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…

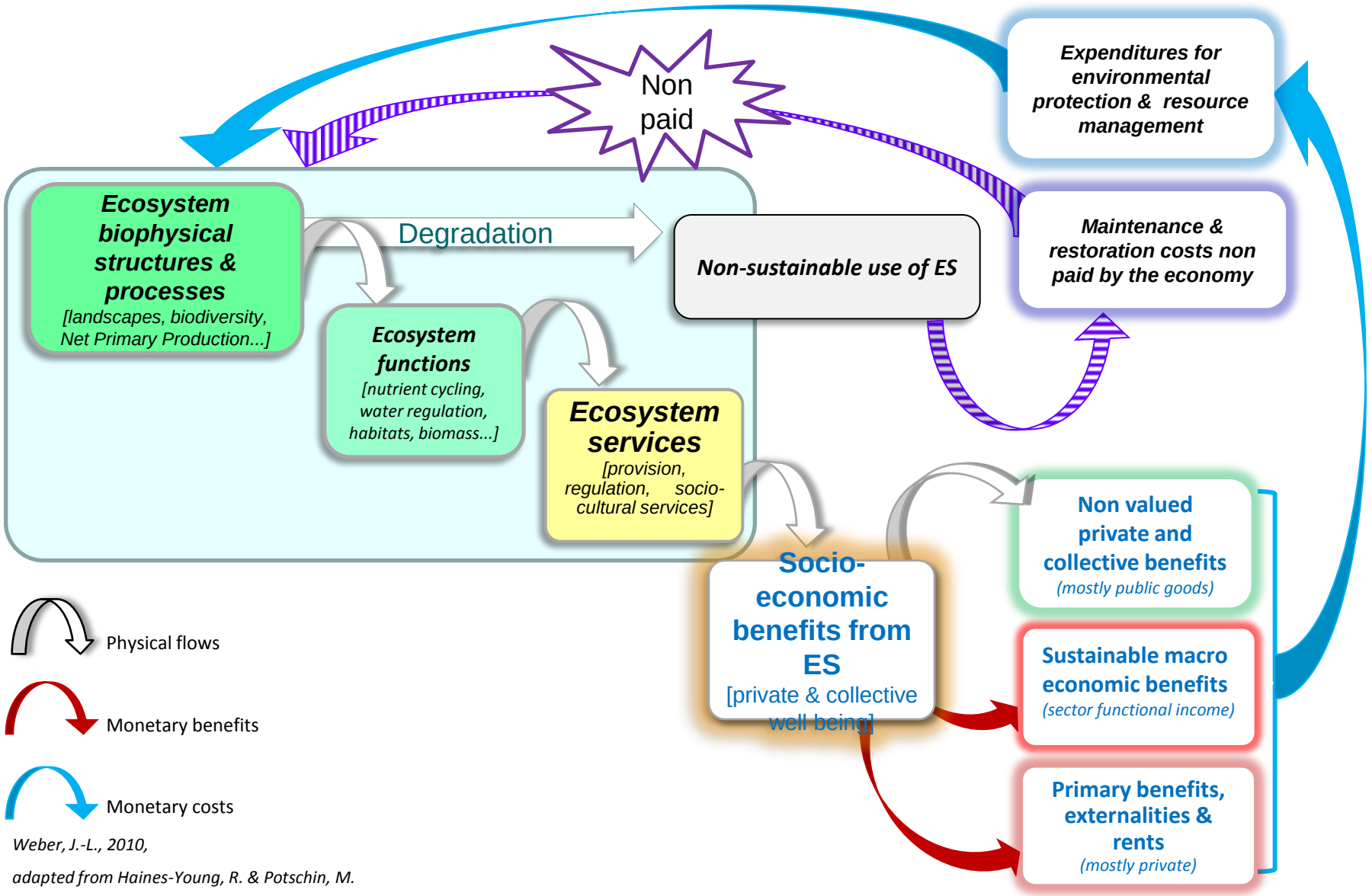
Fast Track Implementation of Simplified Ecosystem Capital Accounts in Europe (2009-2012)

- 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

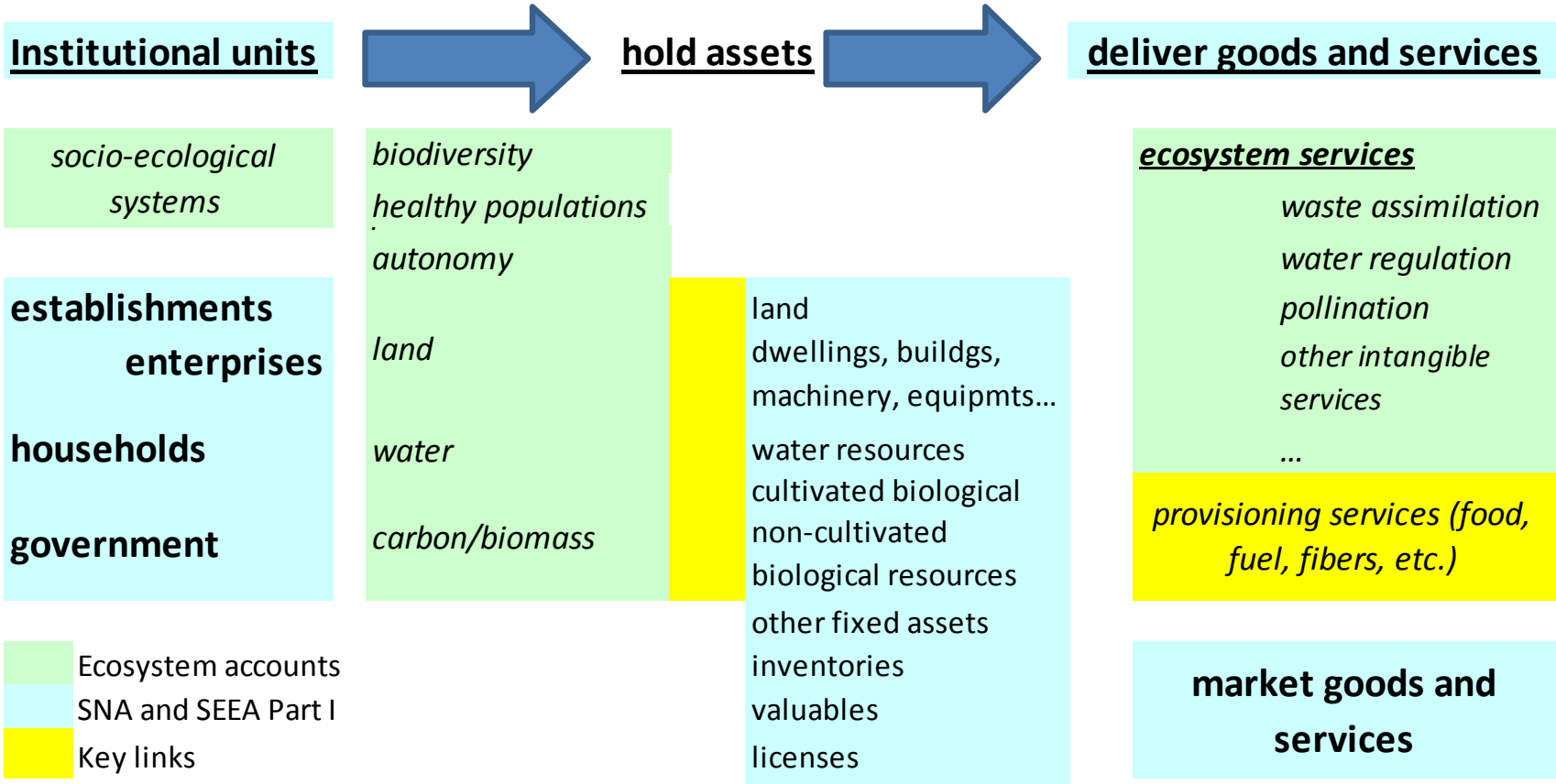
Ecosystem capital: systems & services, benefits & costs



