

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

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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 <u>special volume on</u> ecosystem accounts and valuation
  - WB's Global Partnership...

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

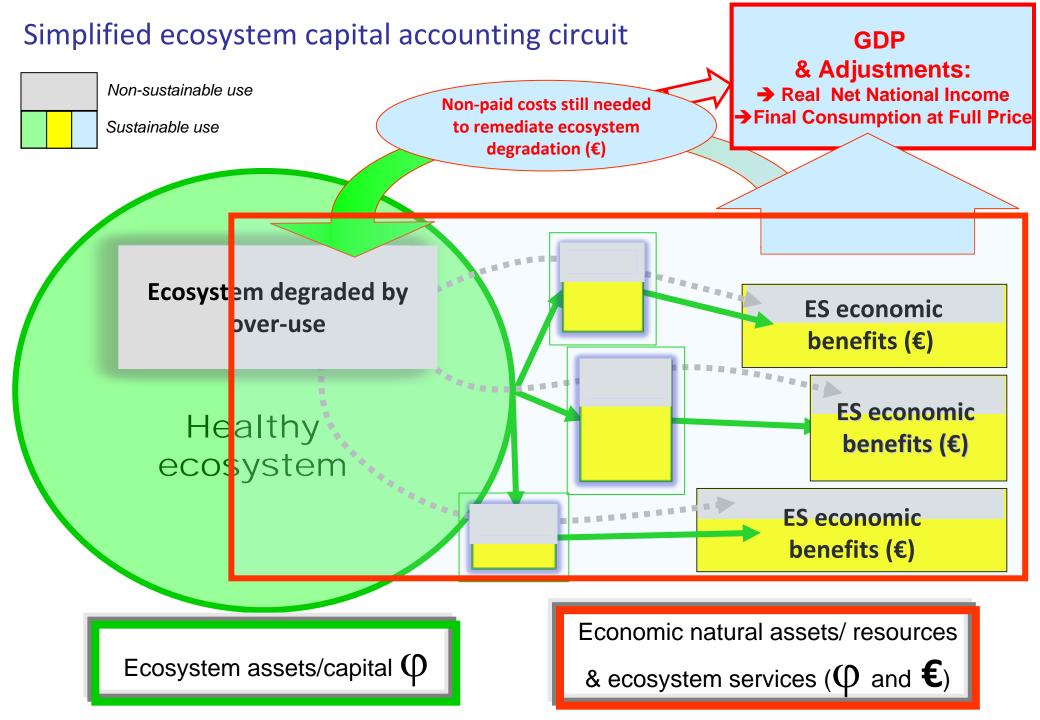


- Need of a minimum common reference for multiple national initiatives in 35 EEA member countries (and further on, Eastern and Southern European neighborhoods)
- Feasible with existing data and statistics
- Responding main policy questions:
  - "resource efficiency": sustainable use of ecosystem (agriculture, 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

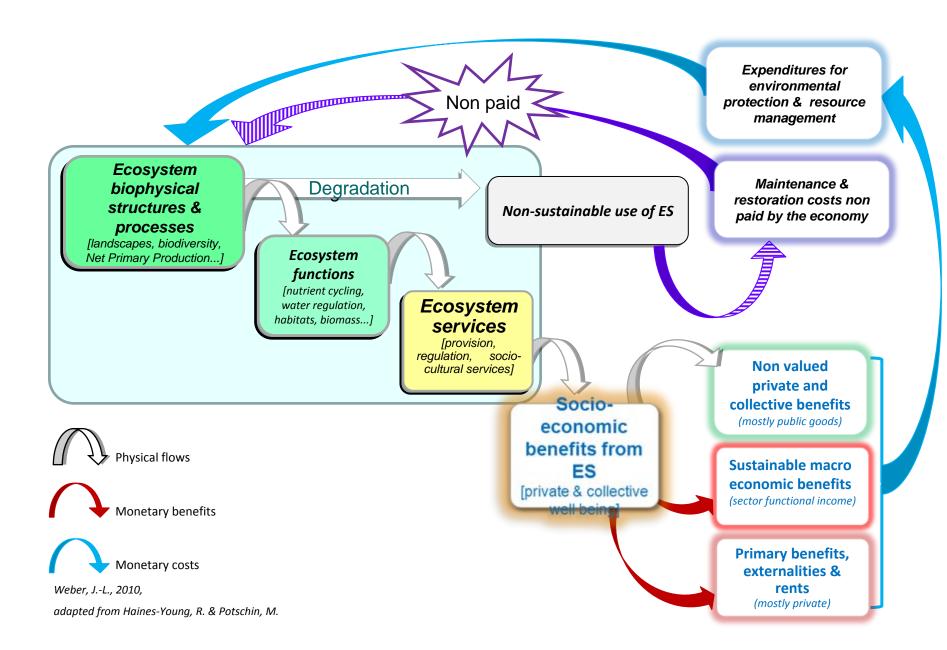


- Meet the policy demand:
  - Measure resource efficiency: maximize benefits while maintaining capital
  - Indicators to supplement and/or adjust sector and macro-economic aggregates
  - Policy agenda: continuity, annual updates for year t 1 are needed
  - National statements, internationally comparable...
- 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

