internationally comparable...
- Physical accounts supporting monetary accounts:
  - Ecosystem services & sustainable benefits
  - Ecosystem capital state/degradation & depreciation (consumption of ecosystem capital)
- Accounts deep rooted into verifiable observation datasets:
  - Socio-economic statistics (agriculture, forestry, fisheries, tourism, population)
  - Monitoring by satellites (land cover, biomass, climate variables...)
  - Best available in situ monitoring data (water, biodiversity...)
- At the start, relevance matters more than accuracy:
  - Modeled or surrogate estimations are acceptable if based on verifiable datasets
  - Estimations need to be transparent and reproducible (for measuring change)
- Accounts need to be compiled at various scales:
  - National as well as Global, local government, business
  - Implementation: in parallel top-down and bottom-up

# Simplified ecosystem capital accounting circuit



Ecosystem capital

Natural resources,  
ecosystem services ( $\varphi$ )

Economy

**GDP**  
**& Adjustments:**  
→ Real Net National Income  
→ Final Consumption at Full Price

Ecosystem degraded by over-use

Healthy ecosystem

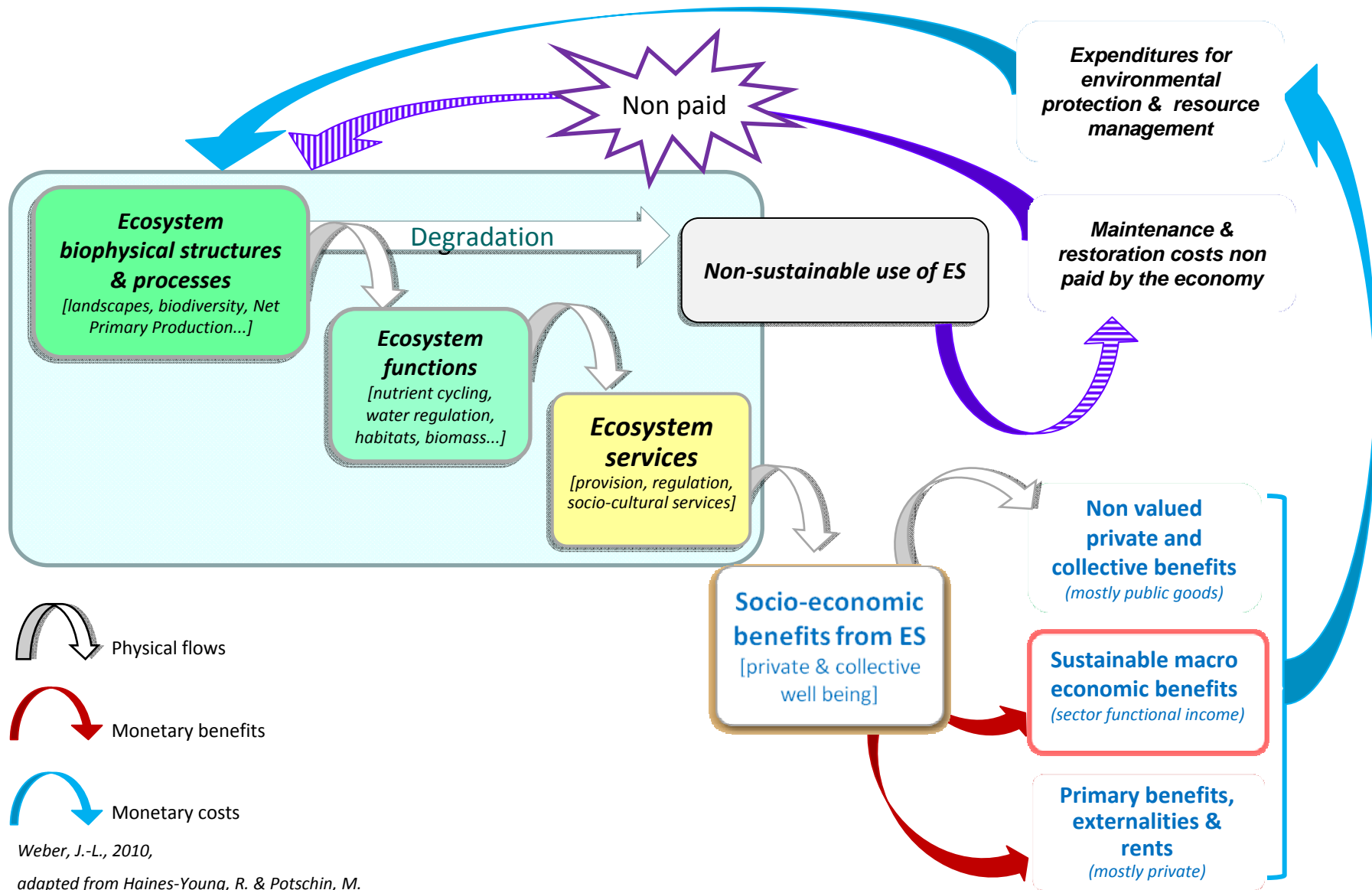
ES economic benefits (€)

ES economic benefits (€)

ES economic benefits (€)

Non-paid costs still needed to remediate ecosystem degradation (€)

# Ecosystem capital: systems & services, benefits & costs

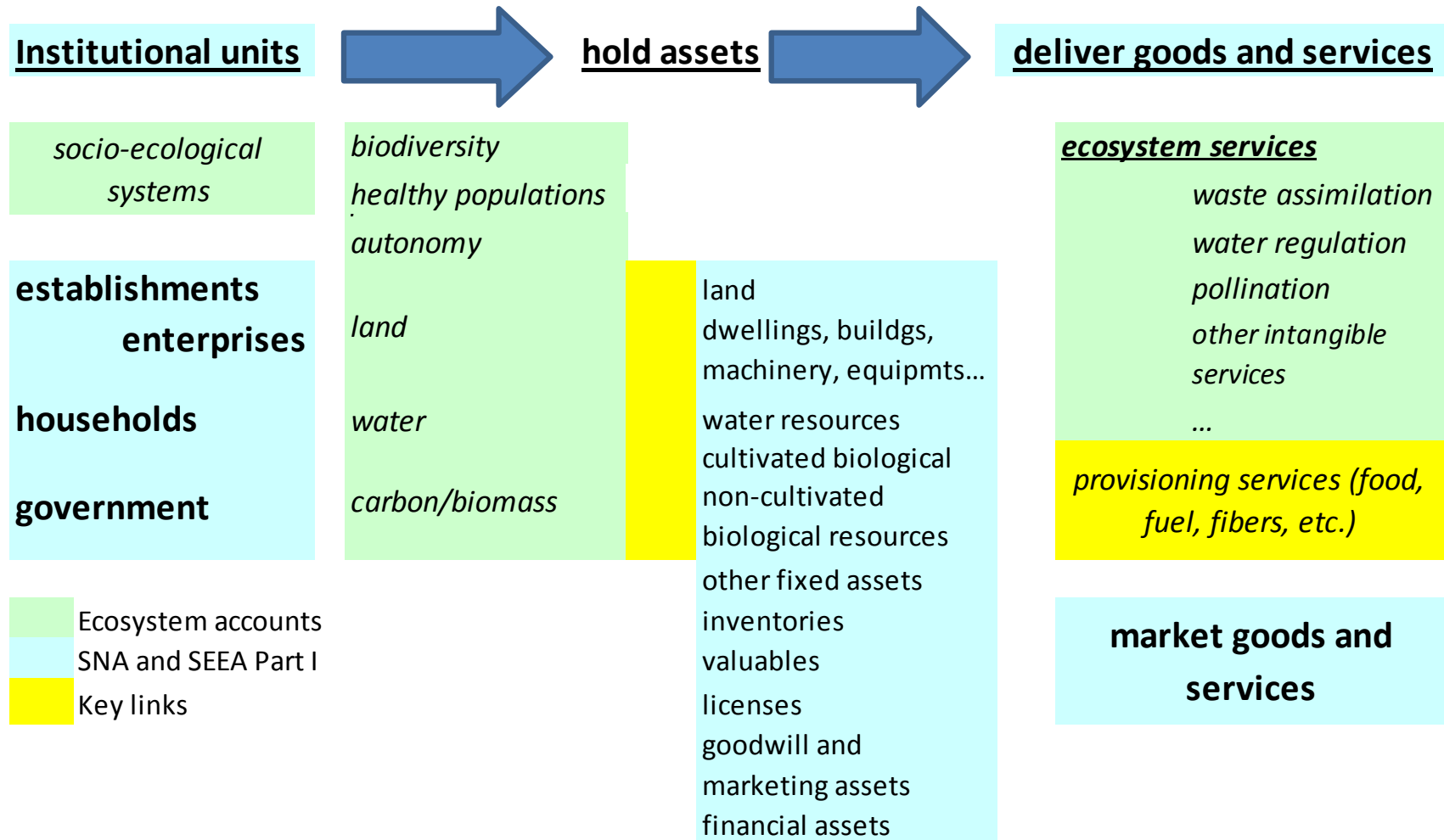


Weber, J.-L., 2010,

adapted from Haines-Young, R. & Potschin, M.



# SNA & SEEA: economic and ecosystem assets





# SNA & SEEA: economic and ecosystem assets

Assets hold by ecosystem units (forests, agro-systems, wetlands...)	Assets hold by economic units (enterprises, government bodies, households...)									
	Produced assets					Non produced assets				
	Dwellings & other buildings and structures	Machinery and equipment	Cultivated biological resources	Inventories	Other products	Land	Mineral and energy reserves	Noncultivated biological resources	Water and other natural resources	Intangible assets (contracts, licences...)
Land			X			X				
Land cover systems	X		X			O		X	X	
Biomass/carbon			X	X			O	X	O	
Water								O	X	
Biodiversity			O			O		O	O	O
Self regulating capacity	O		O			O		O	O	
Health, overall regenerative capacity			N			N		N	N	

X	explicitly recorded as economic asset
O	partly or indirectly recorded as economic asset
N	not recorded, externality





## Physical accounts for all ecosystems

- All ecosystems:
  - Inland systems,
  - Seas/oceans
  - Atmosphere
- Inland ecosystems include:
  - Land systems
    - Forests (natural or managed)
    - Other terrestrial systems (wetlands, shrubland, grassland...)
    - Inland water systems (rivers, lakes)
    - Agro-ecosystems
    - Urban systems
  - Below-surface systems functionally related to land
    - Soil
    - Aquifers



## Physical accounts for ecosystems

- **Ecosystem capacity to deliver services in a sustainable way → change matters as much as state**
- Ecosystem capital state = quantity\*health
- Ecosystem assets: basic balances of surface, length, volume, mass, energy, number of units...
- Ecosystem health (or distress syndrome): diagnostic approach based on a limited set of symptoms (*David J. Rapport*)
- Ecosystem services: material/energy resources and functional services
- Ecosystem resource (services) depletion is a subset of ecosystem degradation