Weber, J.-L., 2010,

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

SNA & SEEA: economic and ecosystem assets



Courtesy Daniel Clarke, 2011

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

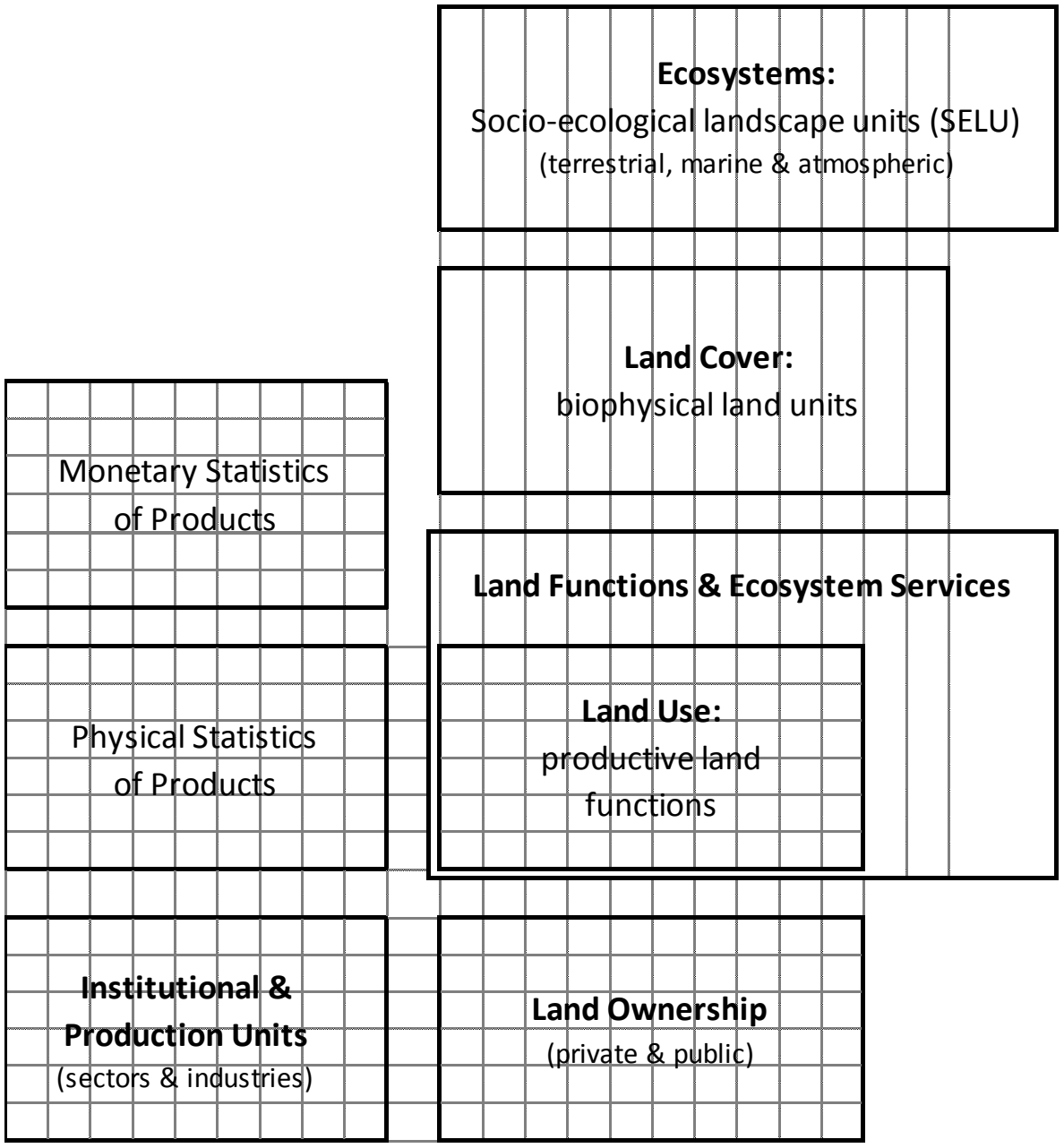
Physical accounts for ecosystems

- **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

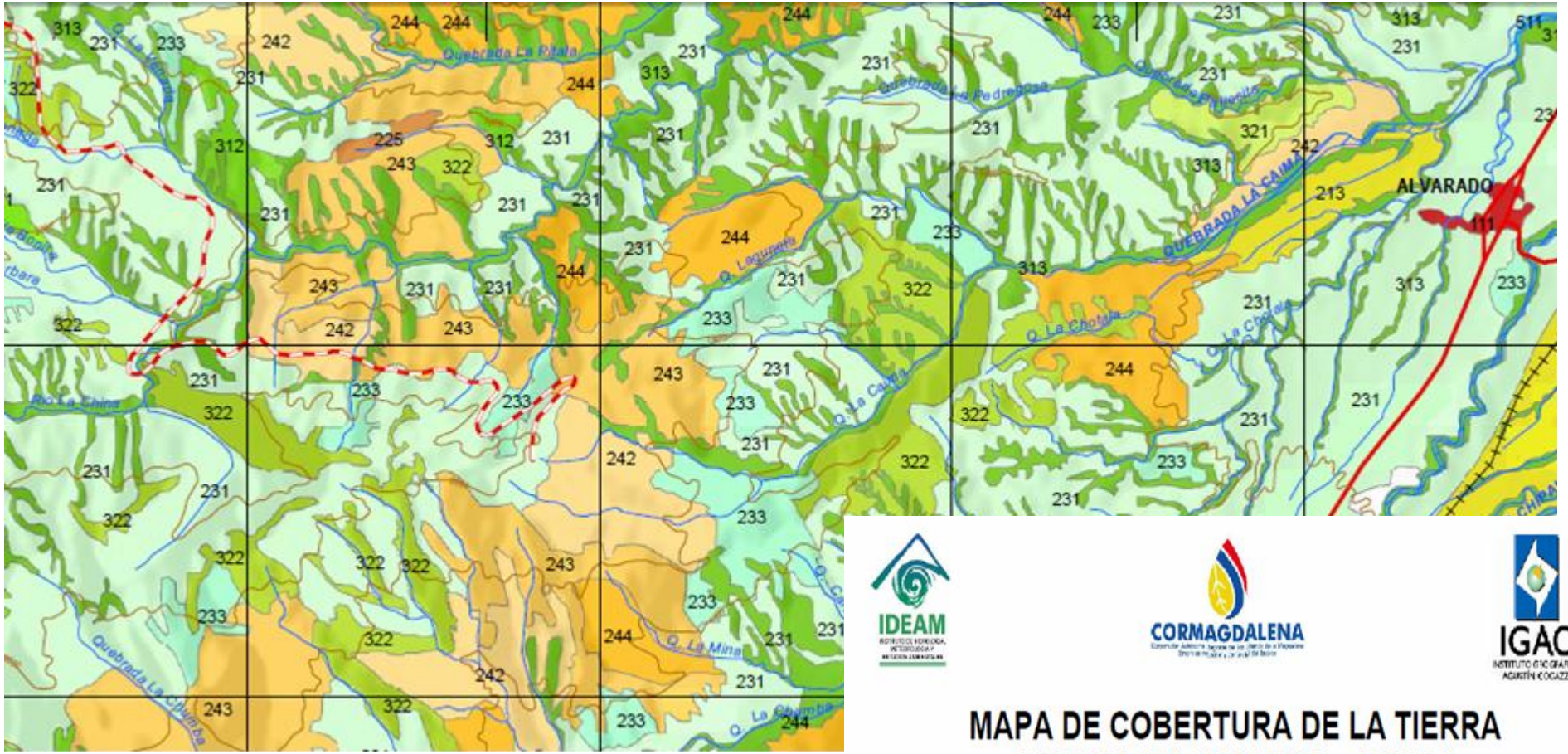
SNA statistical units don't record ecosystem degradation ➔ need for other units…

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…)



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

Theoretical analytical unit

SES / SEPL

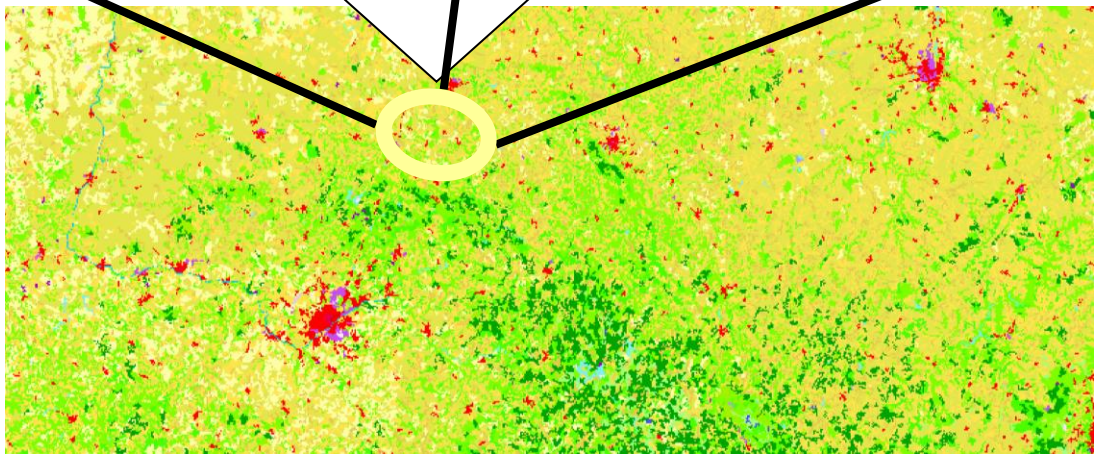
Candidate **socio-ecosystem landscape units** for observation & accounting **(SELU)**

Modeled SES/ SEPL

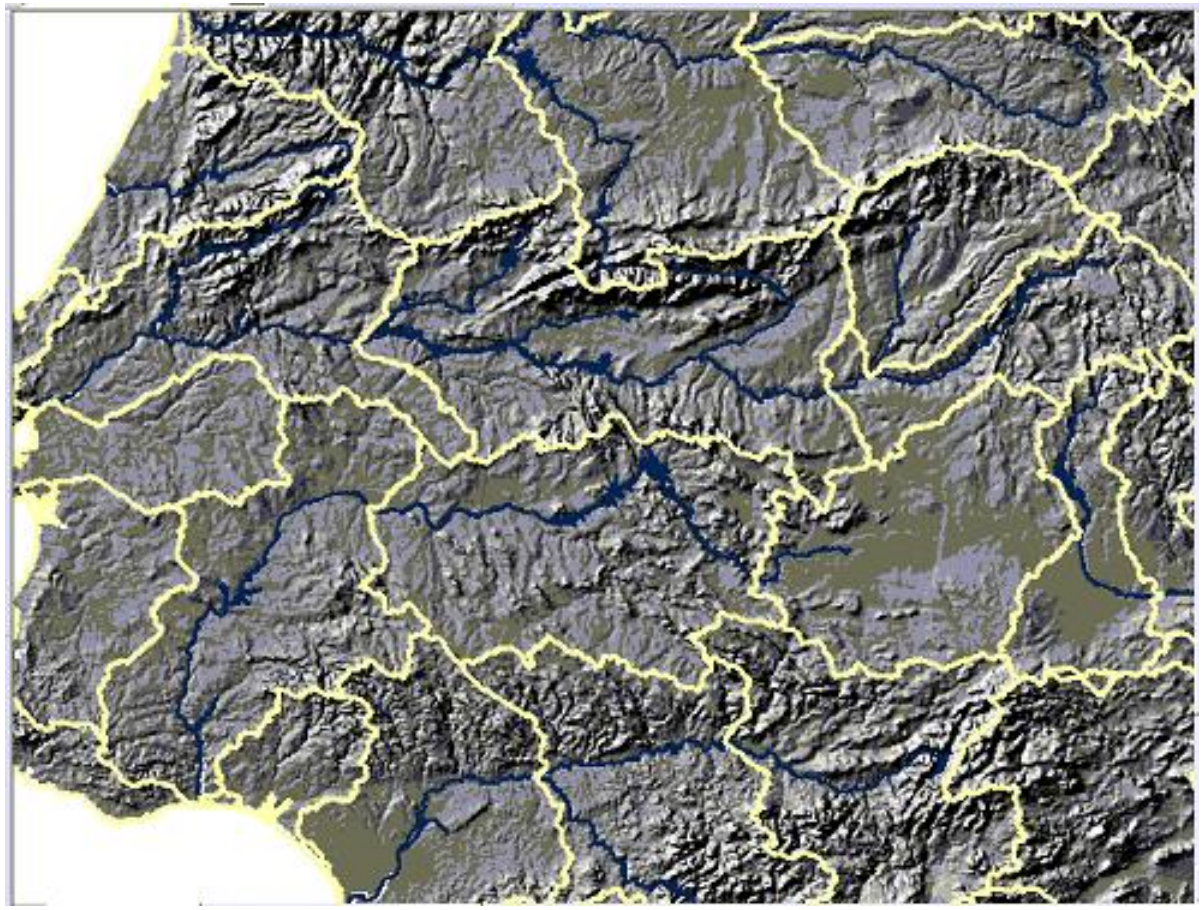
Topographic unit (eg. catchment)