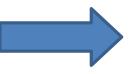




#### SNA & SEEA: economic and ecosystem assets



#### **Institutional units**



#### hold assets

land

#### deliver goods and services

socio-ecological systems

establishments enterprises

households

government

Ecosystem accounts SNA and SEEA Part I Key links healthy populations autonomy

land

water

carbon/biomass

dwellings, buildgs, machinery, equipmts... water resources cultivated biological non-cultivated biological resources other fixed assets inventories valuables licenses

goodwill and

marketing assets financial assets

#### ecosystem services

waste assimilation water regulation pollination other intangible services

...

provisioning services (food, fuel, fibers, etc.)

market goods and services



# SNA & SEEA: economic and ecosystem assets

	Assets hold by economic units (enterprises, government bodies, households)											
		Pro	duced as:	sets		Non produced assets						
Assets hold by ecosystem units (forests, agro-systems, wetlands)	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			Х			X						
Land cover systems	Х		Х			0		Х	Х			
Biomass/carbon			Х	Х			0	Х	0			
Water								0	Х			
Biodiversity			0			0		0	0	0		
Self regulating capacity	0		0			0		0	0			
Health, overall regenerative capacity			N			N		N	N			

Х	explicitly recorded as economic asset
0	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...)
    - Agro-ecosystems
    - Urban systems
    - Inland water systems (rivers, lakes)
  - 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 + socioecological 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



**Land Cover:** biophysical land units Monetary Statistics of Products Land Functions & Ecosystem Services Land Use: Physical Statistics productive land of Products functions Institutional & Land Ownership **Production Units** (private & public) (sectors & industries)

Socio-ecological landscape units (\$ELU)

(terrestrial, marine & atmospheric)

#### Ecosystem accounting and statistical units



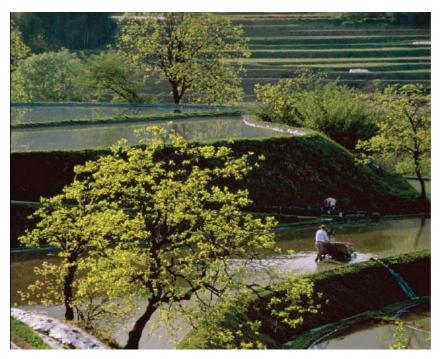
SNA statistical units don't record ecosystem degradation → need for other units...

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:

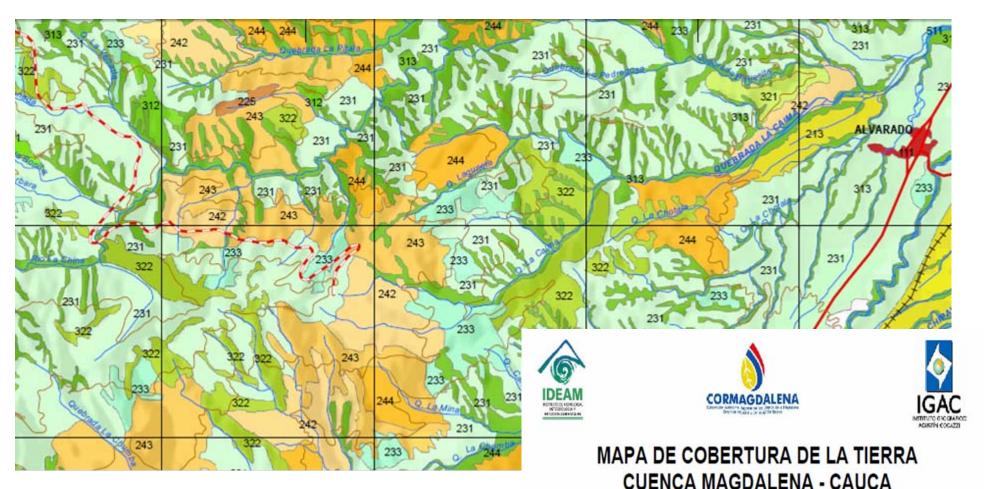
- For which we can collect data in a systematic way
- Mostly surface units: "geo-systems", land cover units, functional administrative units, ownership units...



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: <u>land cover systems</u> (example from Colombia...)