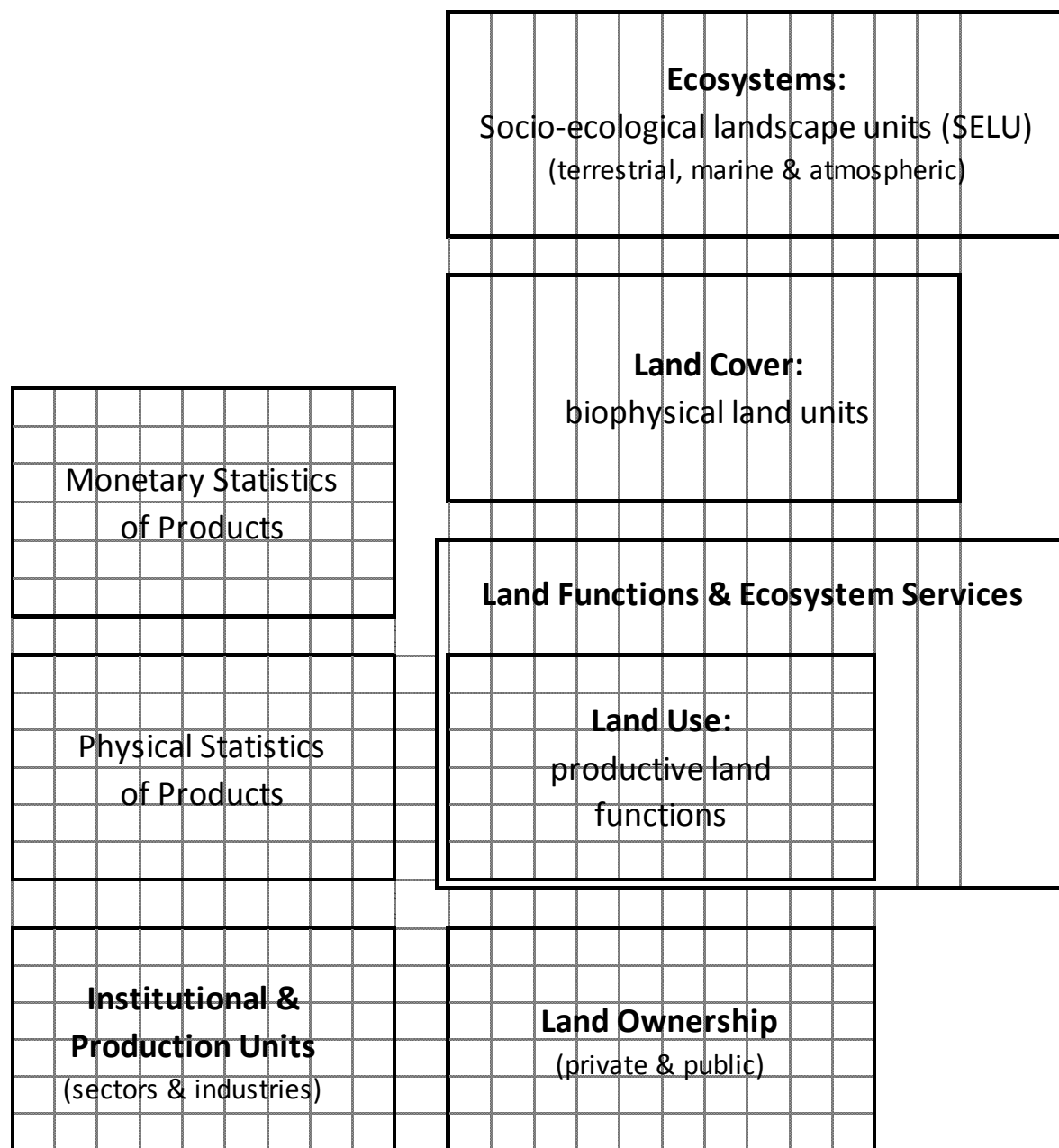


## Scales

- In theory, ecosystems can be described at various scales, from the global to the microscopic.
- SEEA is an extension of the SNA → focus on the same typical scales (macro-economic accounting units): institutional units (e.g. companies, households or public organizations), functional units (e.g. establishments), commodities and assets. *Ecosystem accounts = the same + land use units (ownership) + land cover units + socio-ecological systems...*
- Geographical grouping: administrative units (countries, regions, protected areas), physical regions (river basins, mountains, coastal zones), bio-climatic zones...



# Main relations between classifications & accounting units



# Ecosystem accounting and statistical units



SNA statistical units don't record ecosystem degradation → need for other units...

Theoretical units vs. observation units (proxies for collecting data)

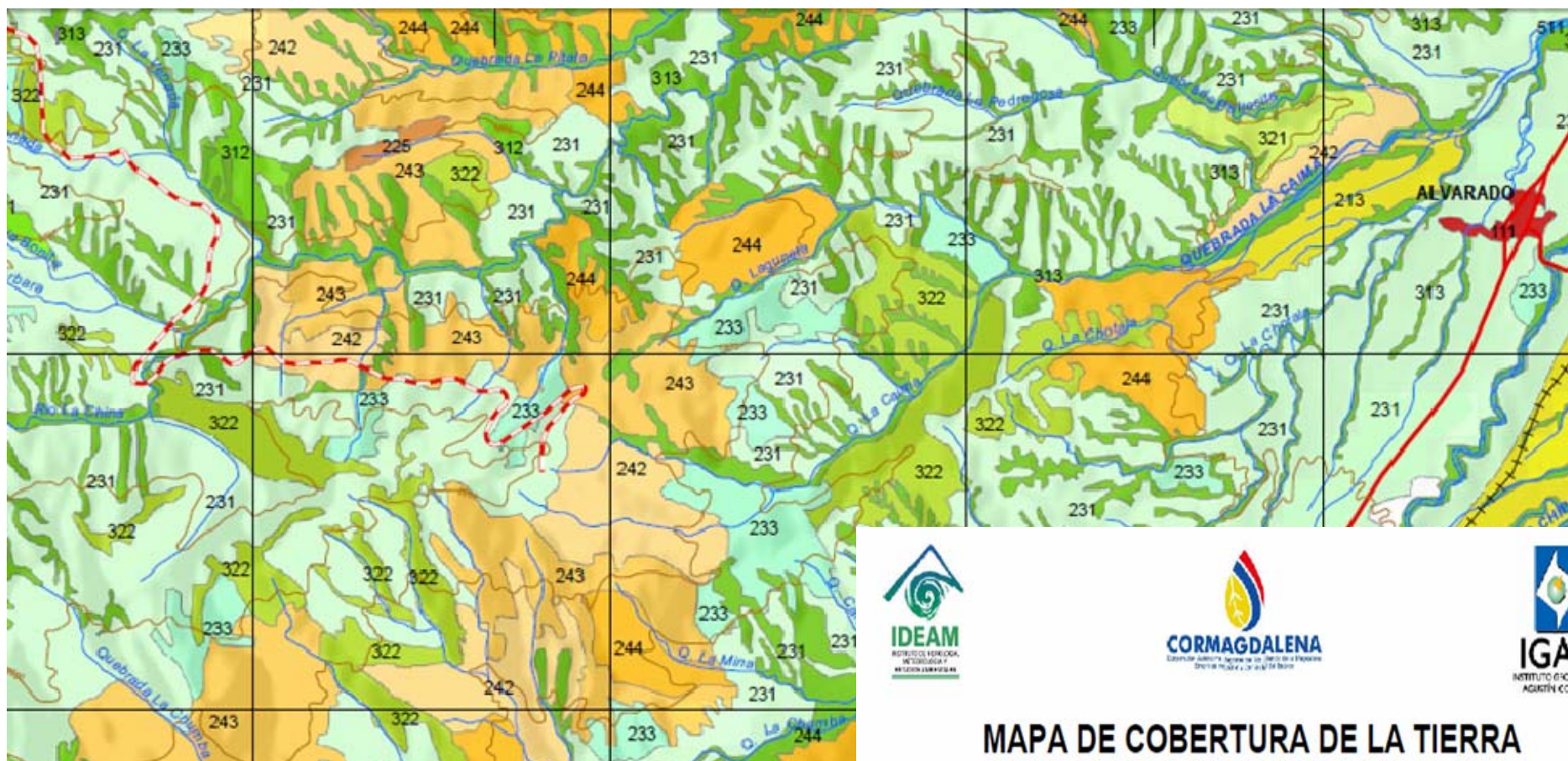
- **Theoretical units**: characteristic systems into which natural and socioeconomic elements interact to transform ecosystem functions into goods and services:
  - Functional units producing elementary services
  - “Socio-ecological systems”, “socio ecosystems” or “Socio-ecological production landscapes” (the Japanese satoyama and satoumi) →
- **Observation units**:
  - For which we can collect data in a systematic way
  - Mostly surface units: “geo-systems”, land cover units, functional administrative units, ownership units...



Japan *Satoyama Satoumi* Assessment, 2010.  
*Satoyama-Satoumi* Ecosystems and Human Well-being: Socio-ecological Production Landscapes of Japan – Summary for Decision Makers.  
United Nations University, Tokyo, Japan.



## Functional units producing elementary services: land cover systems (example from Colombia...)



### MAPA DE COBERTURA DE LA TIERRA CUENCA MAGDALENA - CAUCA

METODOLOGIA CORINE LAND COVER ADAPTADA PARA COLOMBIA

With the same land cover data, the EEA has computed land cover stocks and change accounts for Europe, 1900-2000-2006



# Classification of land cover units: FAO/LCCS3 land cover types (left) and provisional land cover systems for ecosystem accounting (right)

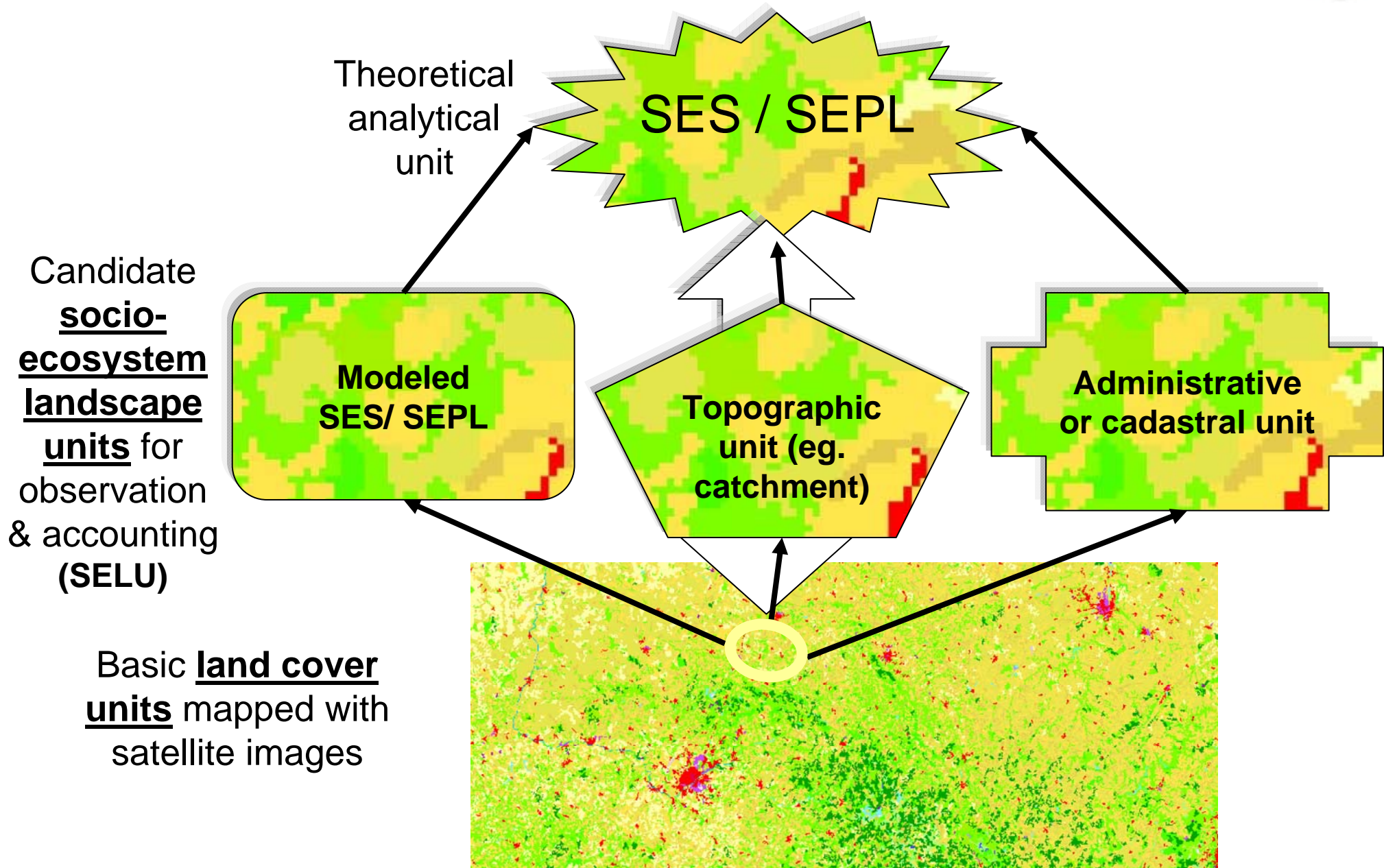
## Land cover types nomenclature for SEEA