Administrative or cadastral unit

Basic **land cover units** mapped with satellite images

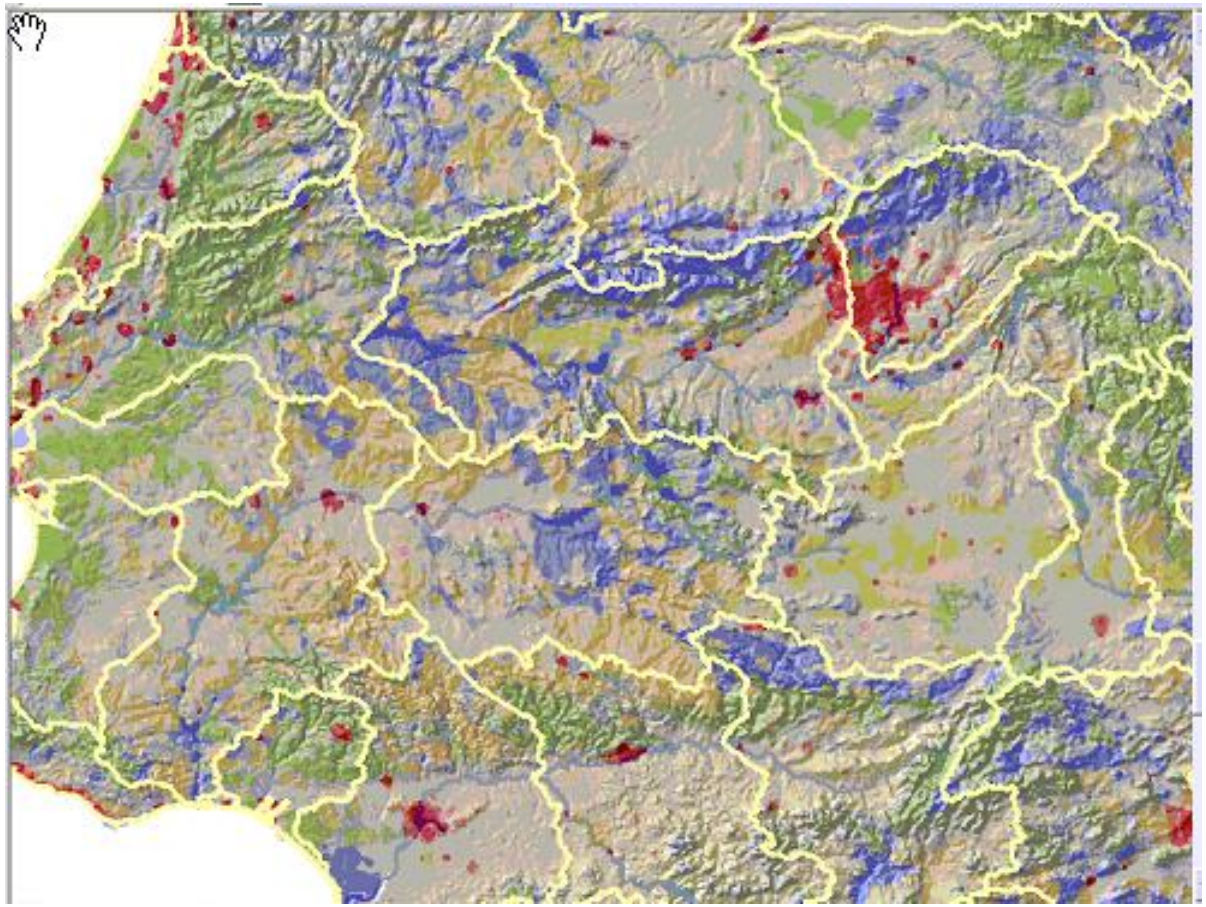


Mapping & classification of socio-ecological landscape units (SELU)
1- river basins and 2- relief