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

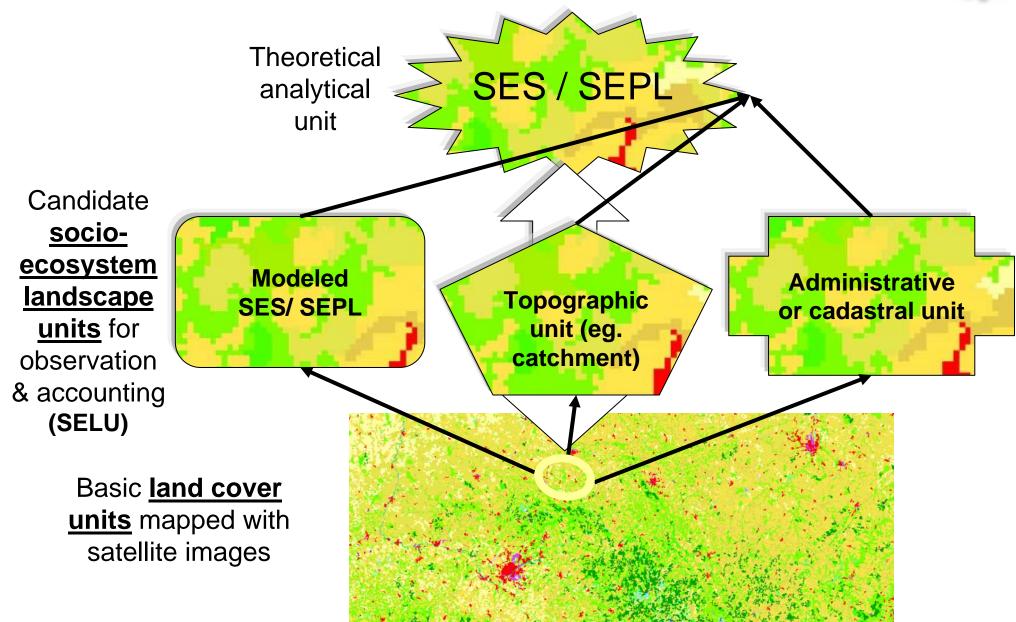
# Classification of land cover units: FAO/LCCS3 <u>land cover types</u> (left) and provisional <u>land cover systems</u> for ecosystem accounting (right)



Land cover types nomenclature for SEEA		Land	cover systems nomenclature - LCSN (provisional)
A1	Herbaceous crop/ Small size fields rainfed (< 2 ha)		
A2	Herbaceous crop/ Medium to large size fields rainfed	01	Artificial surfaces and associated areas
АЗ	Herbaceous crop/ Medium to large size fields irrigated	02	Medium to large fields rainfed herbaceous crops
В	Tree or shrub crop	03	Medium to large fields irrigated herbaceous crops
С	Multiple or layered crop	04	Permanent crops, agriculture plantations
D	Tree covered area	05	Agriculture associations and mosaics
	Shrub covered area	06	Pastures and natural grassland
E -			Forest tree cover
F	Herb covered area	08	Shrubland, bushland, heathland
G	Sparse natural vegetation (terrestrial or aquatic or regularly flooded)	09	Sparsely vegetated areas
Н	Aquatic or regularly flooded tree covered area	10	Bare land
I	Aquatic or regularly flooded shrub or herb covered area	11	Permanent snow and glaciers
J	Bare areas (terrestrial or regularly flooded)	12	Open wetlands
K	Artificial surfaces and associated areas	13	Inland water bodies
L	Inland water bodies	14	Coastal water bodies
М	Glacier and perennial snow	15	Sea

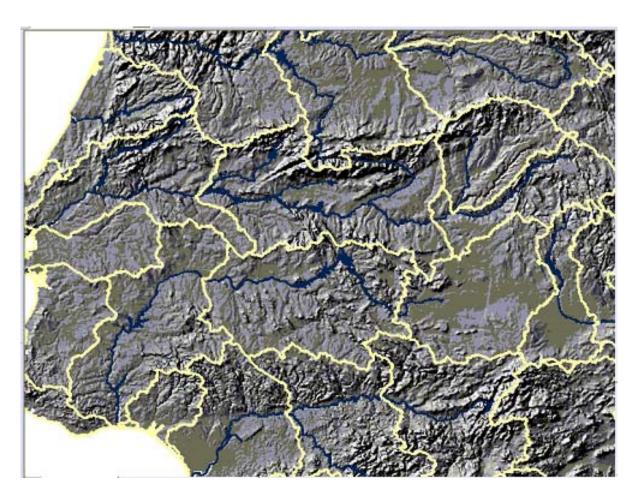
#### From theoretical to observation units





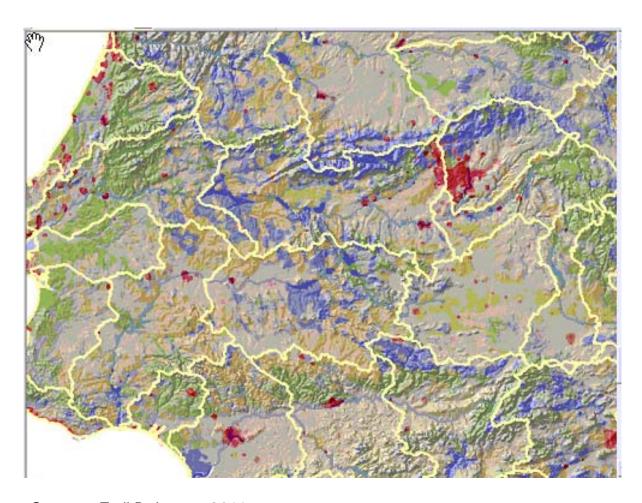
# Mapping & classification of socio-ecological landscape units (SELU) 1- river basins and 2- relief