- A1 Herbaceous crop/ Small size fields rainfed (< 2 ha)
- A2 Herbaceous crop/ Medium to large size fields rainfed
- A3 Herbaceous crop/ Medium to large size fields irrigated
- B Tree or shrub crop
- C Multiple or layered crop
- D Tree covered area
- E Shrub covered area
- F Herb covered area
- G Sparse natural vegetation (terrestrial or aquatic or regularly flooded)
- H Aquatic or regularly flooded tree covered area
- I Aquatic or regularly flooded shrub or herb covered area
- J Bare areas (terrestrial or regularly flooded)
- K Artificial surfaces and associated areas
- L Inland water bodies
- M Glacier and perennial snow

## Land cover systems nomenclature - LCSN (provisional)

- 01 Artificial surfaces and associated areas
- 02 Medium to large fields rainfed herbaceous crops
- 03 Medium to large fields irrigated herbaceous crops
- 04 Permanent crops, agriculture plantations
- 05 Agriculture associations and mosaics
- 06 Pastures and natural grassland
- 07 Forest tree cover
- 08 Shrubland, bushland, heathland
- 09 Sparsely vegetated areas
- 10 Bare land
- 11 Permanent snow and glaciers
- 12 Open wetlands
- 13 Inland water bodies
- 14 Coastal water bodies
- 15 Sea

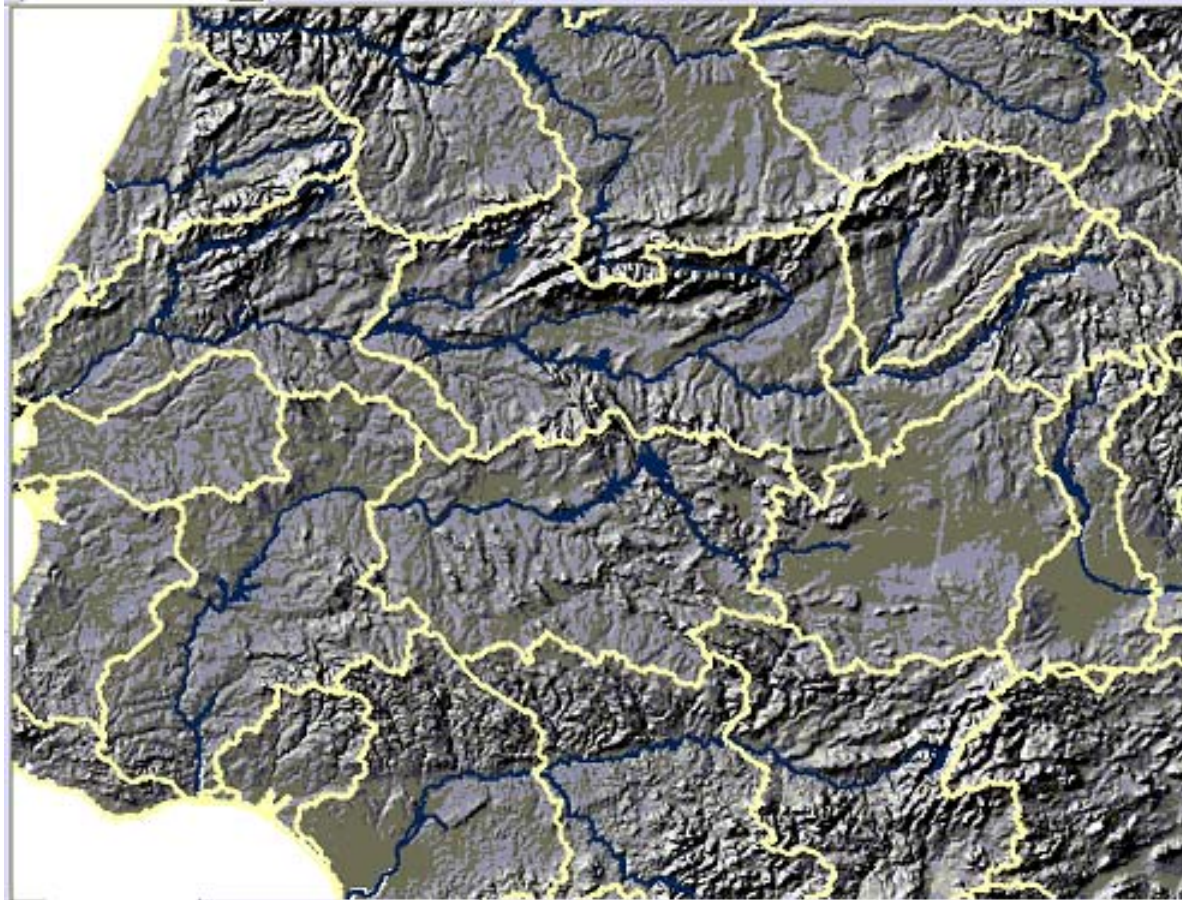
# From theoretical to observation units





# Mapping & classification of socio-ecological landscape units (SELU)

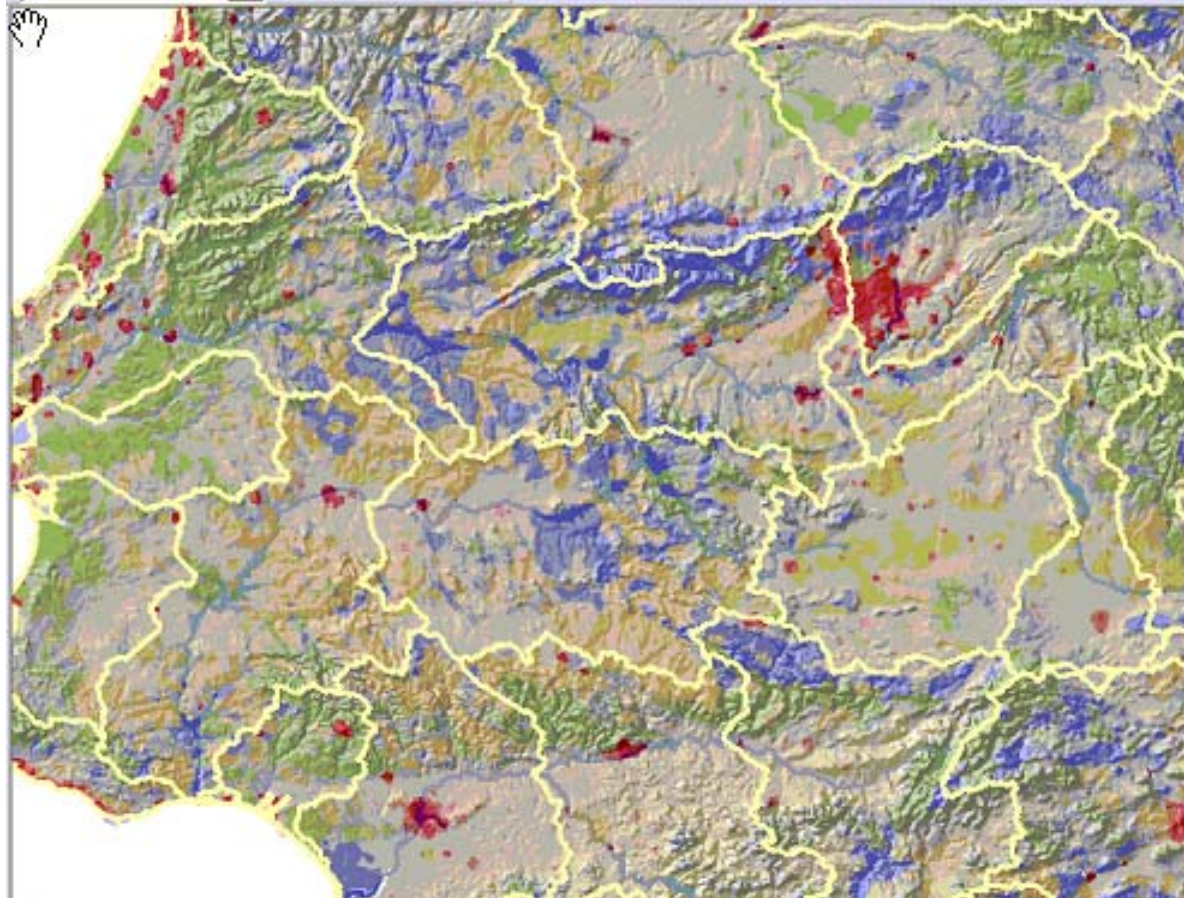
1- river basins and 2- relief



*Courtesy Emil D. Ivanov, 2011*



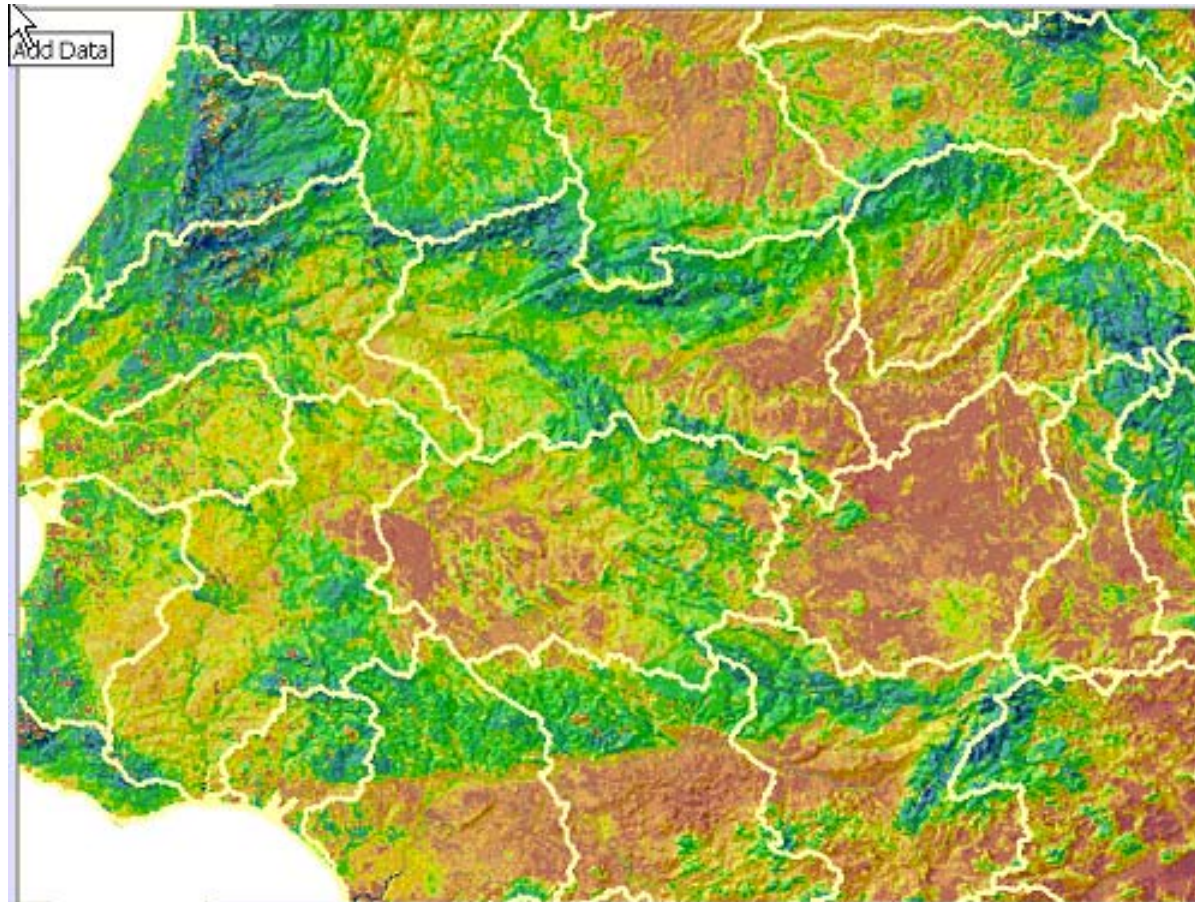
Mapping & classification of socio-ecological landscape units (SELU)  
3- dominant landscape types (urban, intensive agriculture, mosaics, grassland, forests, other natural types and no-dominance)