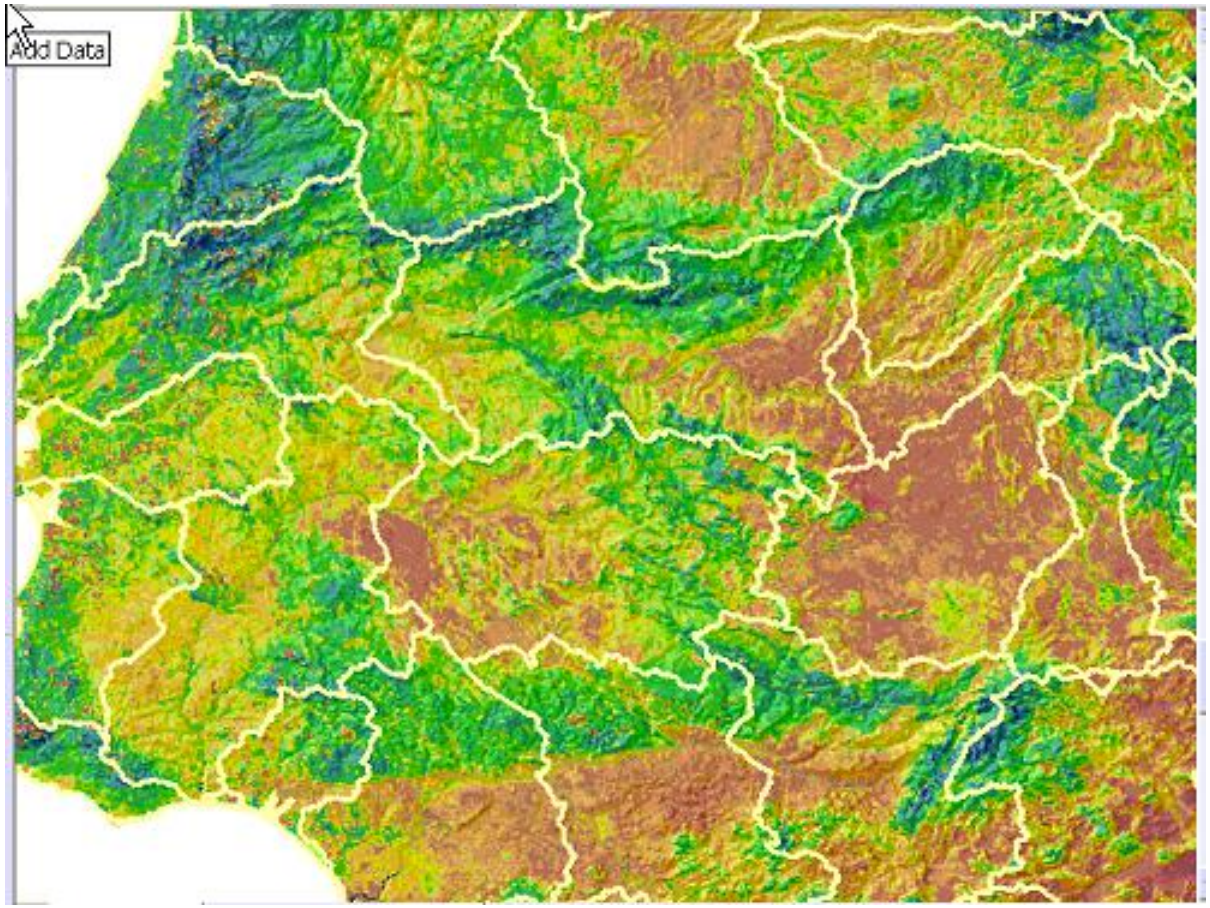
Courtesy Emil D. Ivanov, 2011

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



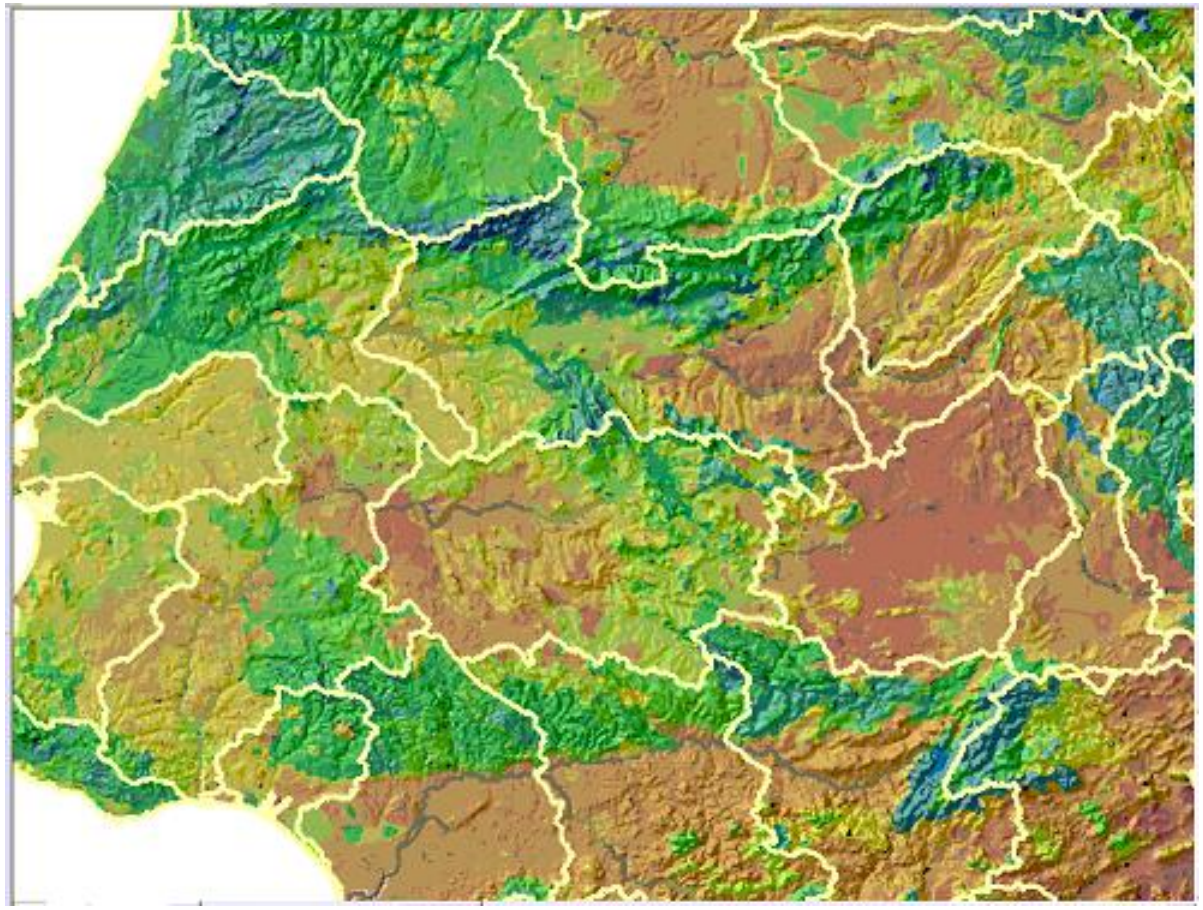
Courtesy Emil D. Ivanov, 2011

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 landcapes**
   - 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
   - 4.4 Coastal ecosystems/ Pastures and natural grassland
   - 4.5 Coastal ecosystems/ Forest tree cover
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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 / Landcover types	11 Food	12 Materials	13 Forest trees related	14 Plant-related	15 Physical support	21 Amenity	22 Identity	23 Didactic	31 Cycling	32 Sink	33 Prevention	34 Religium	35 Breeding
Artificial surfaces/ Urban	●	●			●●●	●●●	●●●	●●		●●●			
Arable land & permanent crops	●●●	●		●●	●	●	●	●	●	●●		●	●
Grassland & mixed farmland	●●●	●	●●	●●	●●	●●	●●●	●●●	●●	●●	●●●	●●	●●●
Forests & woodland shrub	●		●●●	●●	●	●●	●●	●●	●●●	●●	●	●●●	●●●
Heathland, sclerophylous veg.			●	●●		●●	●●	●●	●●	●●	●●●	●●	●●●
Open space with little/ no vegetation		●●		●		●●●	●●●	●●		●●		●●	●●●
Wetlands	●●	●	●	●●	●	●●●	●●●	●●●	●●	●	●●●	●●●	●●●
Water bodies	●●	●		●		●	●●●	●	●●●	●●●		●	●●●

In progress: Classification of ecosystem services

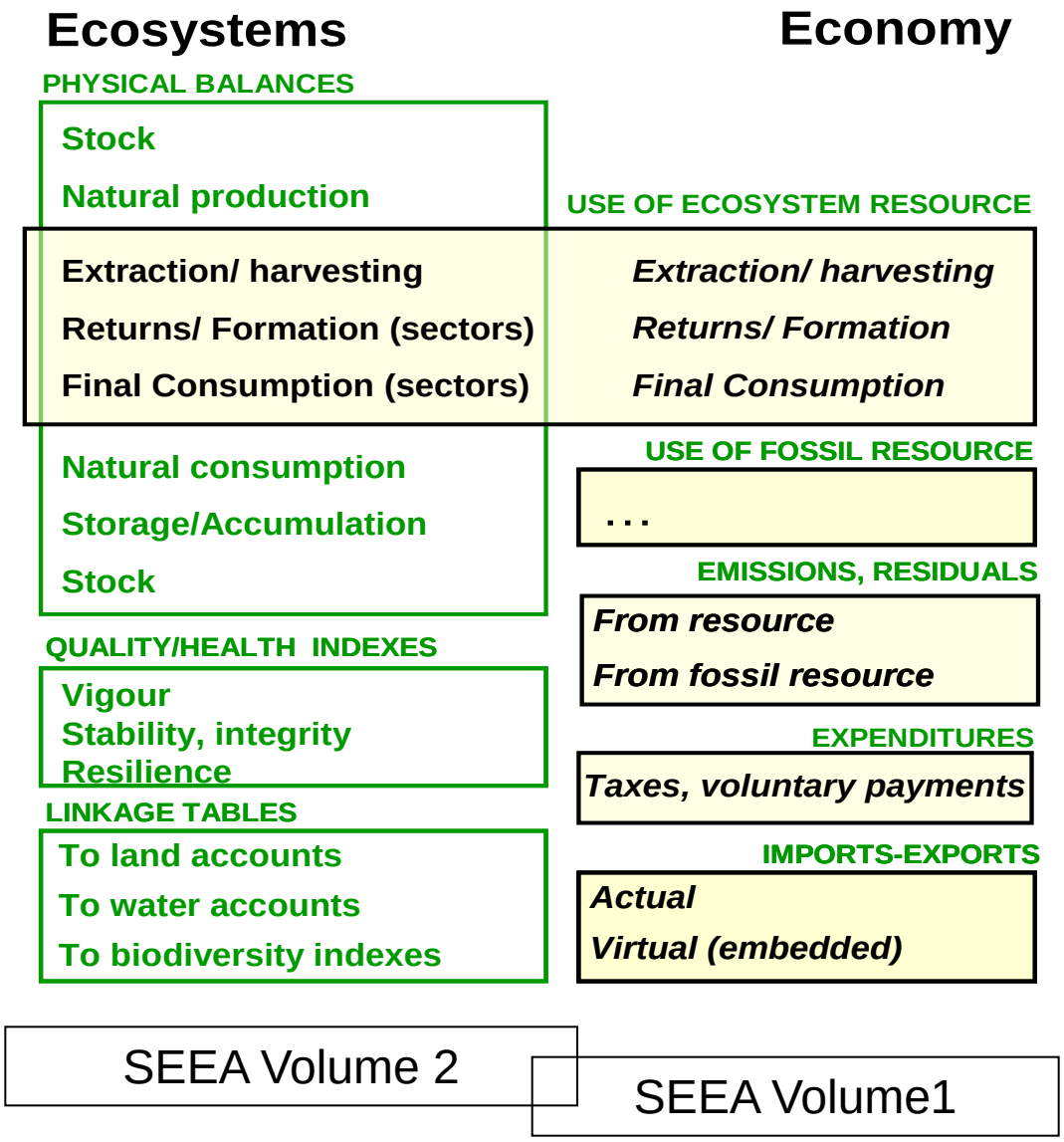
- Early work by Robert Costanza, Rudolf de Groot, Gretchen Daily et al…
- Millennium Ecosystem Assessment (MA 2005) first synthesis
- Further discussion, amendments, variants…: e.g. Robert Costanza (scale dimension), James Boyd (restrictive definition of end use services) and others…

- 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 sued in the various initiatives and researches.
- Second international expert meeting in Dec. 2009, preceded by an electronic consultation.
- Draft CICES presented to UNCEEA 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	Aesthetic, Heritage
		Religious and spiritual
	Intellectual and Experiential	Recreation and community activities
		Information & knowledge

Framework of physical ecosystem-economy integrated accounts



Example: Biomass/carbon accounts

Ecosystem Units Accounts

Ecosystem capital basic balance

1	**E0: Opening stock of ecosystem assets**
2	RESOURCE FORMATION/ Ecosystems
3	***Net Primary Production*** *(NPP= GPP minus plants respiration)*
4	*minus soil respiration*
5	Ecosystem Primary Production (EPP)
6	Returns & leftovers from agriculture & forestry
7	Artificial input (manure, organic fertilizers, plantations…)
8	Transfers from other ecosystems
9	Transfers from other territories
10	Effects of Land Cover formation
11	RESOURCE CONSUMPTION/ Ecosystems
12	Withdrawals
13	Losses and transfers to other ecosystems
14	Transfers to other territories
15	Effects of Land Cover consumption
16	*Net Ecosystem Carbon Balance (NECB) (= 2-11)*
17	**E1: Final stock of ecosystem assets (= 1 + 16)**

Ecosystem health count

16	*Net Ecosystem Carbon Balance (NECB) (= 2-11)*
18	NPP trends, productivity
19	NPP perturbation
20	Change in NPP profiles
21	*Multicriteria ecosystem health index/ biomass*

Stress factors indexes

22	Overharvesting
23	Farming practices
24	Pollution, chemicals
25	Land restructuring
26	Natural & multiple causes

Ecosystem services

27	Provisioning services
28	Regulating services
29	Socio-cultural services

Economic Units Accounts

Ecosystem asset account

1	**S0: Opening stock of economic natural assets**
2	RESOURCE FORMATION/ Sectors & Industries
3	***Net Primary Production*** *(NPP= GPP minus plants respiration)*
4	*minus soil respiration*
5	Ecosystem Primary Production (EPP)
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Ecosystem services

27	Provisioning services
28	Regulating services
29	Socio-cultural services

Supply & Use, MFA, I-OT

1	SUPPLY/ Sectors & Industries
2	Supply of biomass to other domestic economic units
3	Biomass content of exports
4	Returns & leftovers from agriculture & forestry
5	Artificial input (manure, organic fertilizers, plantations…)
6	USE/ Sectors & Industries
7	Withdrawals
8	Biomass received from other domestic economic units
9	Biomass content of imports
10	Final consumption/combustion of biomass
11	*Net biomass accumulation in the user system (=1-6-10)*