Courtesy Emil D. Ivanov, 2011

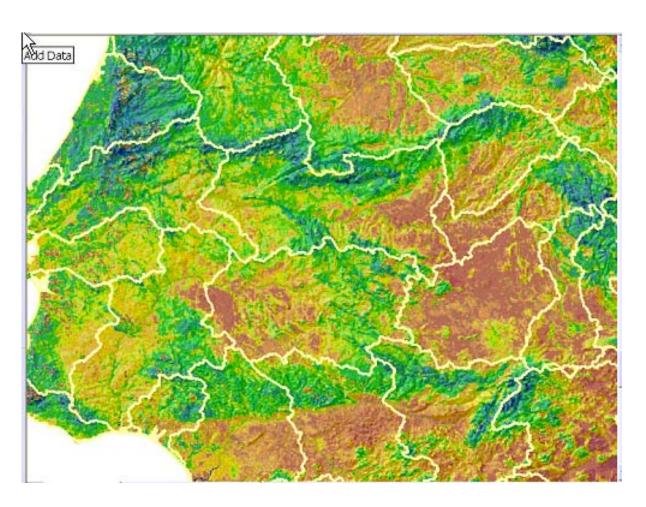
Mapping & classification of socio-ecological landscape units (SELU) 3- dominant landscape types (urban, intensive agriculture, mosaics, grassland, forests, other natural types and no-dominance)



Courtesy Emil D. Ivanov, 2011

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

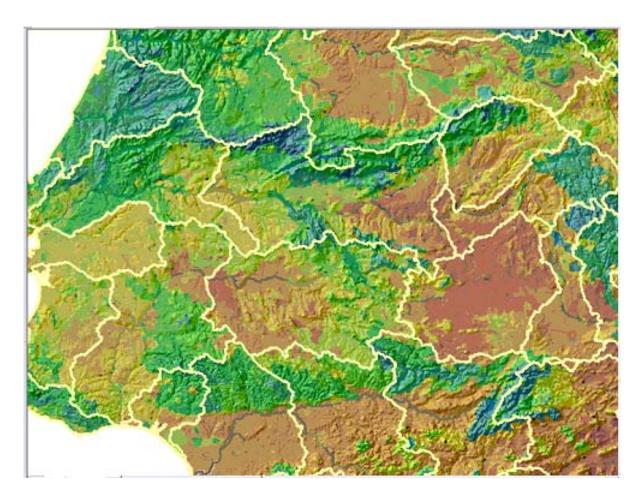




Courtesy Emil D. Ivanov, 2011

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





Courtesy Emil D. Ivanov, 2011

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4.7 Composite land cover (no dominant land cover	_		
5. River systems	4.7	Composite land cover (no dominant land cover	
	5.	River systems	



#### Mountain ecosystem landscapes Classification of socio-ecological 1.1 Urban and associated developed areas 1.2 Broad pattern agriculture landscape units (SELU) 1.3 Agriculture associations and mosaics 1.4 Pastures and natural grassland 1.5 Forest tree cover Classification of Socio-ecological landscape units (SELU) 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) Highland ecosystem landcapes 2.1 Highland ecosystems/ Built up and associated areas

2.2 Highland ecosystems/ Broad pattern agriculture

4.3 Agriculture associations and mosaics4.4 Pastures and natural grassland

4.6 Other dominant natural land cover

4.7 Composite land cover (no dominant land cover

4.5 Forest tree cover

5. River systems

2.3 Highland ecosystems/ Agriculture associations and mosaics



### 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
Land cover types	Food	Materials	Forest trees- related	Plant-related	Physical support	Amenity	Identity	Didactic	Cycling	Sink	Prevention	Refugium	Breeding
Artificial surfaces/ Urban	£	£			웃	웃	웃	웃		웃			
Arable land & permanent crops	웃	£		웃	£	र्द्र	웃	£	£	웃		£	<b>X</b>
Grassland & mixed farmland	웃	*	<b>%</b>	ठ्र	웃	웃	웃	웃	웃	웃	웃	웃	犬
Forests & woodland shrub	*		웃	<del>አ</del>	£	웃	<del>አ</del>	웃	웃	£	<del>አ</del>	웃	웃
Heathland, sclerophylous veg.			*	<del>አ</del>		<del>ያ</del>	£	웃	£	£	웃	웃	웃
Open space with little/ no vegetation		र्		£		웃	웃	웃		웃		웃	웃
Wetlands	<b>X</b>	£	*	र्द्र	£	웃	웃	웃	웃	¥	웃	웃	웃
Water bodies	<b>웃</b>	¥		*		£	웃	¥	웃	웃		웃	웃

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

#### Framework of physical ecosystem-economy integrated accounts



<b>Ecosystems</b>
-------------------

**Economy** 

PHYSICAL BALANCES

Stock

**Natural production** 

**USE OF ECOSYSTEM RESOURCE** 

**Extraction/ harvesting** 

**Returns/ Formation (sectors)** 

Final Consumption (sectors)

Extraction/ harvesting

Returns/ Formation

Final Consumption

**Natural consumption** 

Storage/Accumulation

Stock

USE OF FOSSIL RESOURCE

..