*Courtesy Emil D. Ivanov, 2011*



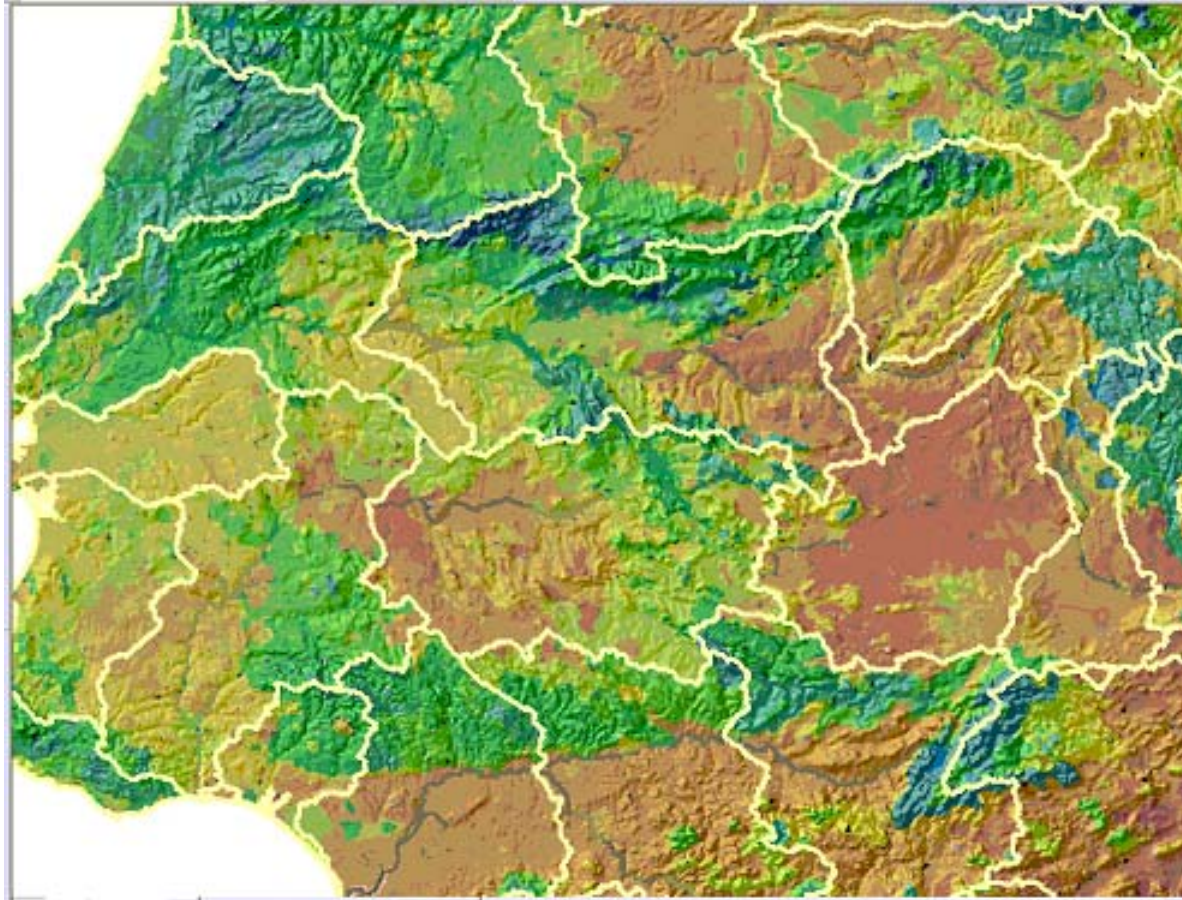
Application: NECB (net ecosystem carbon balance)  
*here by 1x1 km grid*



*Courtesy Emil D. Ivanov, 2011*



Application: NECB (net ecosystem carbon balance)  
*here mean NECB value by SELUs within river basins*



*Courtesy Emil D. Ivanov, 2011*



## Classification of Socio-ecological landscape units (SELU)

## Classification of socio-ecological landscape units (SELU)

1. **Mountain ecosystem landscapes**
  - 1.1 Mountain ecosystems/ Built up and associated areas
  - 1.2 Mountain ecosystems/ Broad pattern agriculture
  - 1.3 Mountain ecosystems/ Agriculture associations and mosaics
  - 1.4 Mountain ecosystems/ Pastures and natural grassland
  - 1.5 Mountain ecosystems/ Forest tree cover
  - 1.6 Mountain ecosystems/ Other dominant natural land cover
  - 1.7 Mountain ecosystems/ Composite land cover (no dominant land cover)
2. **Highland ecosystem landscapes**
  - 2.1 Highland ecosystems/ Built up and associated areas
  - 2.2 Highland ecosystems/ Broad pattern agriculture
  - 2.3 Highland ecosystems/ Agriculture associations and mosaics
  - 2.4 Highland ecosystems/ Pastures and natural grassland
  - 2.5 Highland ecosystems/ Forest tree cover
  - 2.6 Highland ecosystems/ Other dominant natural land cover
  - 2.7 Highland ecosystems/ Composite land cover (no dominant land cover)
3. **Lowland ecosystems inland landscapes**
  - 3.1 Lowland ecosystems/ Built up and associated areas
  - 3.2 Lowland ecosystems/ Broad pattern agriculture
  - 3.3 Lowland ecosystems/ Agriculture associations and mosaics
  - 3.4 Lowland ecosystems/ Pastures and natural grassland
  - 3.5 Lowland ecosystems/ Forest tree cover
  - 3.6 Lowland ecosystems/ Other dominant natural land cover
  - 3.7 Lowland ecosystems/ Composite land cover (no dominant land cover)
4. **Coastal**
  - 4.1 Coastal ecosystems/ Built up and associated areas
  - 4.2 Coastal ecosystems/ Broad pattern agriculture
  - 4.3 Coastal ecosystems/ Agriculture associations and mosaics
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## Physical measurement of ecosystem services

- Material & energy (provisioning services) v.s. functional services (regulating & socio-cultural)
  - Material & energy: the basic accounting balances for assets
  - Functional services: indirect measurement from the observation of land cover/land use:
    - Number of individuals\*presence in the SES
    - Number of estates benefiting of the service
    - Measurement of the change in service supply as a function of the change in land cover



# Supply of ecosystem services by land cover types

Services	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	3.1	3.2	3.3	3.4	3.5
	<i>Food</i>	<i>Materials</i>	<i>Forest trees-related</i>	<i>Plant-related</i>	<i>Physical support</i>	<i>Amenity</i>	<i>Identity</i>	<i>Didactic</i>	<i>Cycling</i>	<i>Sink</i>	<i>Prevention</i>	<i>Refugium</i>	<i>Breeding</i>
<i>Land cover types</i>													
Artificial surfaces/ Urban													
Arable land & permanent crops													
Grassland & mixed farmland													
Forests & woodland shrub													
Heathland, sclerophyllous veg.													
Open space with little/ no vegetation													
Wetlands													
Water bodies													





## In progress: Classification of ecosystem services

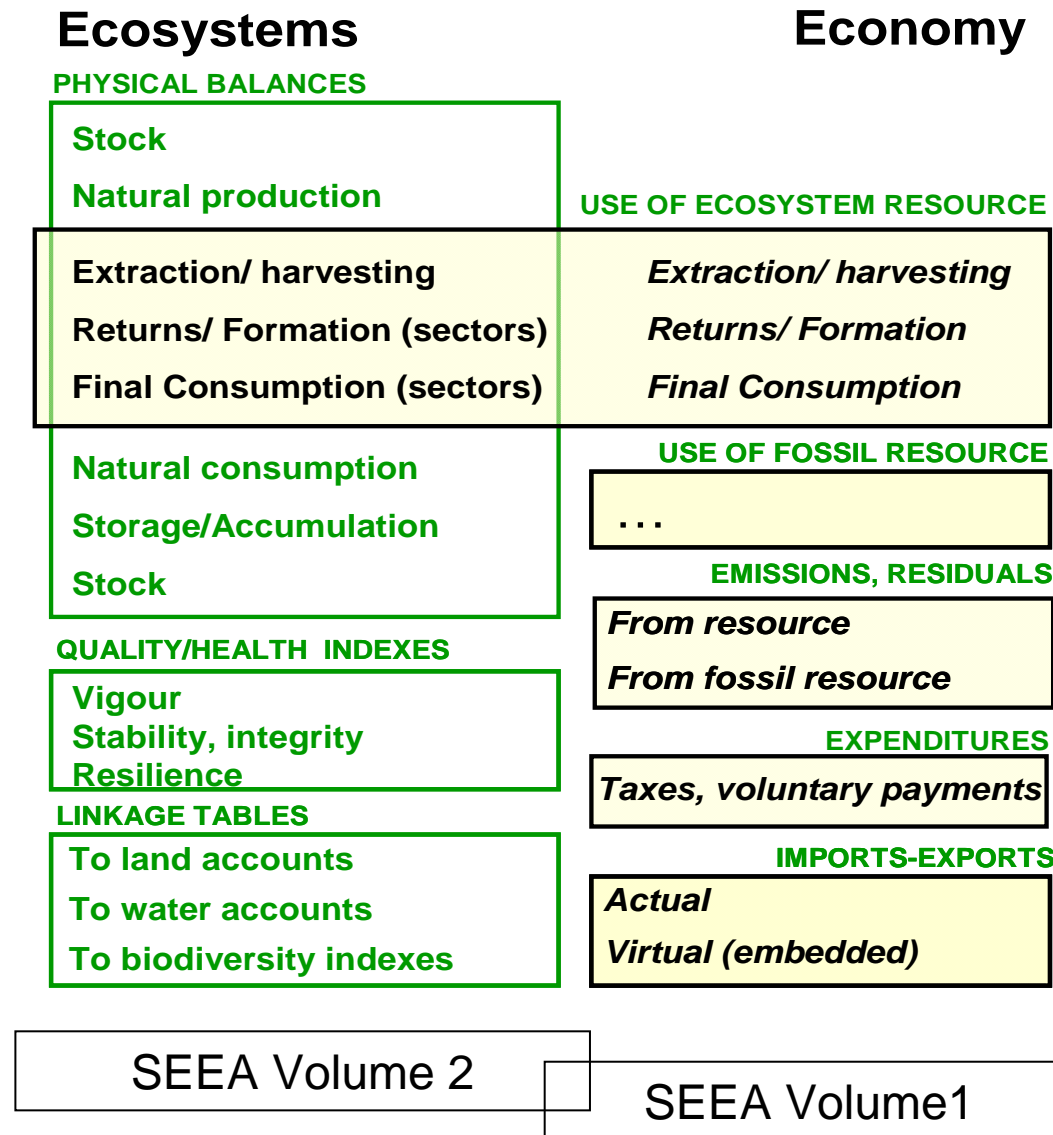
- Early work by Robert Costanza, Rudolf de Groot, Gretchen Daily et al...
- Millennium Ecosystem Assessment (MA 2005) first synthesis
- Further discussion, amendments, variants....: e.g. Robert Costanza (scale dimension), James Boyd (restrictive definition of end use services) and others...
- In December 2008, international expert meeting on the project of a **Common International Classification of Ecosystem Services (CICES)** convened by the EEA, together with UNEP and the German Federal Ministry of Environment. Purpose: have a common tools to be used in the various initiatives and researches.
- Second international expert meeting in Dec. 2009, preceded by an electronic consultation.
- Draft CICES presented to UNCEEAA in June 2010