Transfers of biomass between economic units

2 Supply of biomass to other domestic economic units	ISIC						
	ISIC						

8 Biomass received from other domestic economic units

Total Import-Exports of biomass

9	Biomass content of imports
13	Virtual flows of biomass embedded in imports
3	Biomass content of exports
14	Virtual flows of biomass embedded in exports

Total emissions of carbon residuals

15	Air emissions from consumption/combustion of biomass
16	Air emissions from combustion of fossil fuel
17	Other CO2/CH4/VOC emissions
18	Discharge of organic residuals to the water systems
19	Carbon content of solid waste

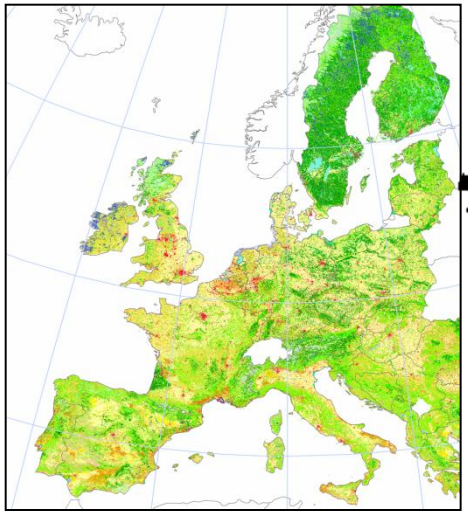
Making it happen…

- 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)*

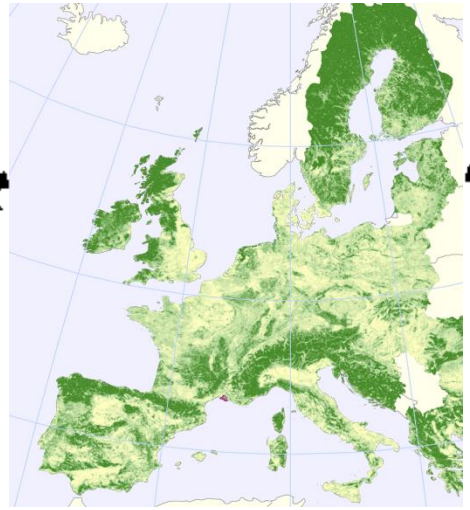
- **Loss of EPP = <u>Ecosystem Capital Degradation</u>**

Example 1: multicriteria diagnosis / land: landscape ecological potential



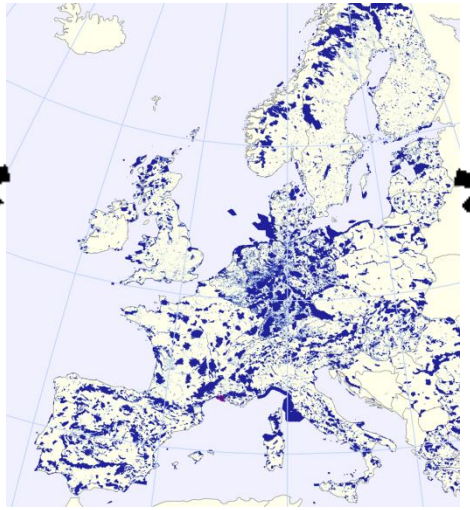
Corine land cover map *(CLC is derived from satellite images)*

*



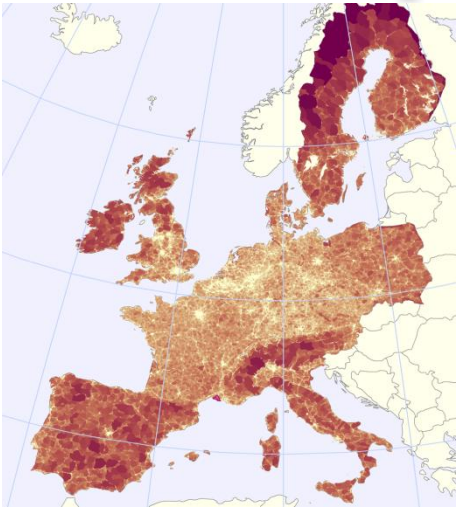
Green Landscape Index *(derived from CLC)*

*



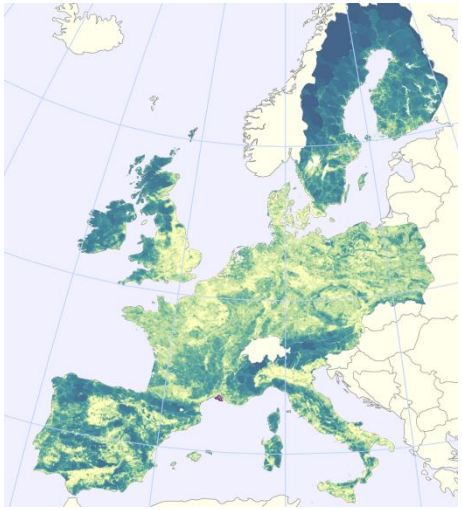
Nature Value (*Naturilis, derived from Natura2000 designated areas)*

*



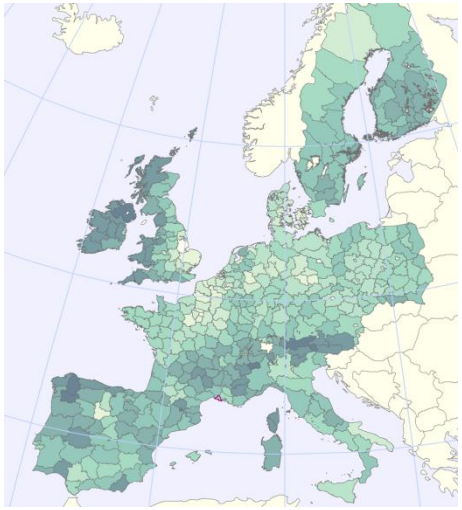
Fragmentation (*Effective Mesh Size (MEFF) derived from TeleAtlas Roads and CLC)*

➔



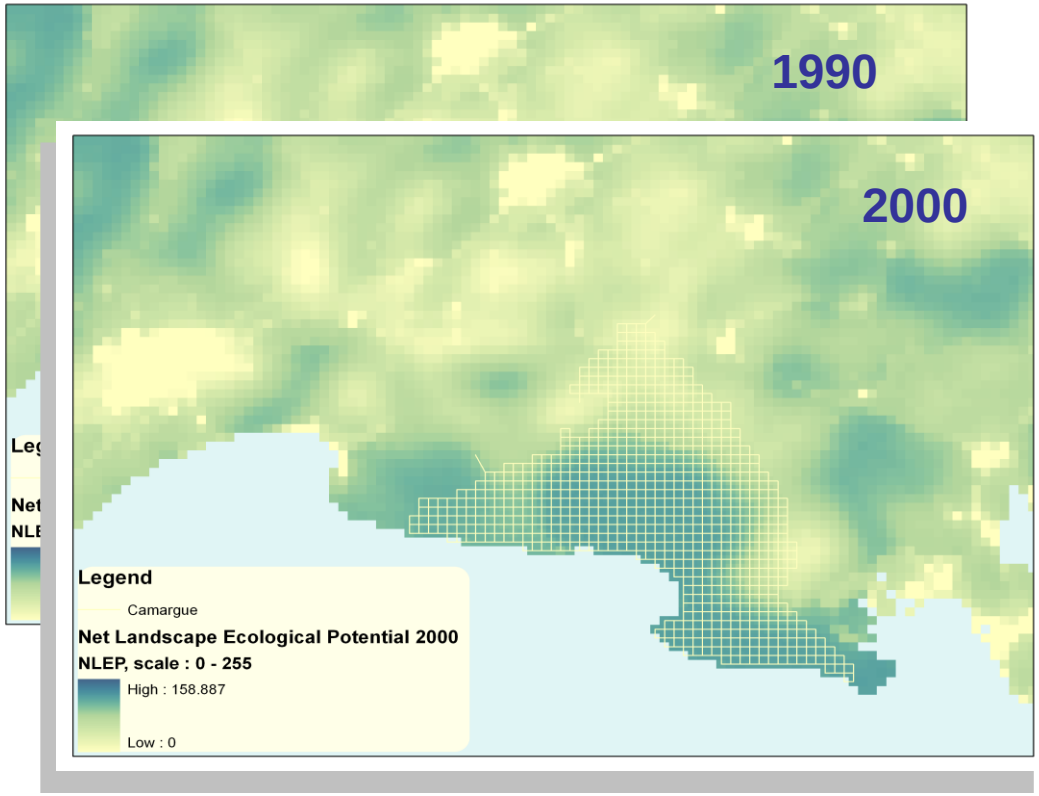
Landscape Ecological Potential (LEP) 2000, by 1km² grid cell