**EMISSIONS, RESIDUALS** 

From resource

From fossil resource

QUALITY/HEALTH INDEXES

Vigour

Stability, integrity

Resilience

**EXPENDITURES** 

Taxes, voluntary payments

**IMPORTS-EXPORTS** 

Actual

Virtual (embedded)

LINKAGE TABLES

To land accounts

To water accounts

To biodiversity indexes

SEEA Volume 2

SEEA Volume1

### Example: Biomass/carbon accounts

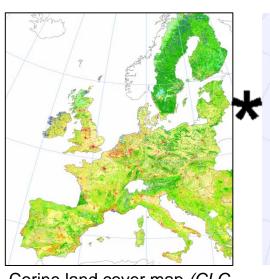
Ecosystem Units Accounts	Economic Units Accounts					
Ecosystem capital basic balance	Ecosystem asset account	Supply & Use, MFA, I-OT				
1 E0: Opening stock of ecosystem assets	1 S0: Opening stock of economic natural assets					
2 RESOURCE FORMATION/ Ecosystems	2 RESOURCE FORMATION/ Sectors & Industries	1 SUPPLY/ Sectors & Industries				
3 <b>Net Primary Production</b> (NPP=GPP minus plants respiration)	3 Net Primary Production (NPP=GPP minus plants respiration)					
4 minus soil respiration	4 minus soil respiration	2 Supply of biomass to other domestic economic units				
5 Ecosystem Primary Production (EPP)	5 Ecosystem Primary Production (EPP)	3 Biomass content of exports				
6 Returns & leftovers from agriculture & forestry	6 Returns & leftovers from agriculture & forestry	4 Returns & leftovers from agriculture & forestry				
7 Artificial input (manure, organic fertilizers, plantations)	7 Artificial input (manure, organic fertilizers, plantations)	5 Artificial input (manure, organic fertilizers, plantations)				
8 Transfers from other ecosystems	8 Transfers from other ecosystems					
9 Transfers from other territories	9 Transfers from other territories					
10 Effects of Land Cover formation	10 Effects of Land Cover formation					
11 RESOURCE CONSUMPTION/ Ecosystems	11 RESOURCE CONSUMPTION/ Sectors & Industries	6 USE/ Sectors & Industries				
12 Withdrawals	12 Withdrawals	7 Withdrawals				
13 Losses and transfers to other ecosystems	13 Losses and transfers to other ecosystems	8 Biomass received from other domestic economic units				
14 Transfers to other territories	14 Transfers to other territories	9 Biomass content of imports				
15 Effects of Land Cover consumption	15 Effects of Land Cover consumption	10 Final consumption/combustion of biomass				
16 Net Ecosystem Carbon Balance (NECB) (= 2-11)	16 Net Ecosystem Carbon Balance (NECB) (= 2-11)	11 Net biomass accumulation in the user system (=1-6-10				
17 E1: Final stock of ecosystem assets (= 1 + 16)	17 S1: Final stock of economic natural assets (= 1 + 16)	Transfers of biomass between economic units				
Ecosystem health count	Ecosystem health count	Olisi Con om ic upply of biom ass				
16 Net Ecosystem Carbon Balance (NECB) (= 2-11)	16 Net Ecosystem Carbon Balance (NECB) (= 2-11)	n its				
18 NPP trends, productivity	18 NPP trends, productivity	SIC u de bir				
19 NPP perturbation	19 NPP perturbation					
20 Change in NPP profiles	20 Change in NPP profiles	t the				
21 Multicriteria ecosystem health index/ biomass	21 Multicriteria ecosystem health index/ biomass	S o o o o o o o o o o o o o o o o o o o				
Stress factors indexes	Stress factors indexes	8 Biomass received from other domestic economic uni				
22 Overharvesting	22 Overharvesting	Total Import-Exports of biomass				
23 Farming practices	23 Farming practices	9 Biomass content of imports				
24 Pollution, chemicals	24 Pollution, chemicals	13 Virtual flows of biomass embedded in imports				
25 Land restructuring	25 Land restructuring	3 Biomass content of exports				
26 Natural & multiple causes	26 Natural & multiple causes	14 Virtual flows of biomass embedded in exports				
Ecosystem services	Ecosystem services	Total emissions of carbon residuals				
27 Provisioning services	27 Provisioning services	15 Air emissions from consumption/combustion of biomass				
28 Regulating services	28 Regulating services	16 Air emissions from combustion of fossil fuel				
29 Socio-cultural services	29 Socio-cultural services	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>