CICES: Table E.2: Proposed Thematic, Class and Group Structure

Theme	Class	Group
Provisioning	Nutrition	Terrestrial plant and animal foodstuffs
		Freshwater plant and animal foodstuffs
		Marine plant and animal foodstuffs
		Potable water
	Materials	Biotic materials
		Abiotic materials
	Energy	Renewable biofuels
		Renewable abiotic energy sources
Regulation and Maintenance	Regulation of wastes	Bioremediation
		Dilution and sequestration
	Flow regulation	Air flow regulation
		Water flow regulation
		Mass flow regulation
	Regulation of physical environment	Atmospheric regulation
		Water quality regulation
		Pedogenesis and soil quality regulation
	Regulation of biotic environment	Lifecycle maintenance & habitat protection
		Pest and disease control
		Gene pool protection
	Cultural	Symbolic
Religious and spiritual		
Intellectual and Experiential		Recreation and community activities
		Information & knowledge

# Framework of physical ecosystem-economy integrated accounts



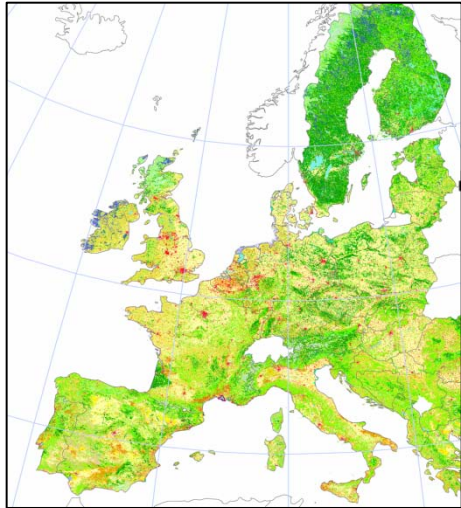




## Making it happen...

- As precise as necessary (relevance) but as simple as possible...
- Using existing data
- “Check list” as restricted as possible: 6 indexes
  - Land, landscape: integrity
  - Carbon/biomass: net balance
  - Biodiversity: trend
  - Water: availability for use (quantity and quality)
  - Dependency from artificial inputs: cultivation (N, irrigation, genes), subsidies
  - Disease prevalence, chemical stress
- Approach based on multicriteria analysis and diagnoses; no need to have the 6 indexes to come to a conclusion
- **Total Ecosystem Potential, TEP** = quantities weighted by health indexes
- ➔ Measured in EP Points, (*very similar to the Common Currency for Nature proposed by Peter Cosier & Jane McDonald*)
- **Loss of EPP = Ecosystem Capital Degradation**

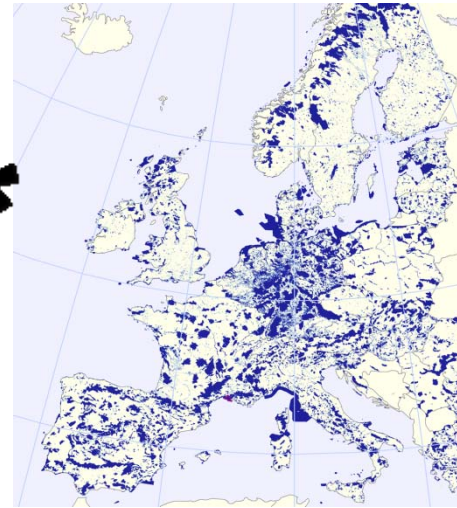
# Example 1: multicriteria diagnosis / land: landscape ecological potential



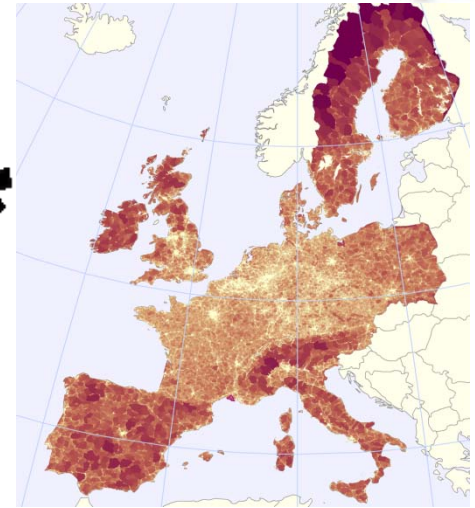
Corine land cover map (CLC is derived from satellite images)



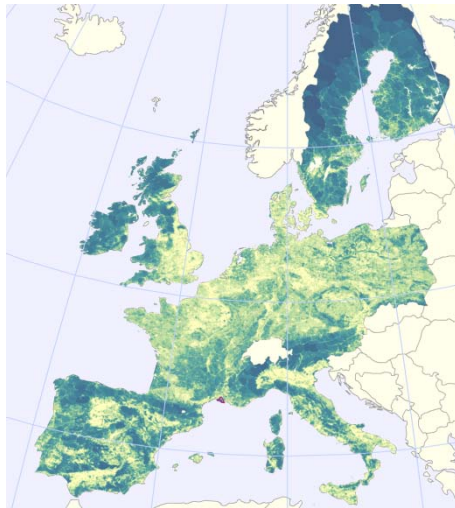
Green Landscape Index (derived from CLC)



Nature Value (*Naturilis*, derived from Natura2000 designated areas)

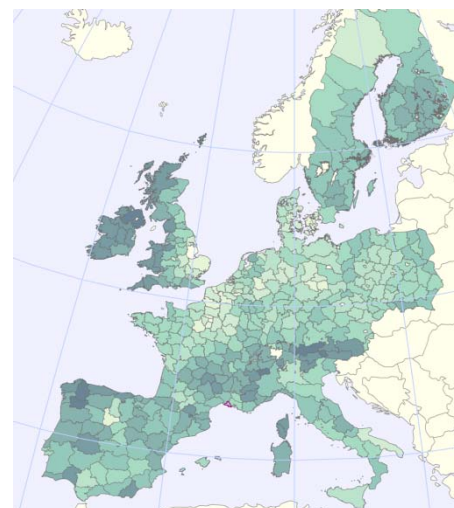


Fragmentation (*Effective Mesh Size (MEFF)* derived from TeleAtlas Roads and CLC)



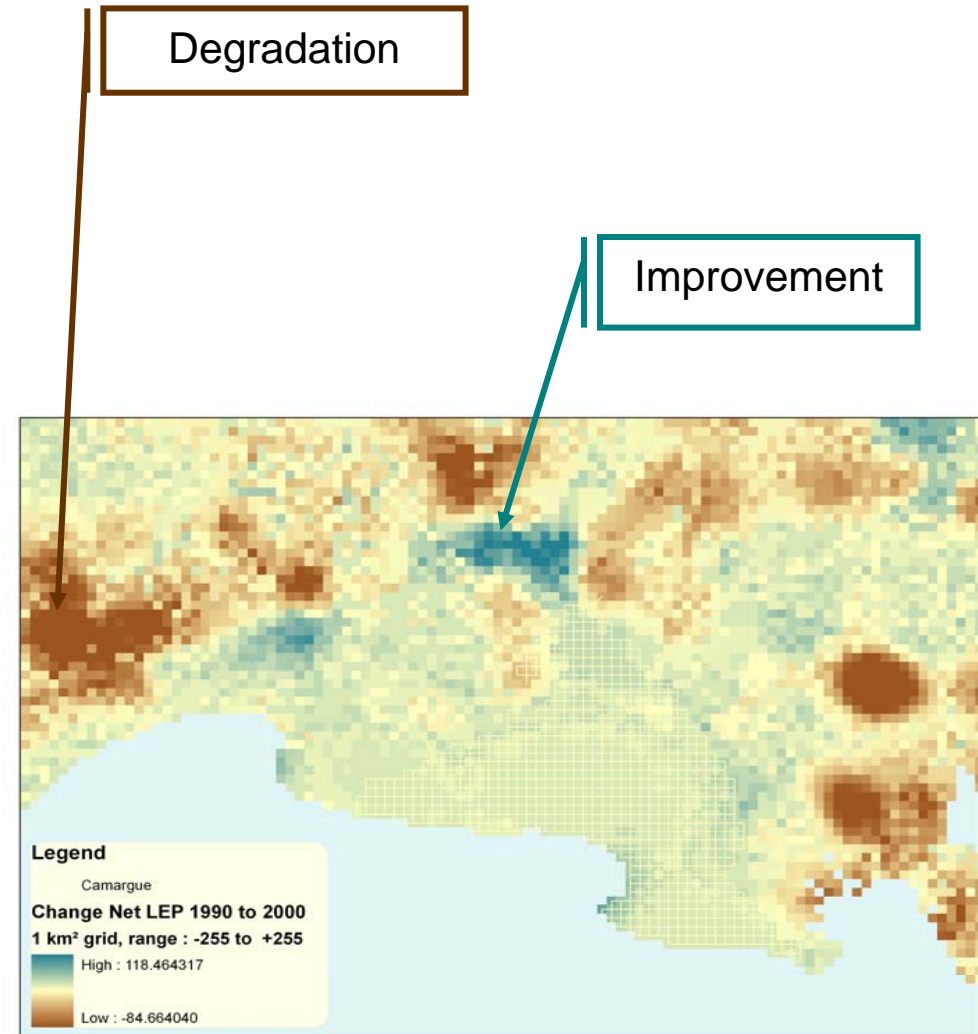
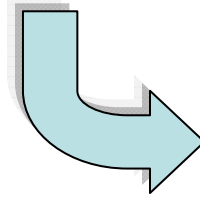
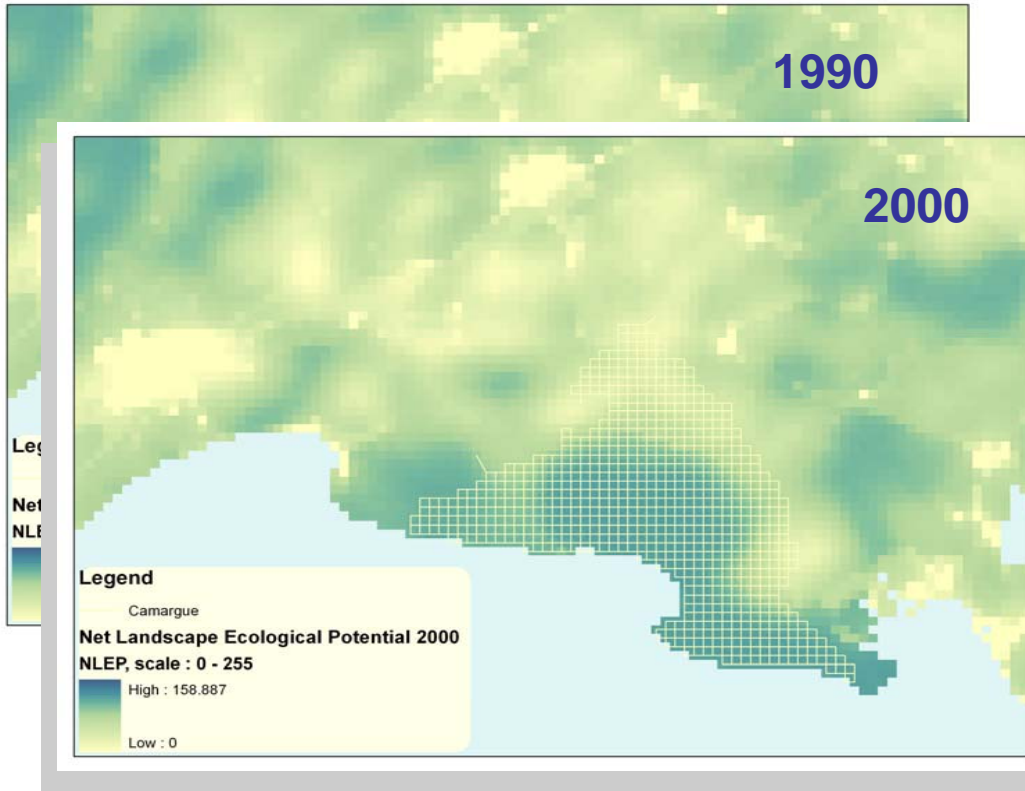
**Landscape Ecological Potential (LEP) 2000, by 1km<sup>2</sup> grid cell**