and



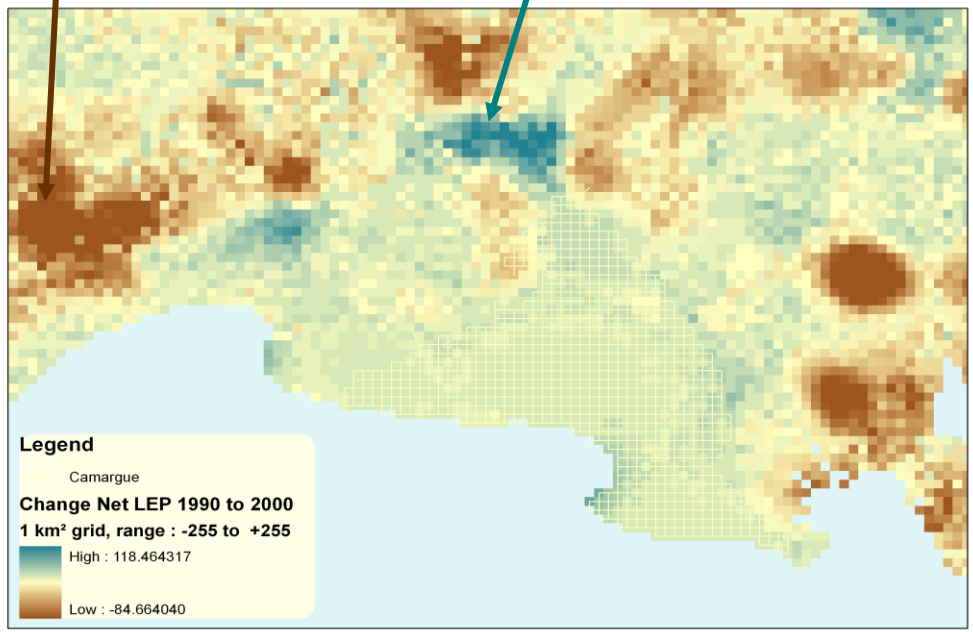
LEP 2000 by NUTS 2/3

Landscape ecosystem potential and change 1990-2000



Degradation

Improvement

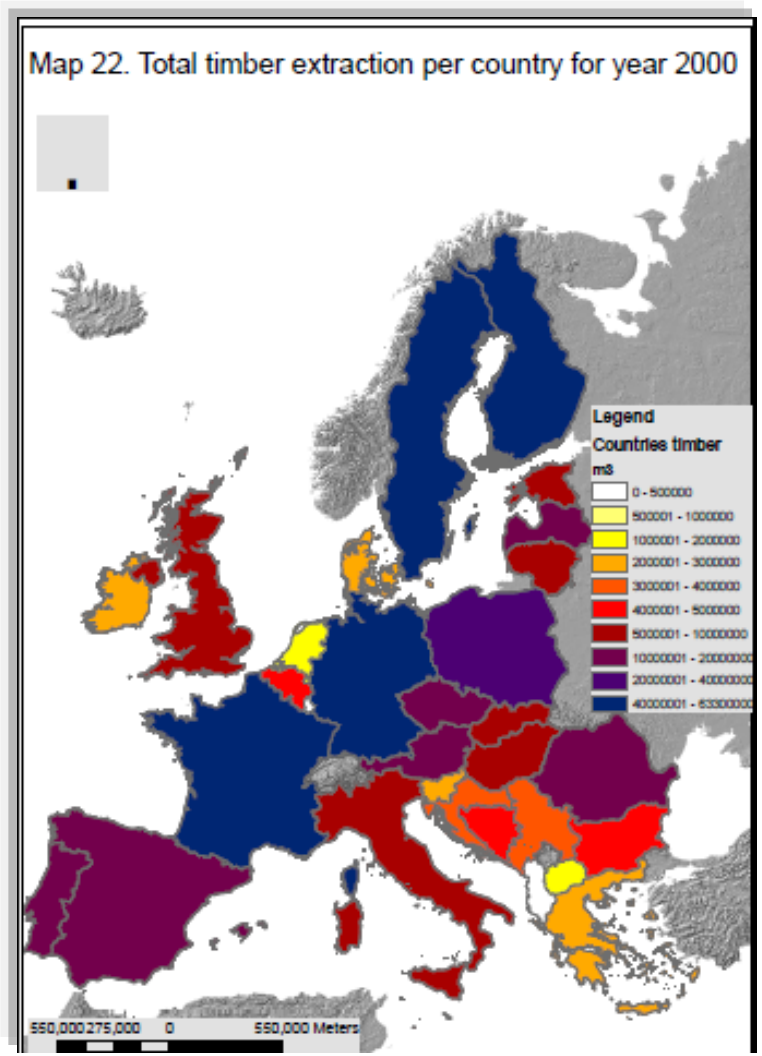


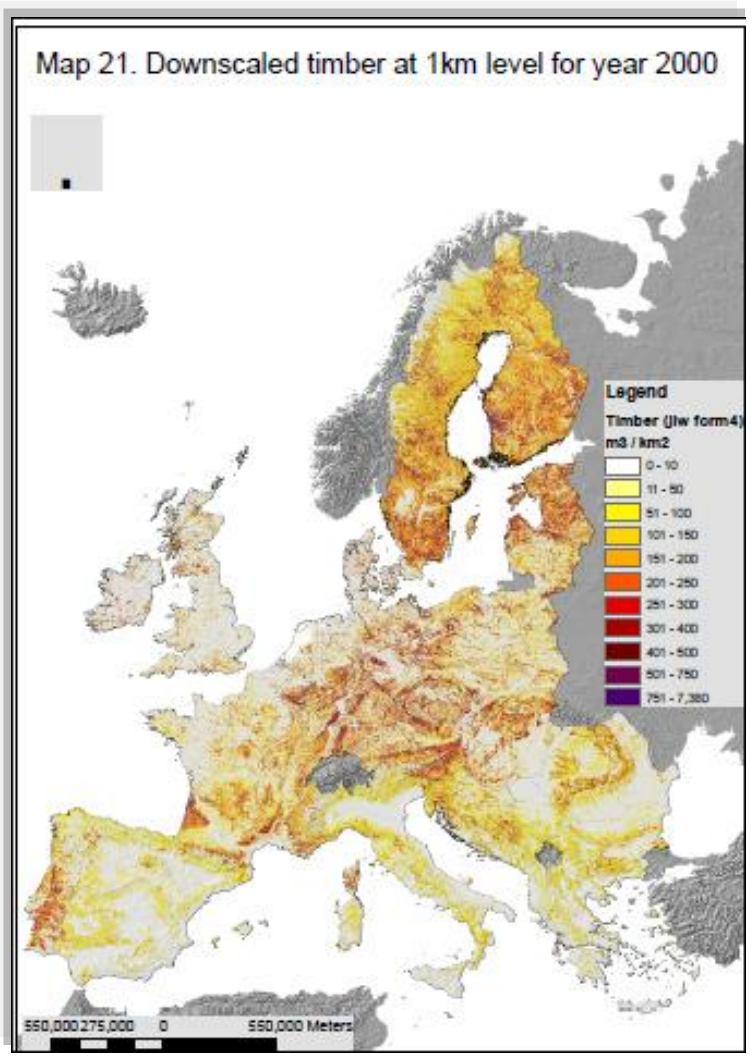
Example 2: biomass/carbon net balance

- 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)

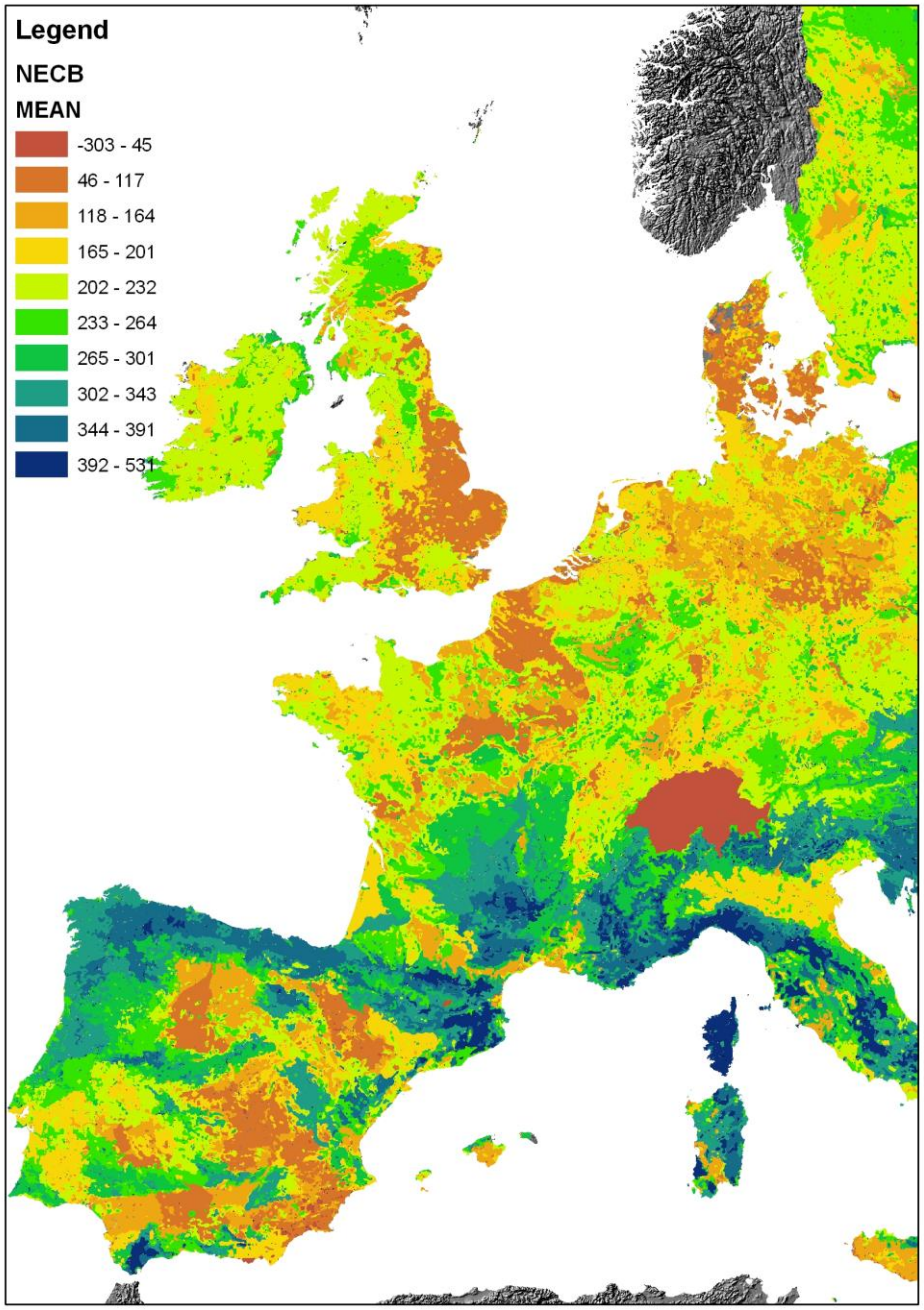
➔ Need to downscale harvest/ felling statistics using land cover and NDVI vegetation indexes