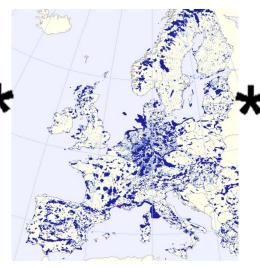
### Example 1: multicriteria diagnosis / land: landscape ecological potential



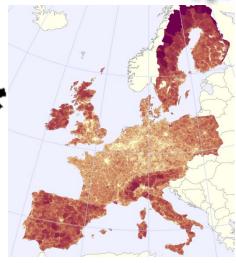
Corine land cover map (CLC is derived from satellite images)



Green Landscape Index (derived from CLC)

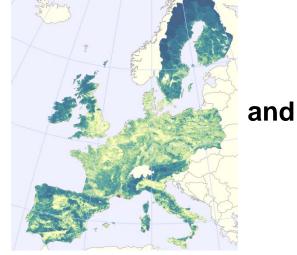


Nature Value (*Naturilis*, derived from Natura2000 designated areas)

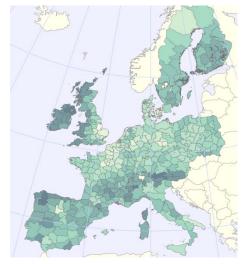


Fragmentation (Effective Mesh Size (MEFF) derived from TeleAtlas Roads and CLC)





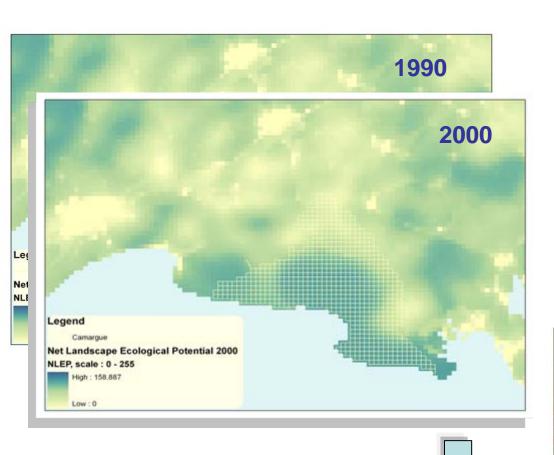
Landscape Ecological Potential (LEP) 2000, by 1km<sup>2</sup> grid cell

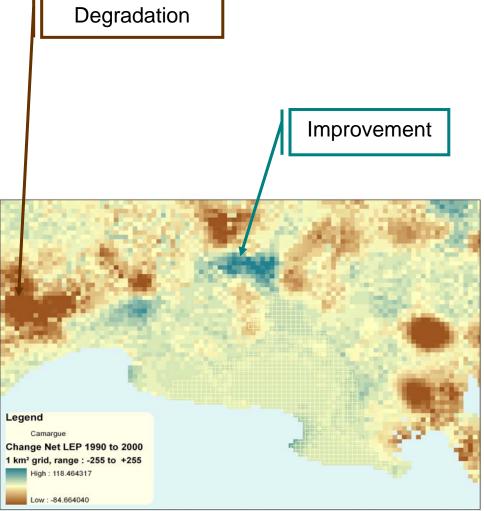


**LEP 2000 by NUTS 2/3** 

# Landscape ecosystem potential and change 1990-2000







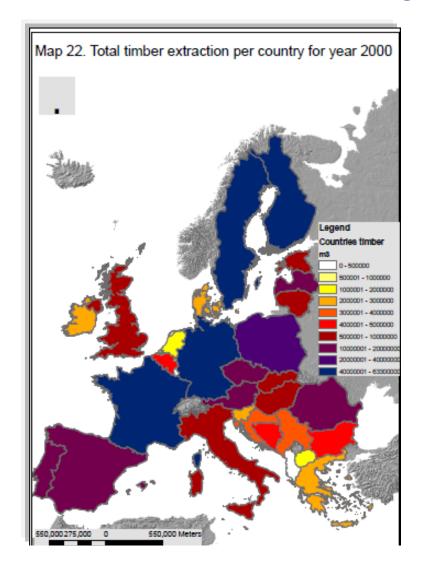
### Example 2: biomass/carbon net balance