and



**LEP 2000 by NUTS 2/3**

# Landscape ecosystem potential and change 1990-2000





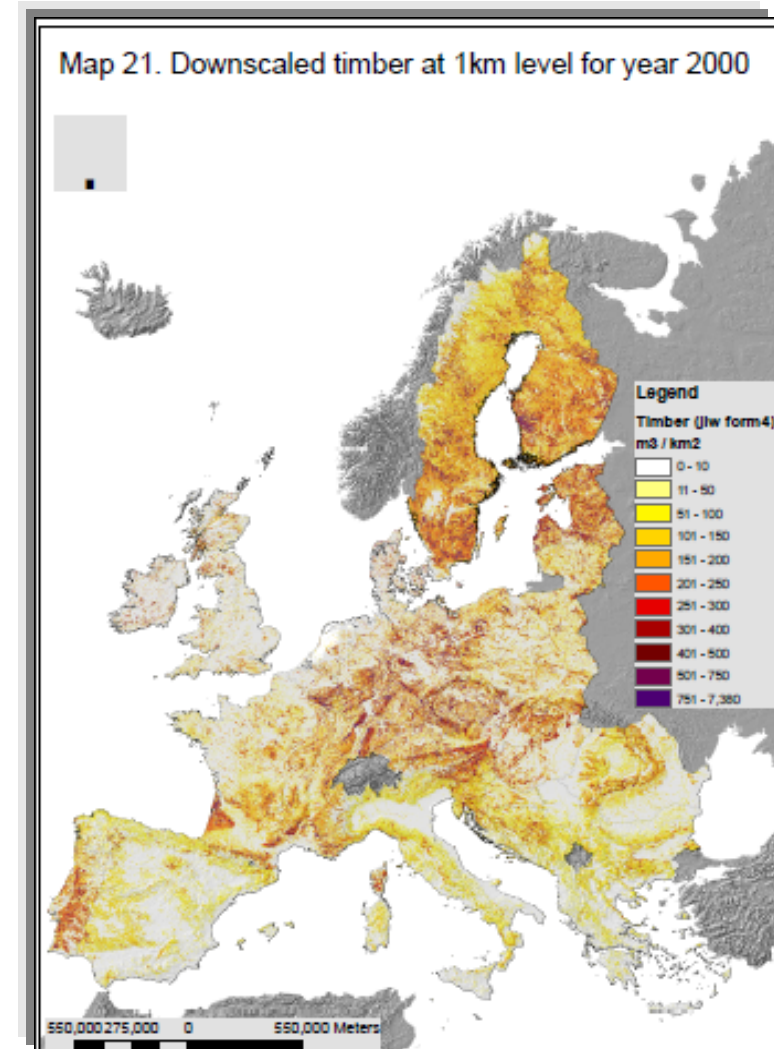
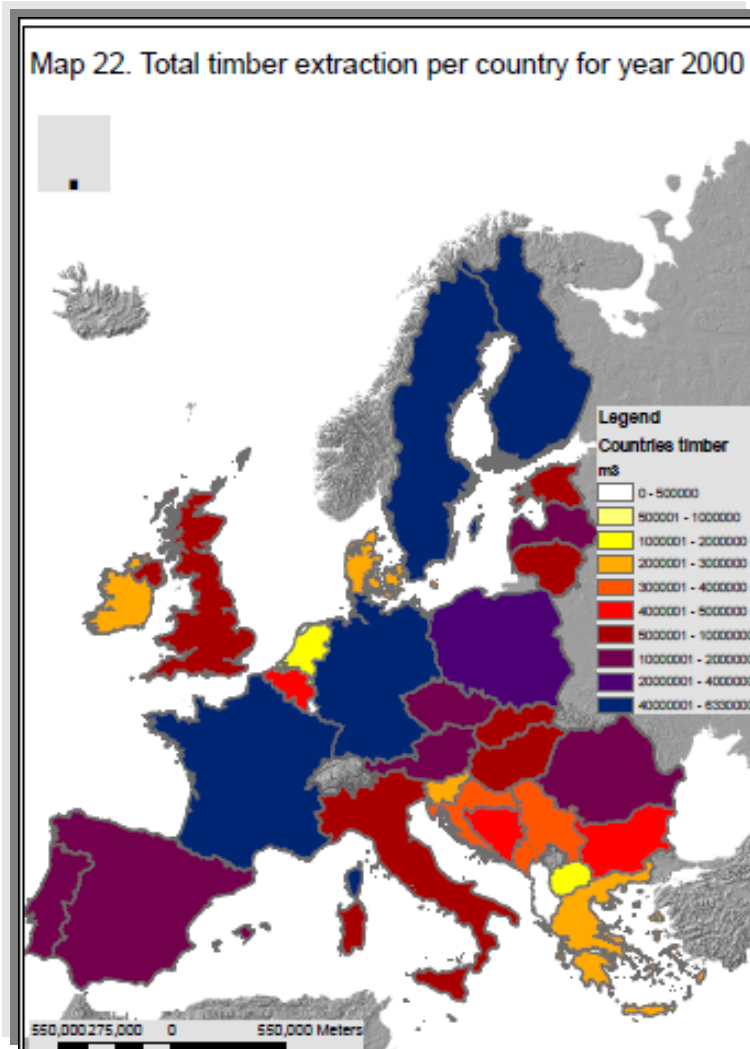
## Example 2: biomass/carbon net balance

- Ecosystem Net Carbon Balance ~ EPP minus Harvest
  - EPP is derived from NPP: regularly computed at the grid level
  - International agriculture and forest statistics are currently available by countries (by administrative regions in some cases)
- ➔ Need to downscale harvest/ felling statistics using land cover and NDVI vegetation indexes

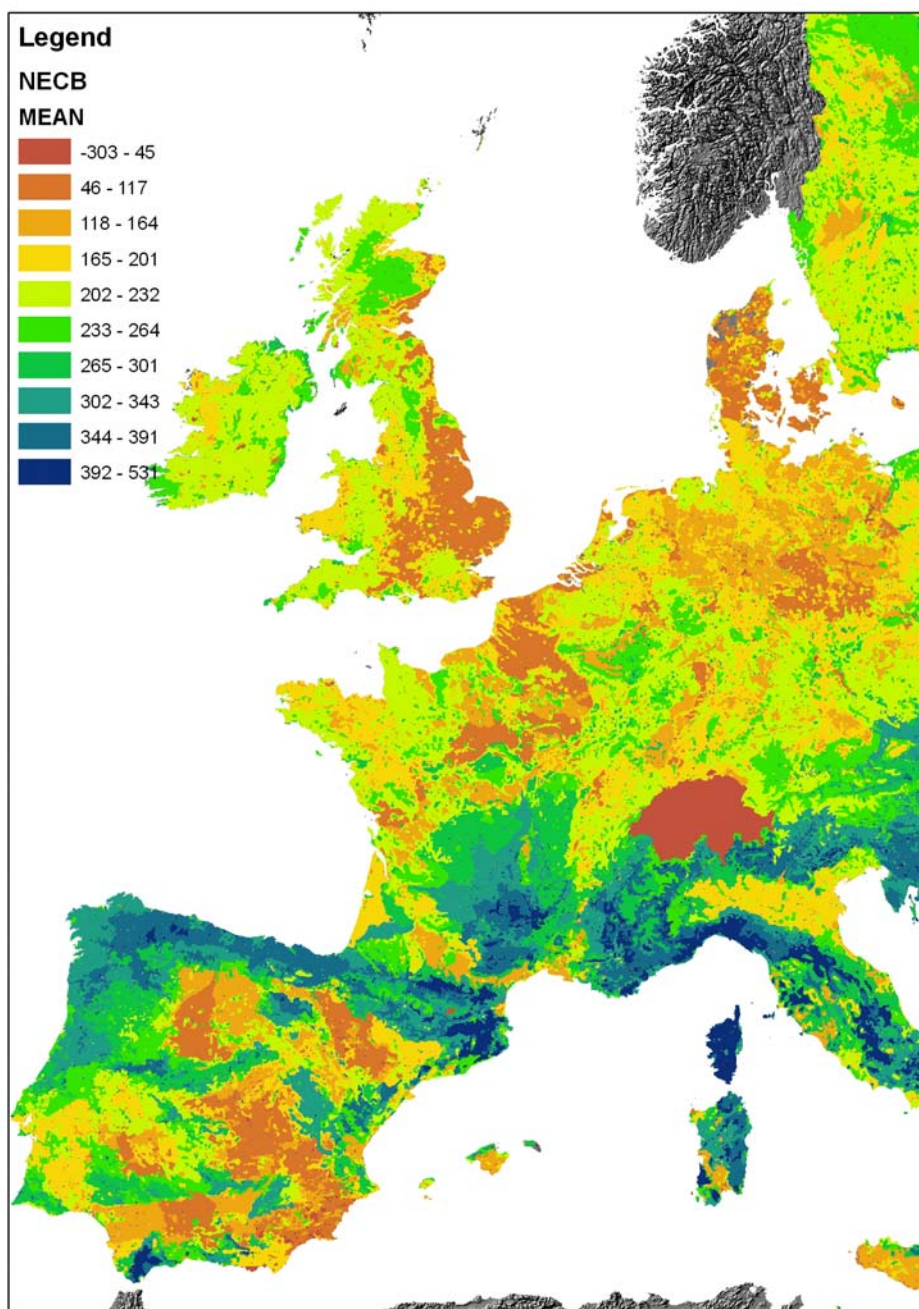




Data assimilation: Available statistics of timber extraction (left) and downscaled data (1 km<sup>2</sup>) (right)