Data assimilation: Available statistics of timber extraction (left) and downscaled data (1 km^2) (right)





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



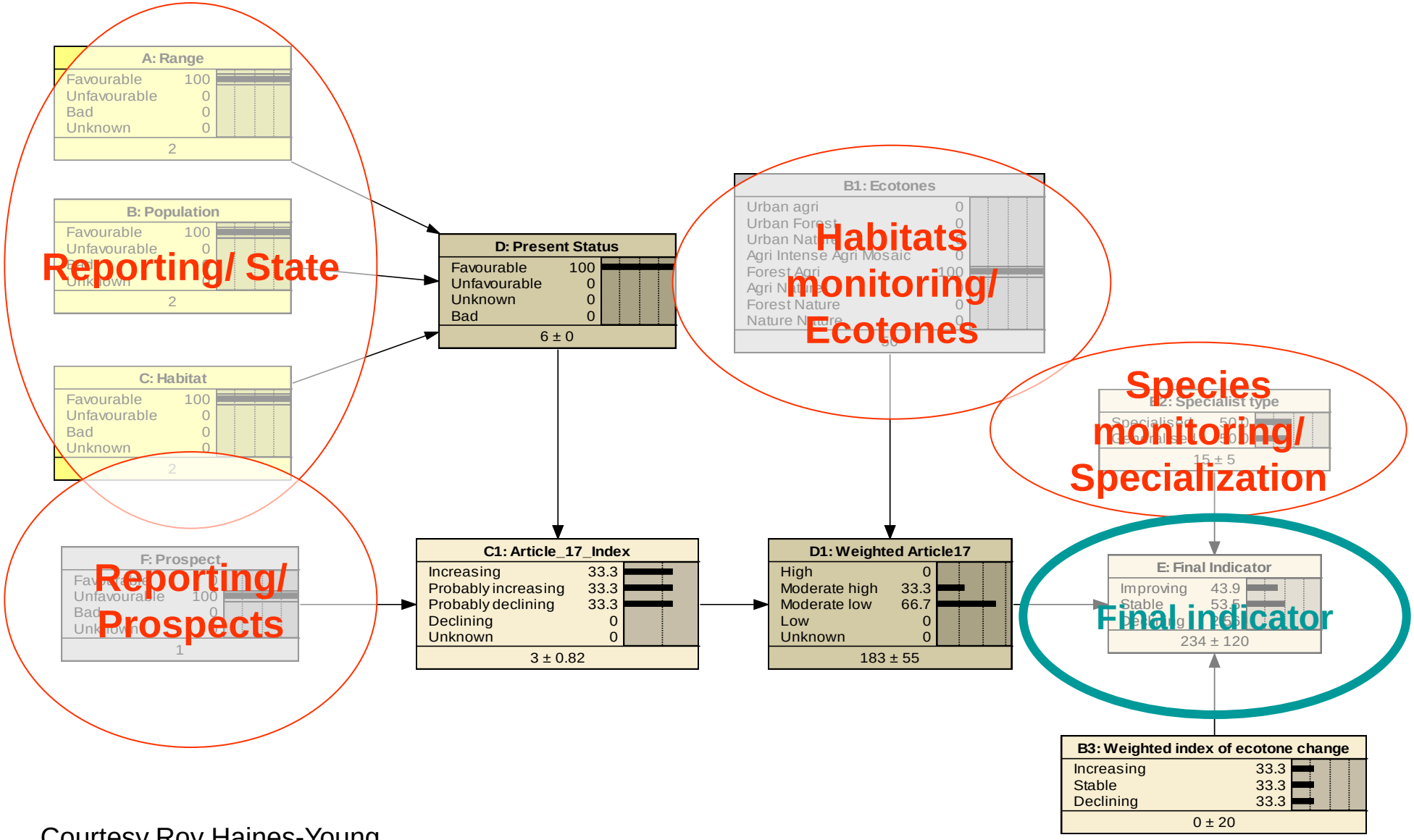
Net Ecosystem Carbon Balance by socio-ecological landscape units (SELU), 2000

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

Example 3: biodiversity index from heterogeneous data

- Downscaling various reporting data to the 1 km2 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 µ

= ***Available water resource***

- Use of water by activities & households µ

- Evapotranspiration by activities

= ***River basin runoff***

Sources:

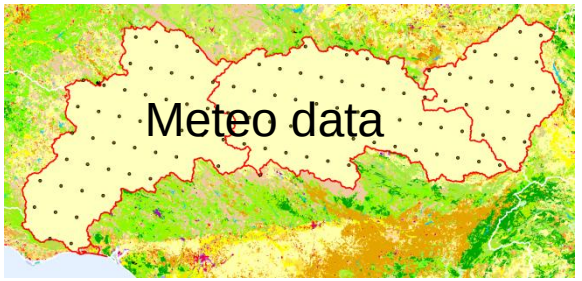
* Meteo

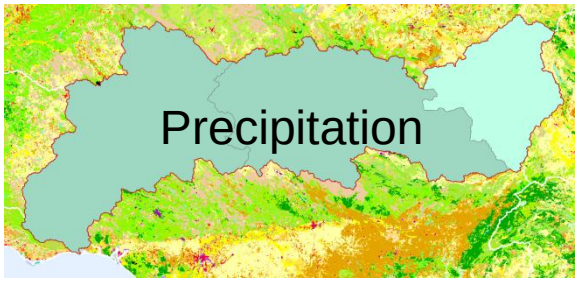
** Modelling from meteo data, land cover & NDVI

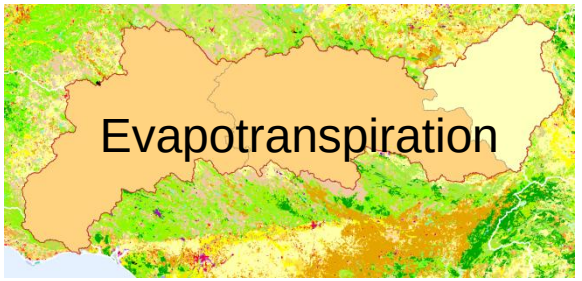
*** Hydrogeological modelling

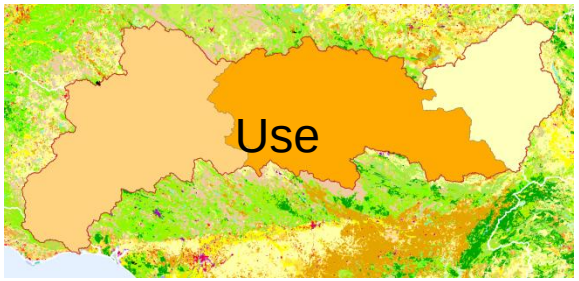
µ Estimation from land cover & socio-economic statistics