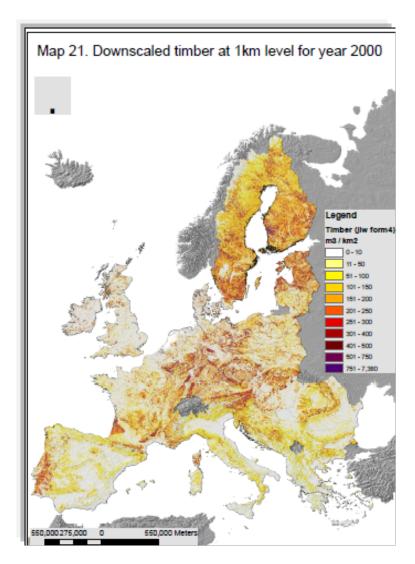


- Ecosystem Net Carbon Balance ~ EPP minus Harvest
- EPP is derived from NPP: regularly computed at the grid level
- International agriculture and forest statistics are currently available by countries (by administrative regions in some cases)
- → Need to downscale harvest/ felling statistics using land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

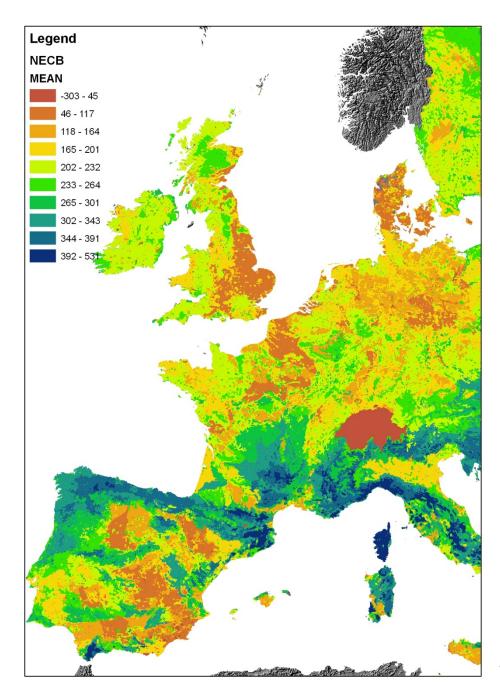
# Data assimilation: Available statistics of timber extraction (left) and downscaled data (1 km<sup>2</sup>) (right)







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

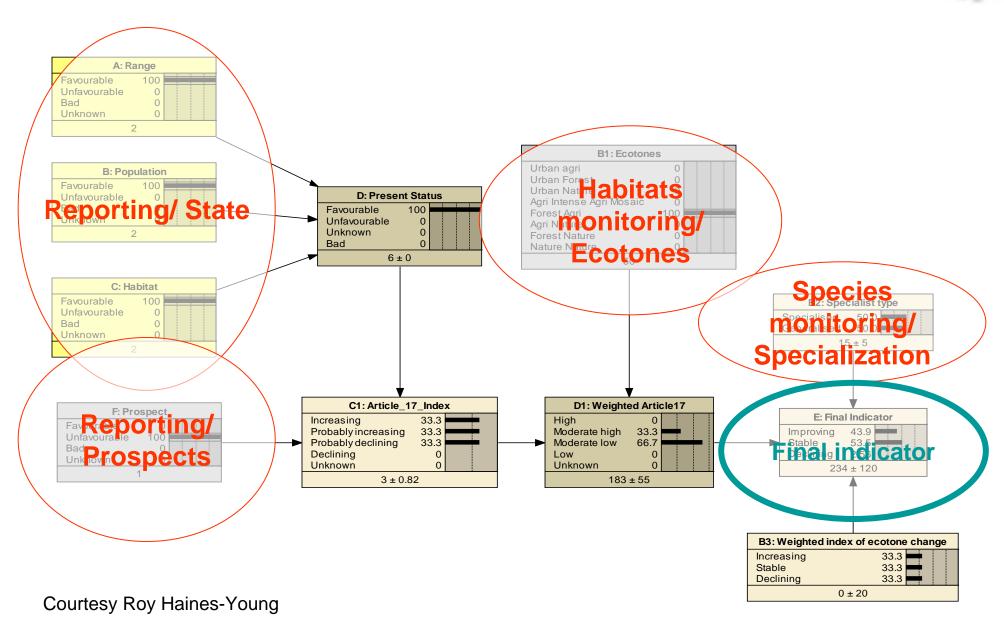
# Example 3: biodiversity index from heterogeneous data



- Downscaling various reporting data to the 1 km2 grid
- Combination of data and expertise
- Multicriteria analysis with decision tree (e.g Bayesian Belief Network) and diagnosis