Source: Emil D. Ivanov, ETCSA/EEA. 2011



## Net Ecosystem Carbon Balance by socio-ecological landscape units (SELU), 2000

Source: Emil D. Ivanov/Jean-Louis Weber, ETCSA/EEA. 2011

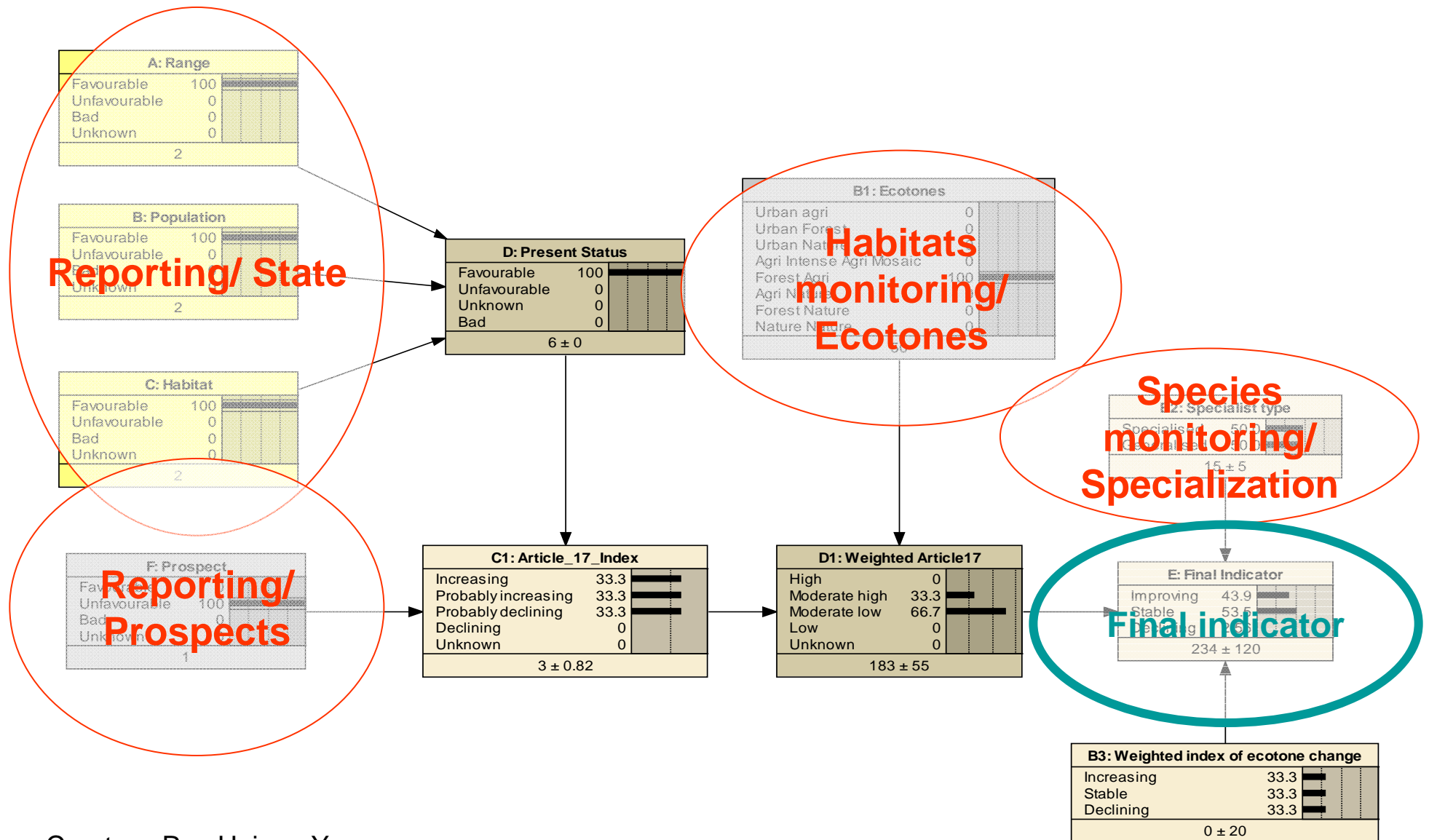


## Example 3: biodiversity index from heterogeneous data

- Downscaling various reporting data to the 1 km<sup>2</sup> grid
- Combination of data and expertise
- Multicriteria analysis with decision tree (e.g Bayesian Belief Network) and diagnosis



# Biodiversity index: combination of data and expertise



Courtesy Roy Haines-Young



## Ex. 4: Simplified basic water balance

Precipitation \*

- Spontaneous Real EvapoTranspiration \*\*
- + Net infiltration to soil/subsoil \*\*\*
- + *Inflows from upstream runoff*
- + Returns of used water & irrigation <sup>μ</sup>
- = ***Available water resource***
- Use of water by activities & households <sup>μ</sup>
- Evapotranspiration by activities
- = ***River basin runoff***

### Sources:

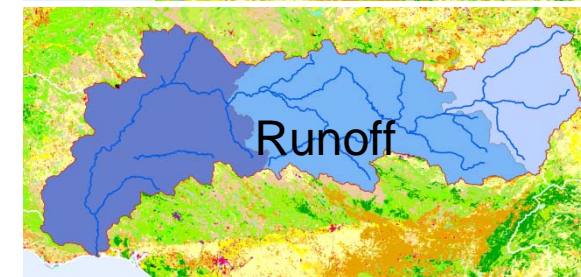
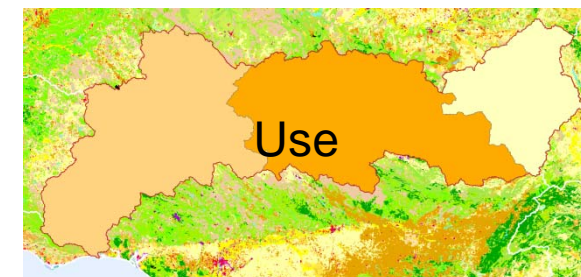
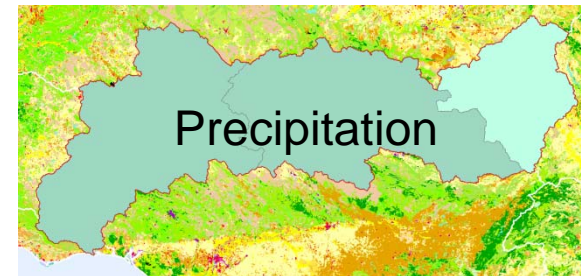
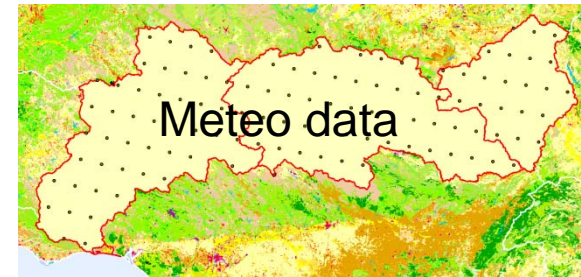
\* Meteo