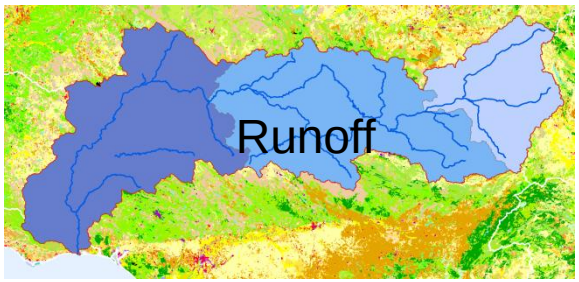
Bold Ital: accounting balances



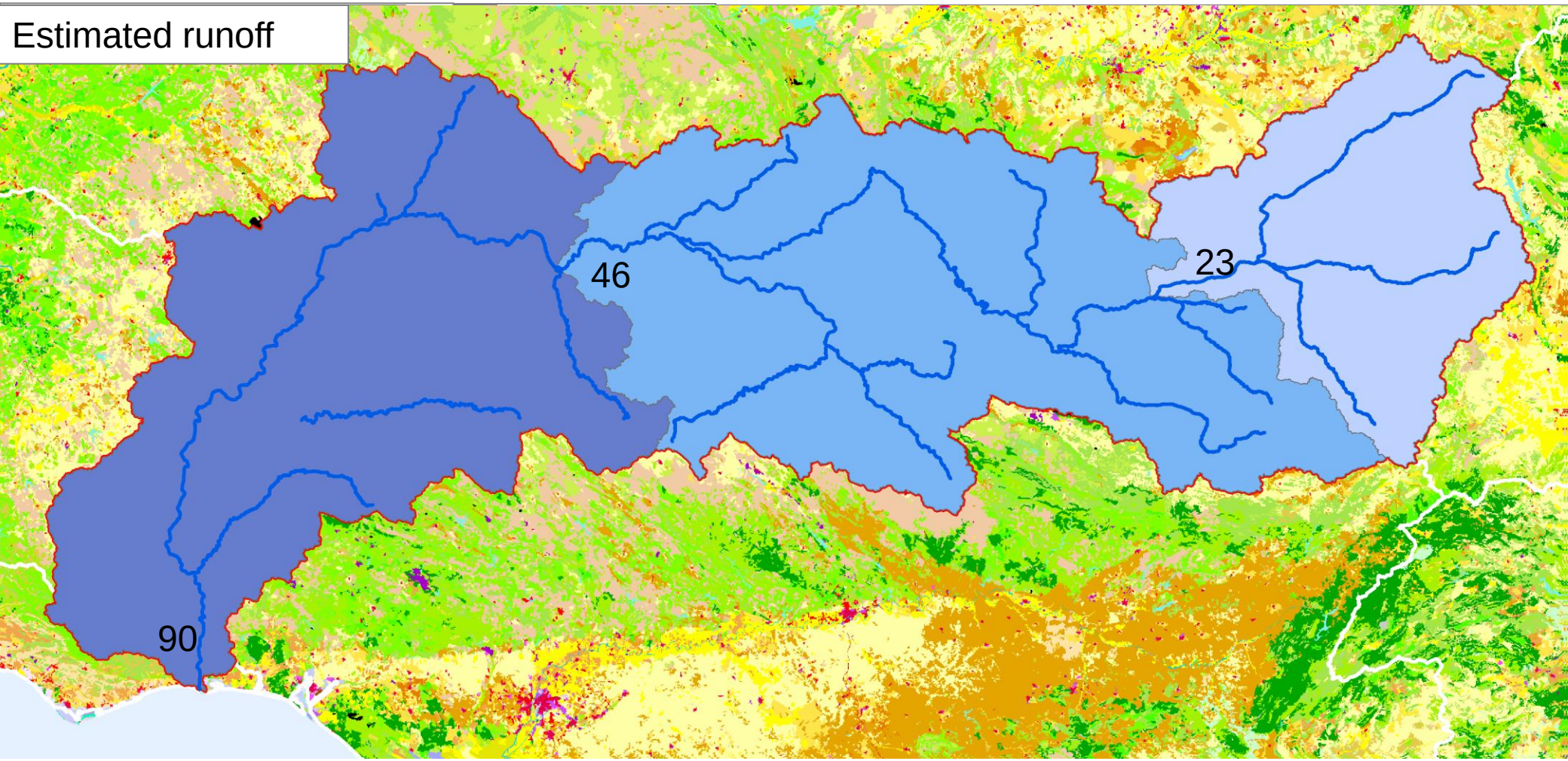








Fast calculation for 3 Guadiana River sub-basins

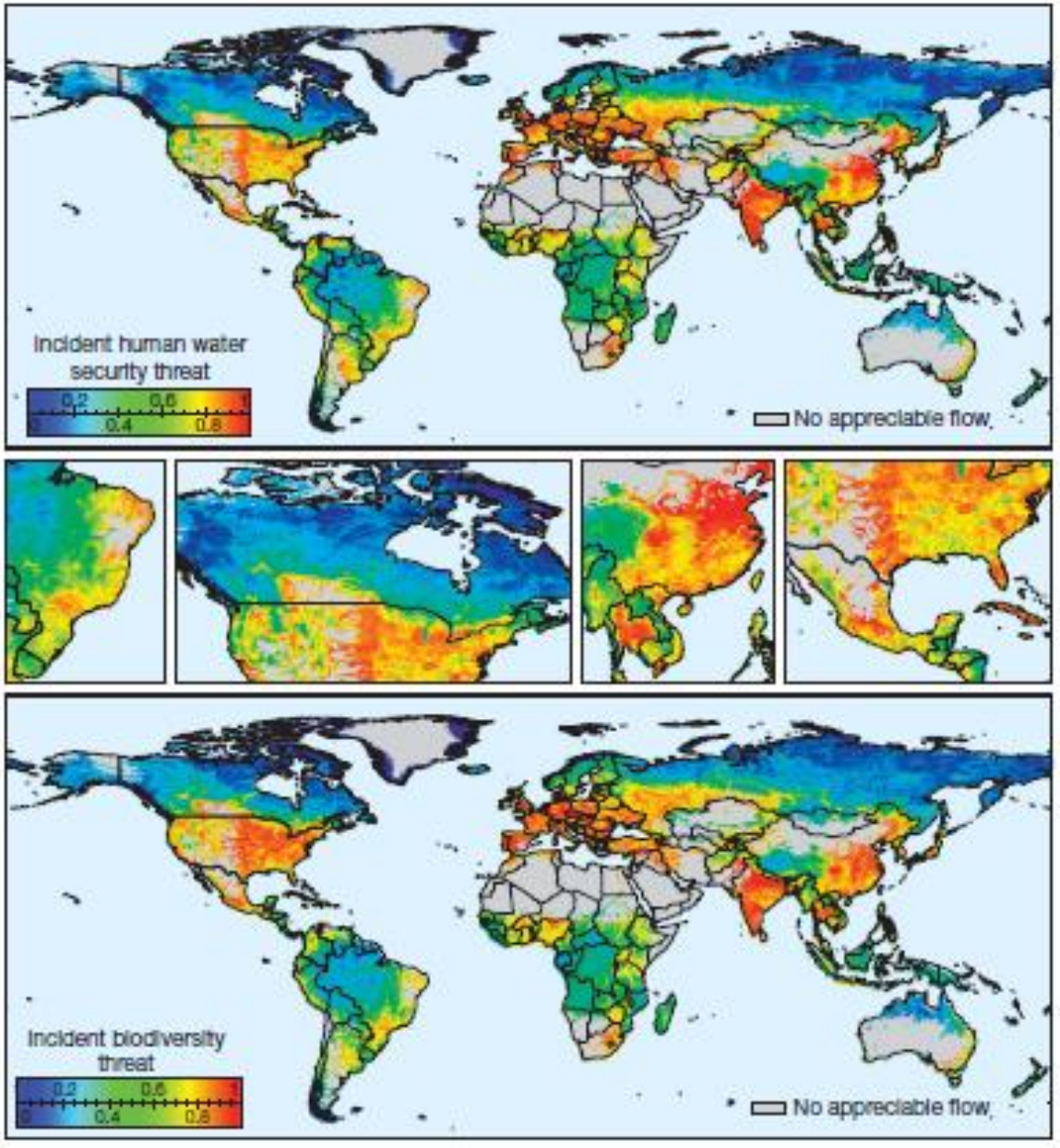


Source: EEA, Corine land cover, ECRINS – Estimations from various sources
by Oscar Gomez Prieto & Jean-Louis Weber

Water quantity & quality data exist at the Global scale

Meteo data

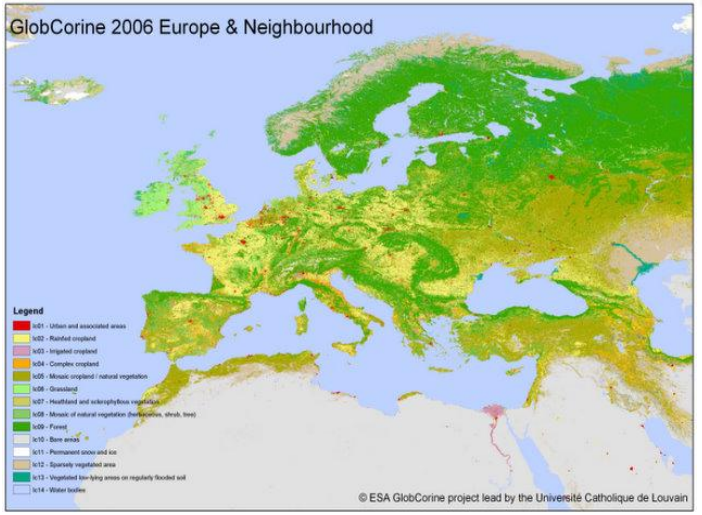
+ ….



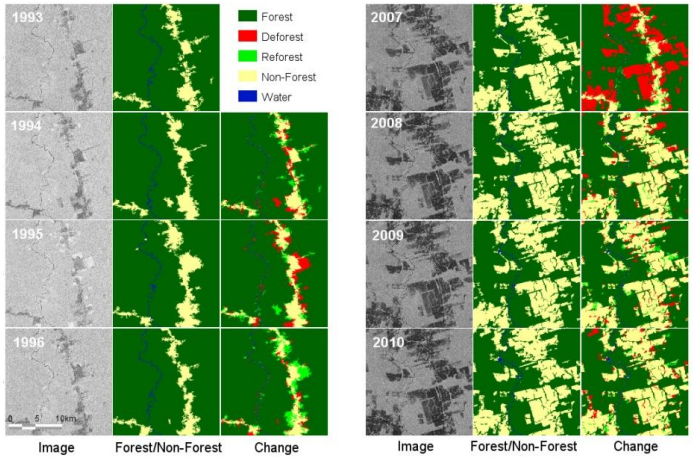
Source: Global threats to human water security and river biodiversity, C. J. Vorosmarty, P. B. McIntyre et al., NATURE, Vol. 467, 30 Sept. 2010

Earth observation data are abundant and more and more free

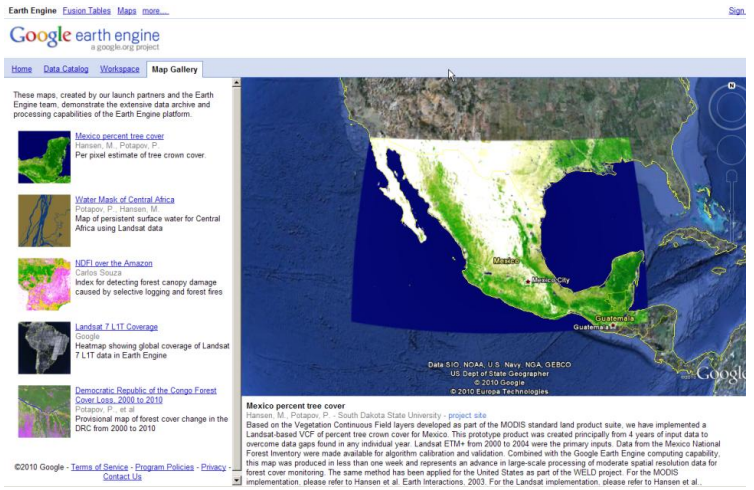
- GEO/GEOSS
- National programmes
- Private programmes



GlobCorine 2005 © European Space Agency



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



Tiered approach to ecosystem capital accounting

Scales	Methodologies	Expected outcomes
Global scale: International Conventions monitoring International comparisons Markets framing & regulation	***Simplified accounts***	Global trade of ecosystem permits Programmes assessment (e.g. REDD+) International financial standards (for loans, SDR…) Contribution to international organisations
National & regional government: Ministries of economy, Environmental agencies, Strategic planning, Statistical offices, Courts	***SEEA 2012/13 Framework***	**Sector accounts** **Green taxes** **Beyond GDP Accounting**
Action level: Local scale, management, Site level, case studies, Projects, Business	***Accounting guidelines, norms***	Impacts assessments, costs & benefits Local government, Agencies assessment Corporate accounting results, rating, trade Markets of specific ecosystem services, PES

Thank you!

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