# 禁

# Biodiversity index: combination of data and expertise



# Ex. 4: Simplified basic water balance

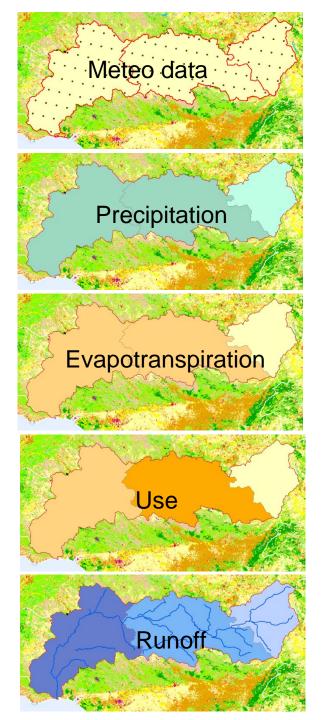
Precipitation \*

- 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

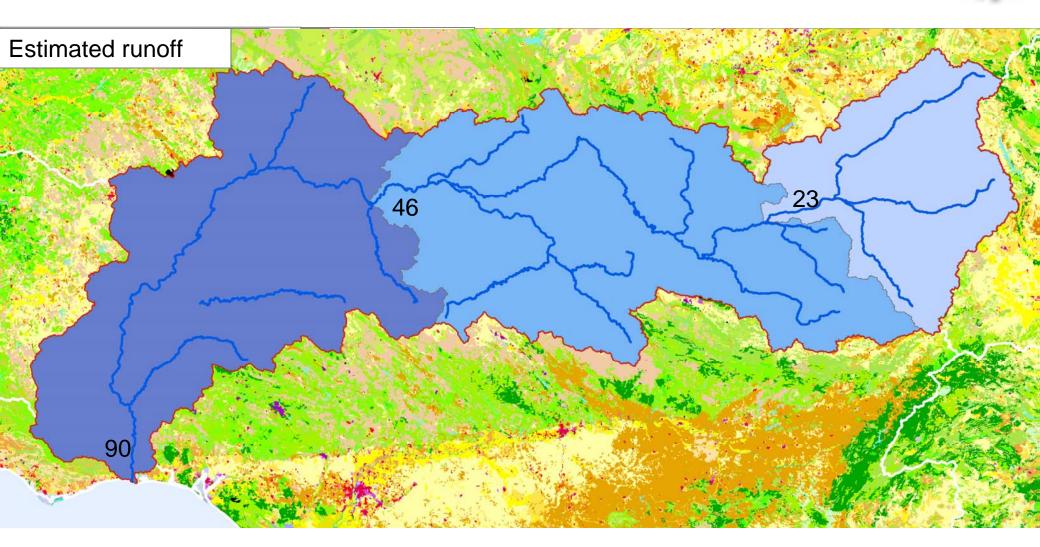
**Bold Ital: accounting balances** 





# 禁

#### 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

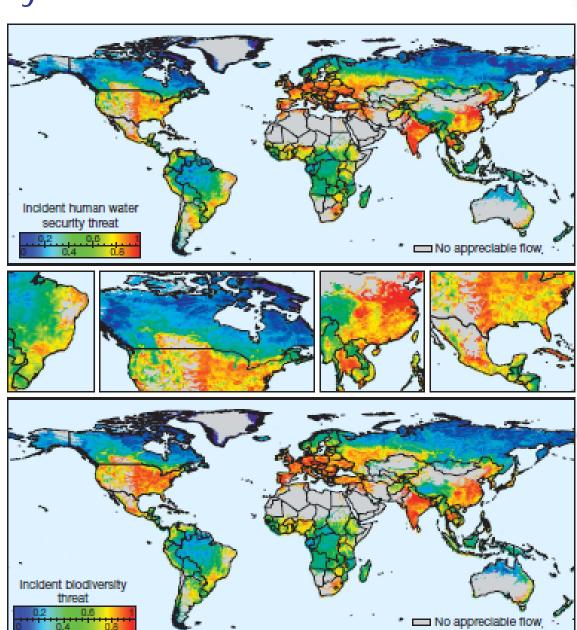
## Water quantity & quality data exist at the Global scale



Meteo data

+ ....

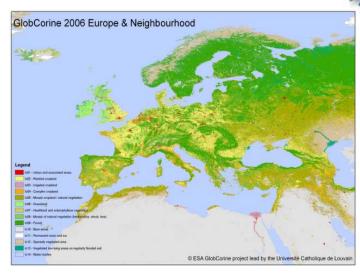
Source: Global threats to human water security and river biodiversity, C. J. Vorosmarty, P. B. McIntyre et al., NATURE, Vol. 467, 30 Sept. 2010



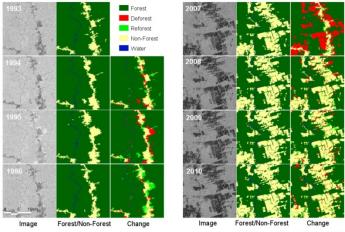
#### Earth observation data are abundant and more and more free



- 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

# National & regional government:

Ministries of economy,
Environmental agencies,
Strategic planning,
Statistical offices,
Courts

#### **Action level:**

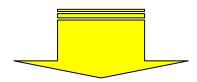
Local scale, management,

Site level, case studies,

Projects,

**Business** 

#### Simplified accounts







Accounting guidelines, norms

Global trade of ecosystem permits

Programmes assessment (e.g. REDD+)

International financial standards (for loans, SDR...)

Contribution to international organisations

**Sector accounts** 

**Green taxes** 

**Beyond GDP Accounting** 

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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jlweber45@gmail.com