\*\* Modelling from meteo data, land cover & NDVI

\*\*\* Hydrogeological modelling

<sup>μ</sup> Estimation from land cover & socio-economic statistics

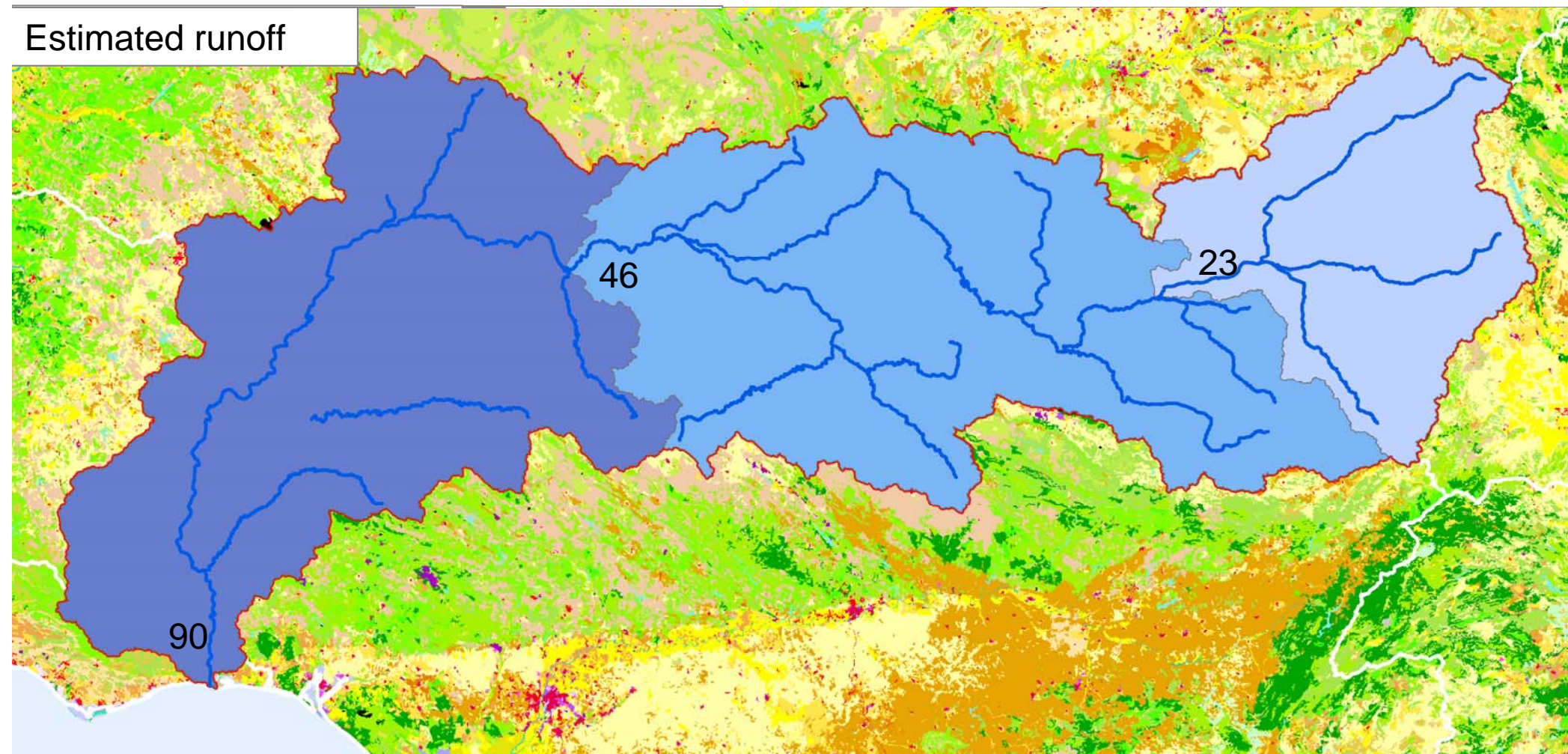
***Bold Ital: accounting balances***





## Fast calculation for 3 Guadiana River sub-basins

Estimated runoff



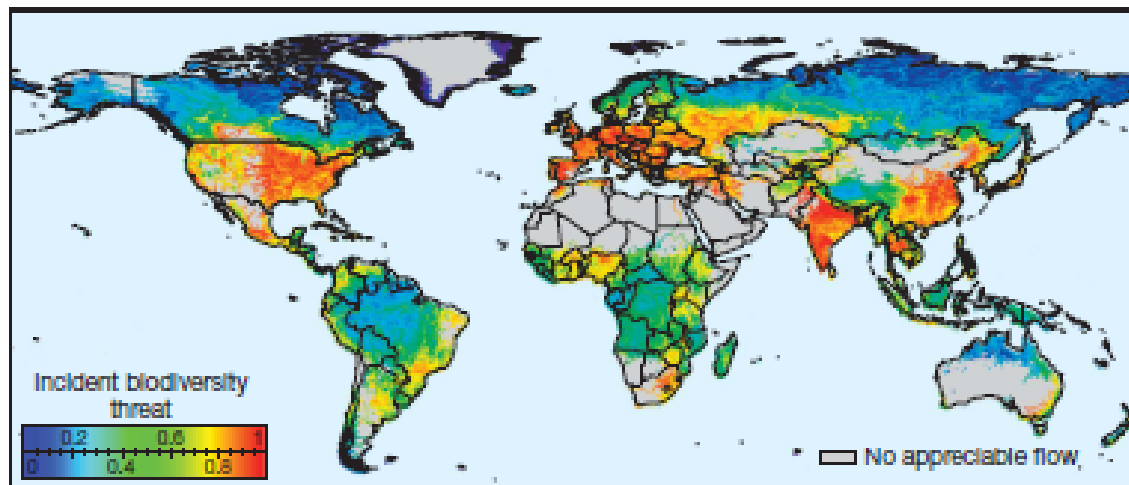
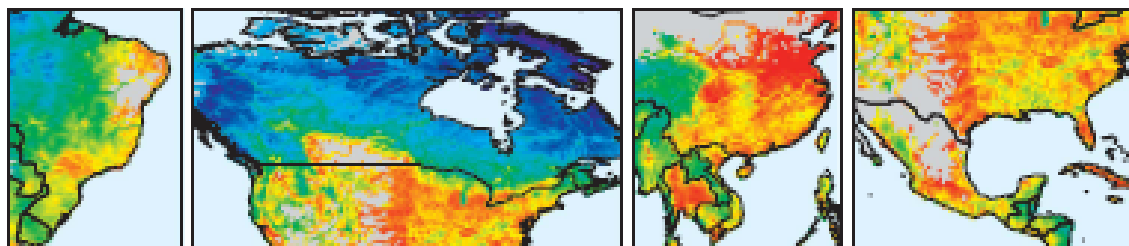
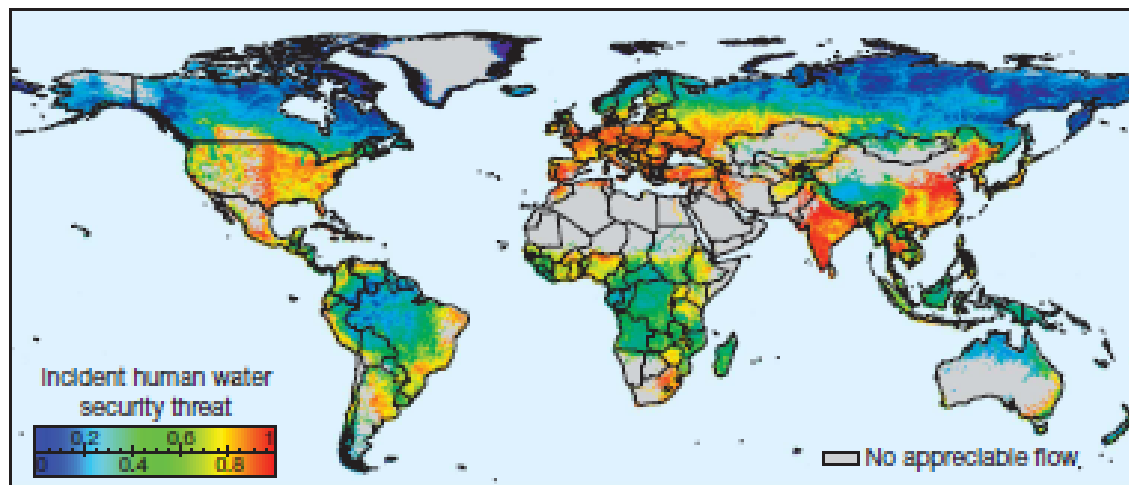
Source: EEA, Corine land cover, ECRINS – Estimations from various sources by Oscar Gomez Prieto & Jean-Louis Weber

# Water quantity & quality data exist at the Global scale



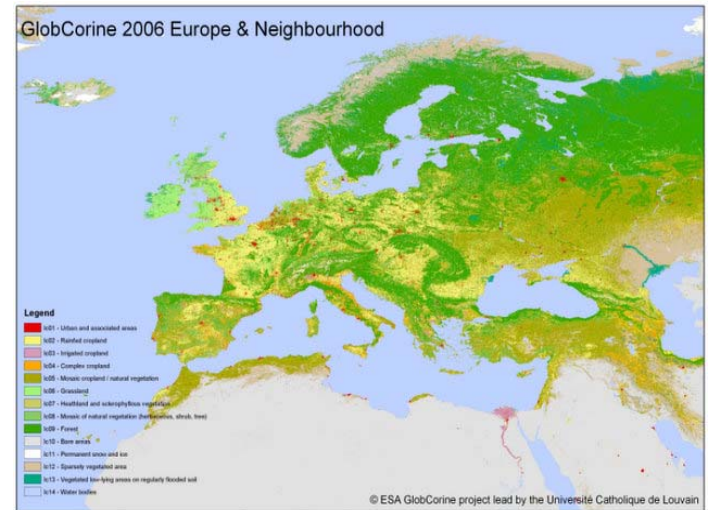
Meteo data

+ .....



Source: Global threats to human water security and river biodiversity, C. J. Vorosmarty, P. B. McIntyre et al., NATURE, Vol. 467, 30 Sept. 2010

# Earth observation data are abundant and more and more free

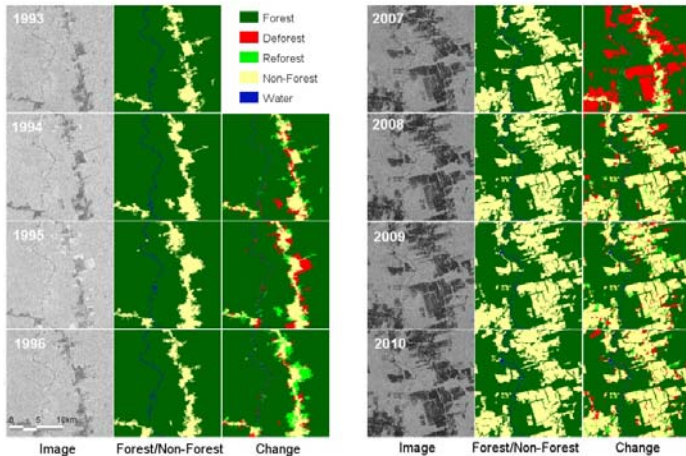


GlobeCorine 2005 © European Space Agency

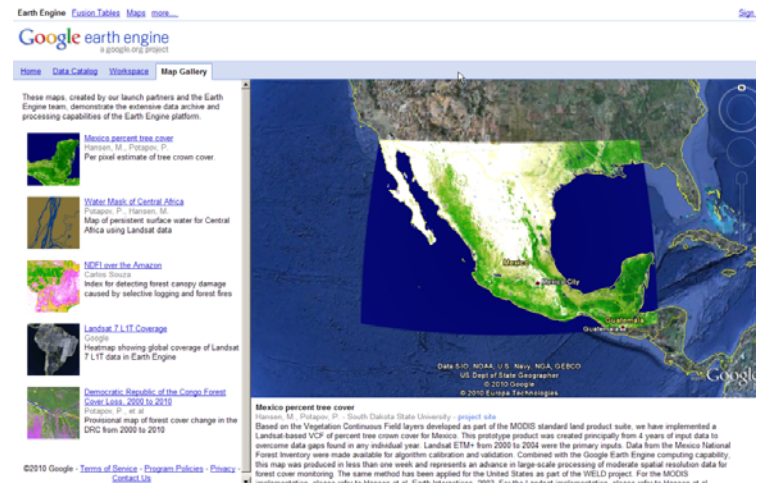
- GEO/GEOSS
- National programmes
- Private programmes



The land cover map for Russia based on MODIS 250 m

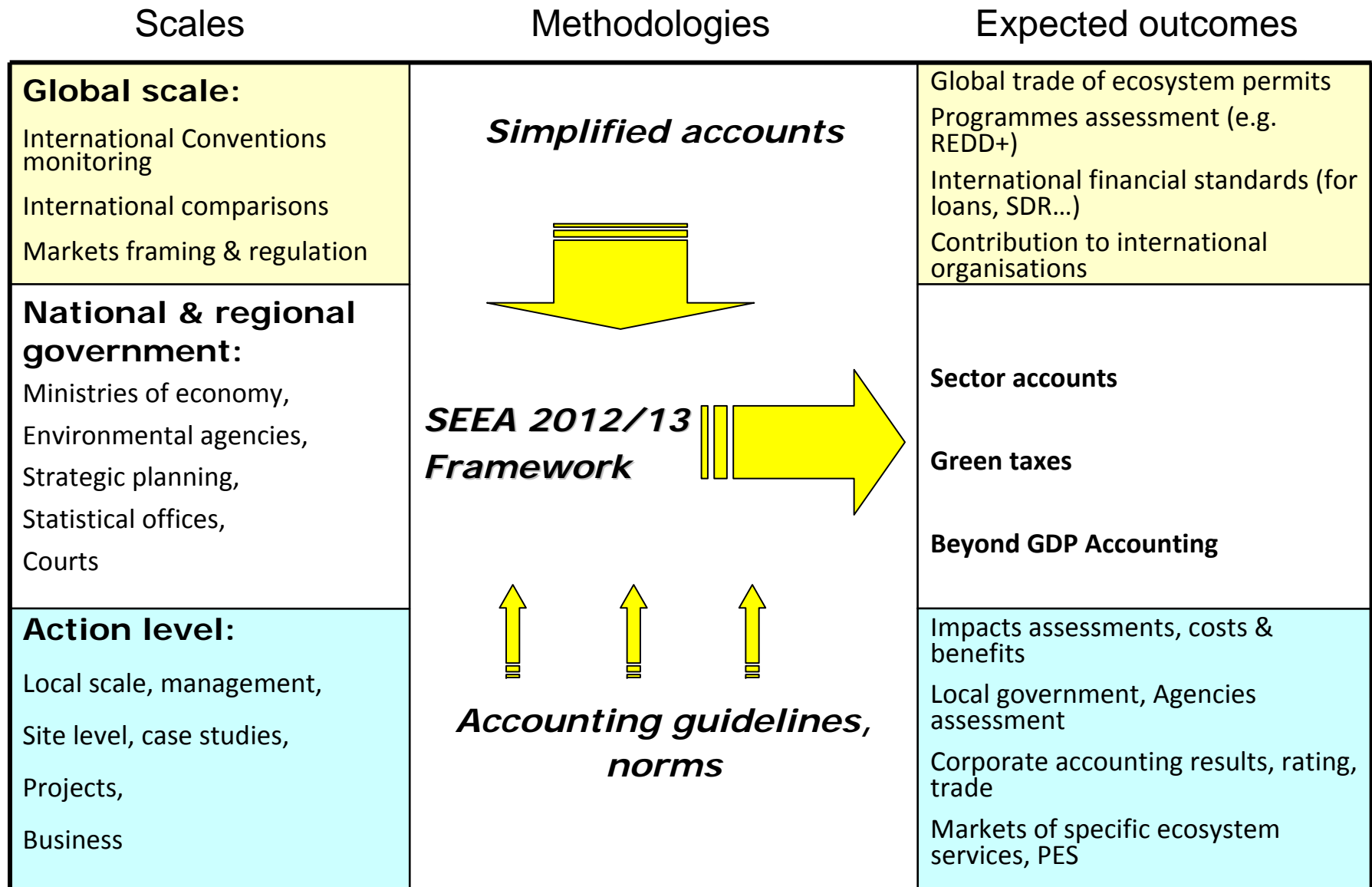


Forestry change over time in the State of Para, Amazon between 1993 and 2010 ©JAXA





# Tiered approach to ecosystem capital accounting



Thank you!



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