

Ecosystem accounting at the European Environment Agency: a summary of progress¹

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The European Environment Agency (EEA) has developed a framework for land and ecosystem accounts (EEA, in press; Weber, in press) based on the System for Environmental and Economic Accounting (SEEA; UN et al., 2003).² The EEA's accounts provide a tool for understanding the links between the ecosystem goods and services that are vital for human well-being and the underlying processes that generate them, in line with the 'ecosystem approach' recommended by the Millennium Ecosystem Assessment.

The EEA's Land & Ecosystem Accounts consist of three components: Land Cover Accounts, Land Use & Ecosystem Accounts, and Economic Accounts (including other socio-economic data). The components are linked by classifications of natural systems, of the economic system (defined by the System of National Accounts and the SEEA), and by common spatial and temporal references. At this time, the EEA's Land Cover Accounts are well developed and implemented. A framework for Land Use & Ecosystem Accounts has been developed but only partially implemented, and the connection between ecosystems and the economic system is still in an exploratory phase. This note summarizes the progress so far.

1. Land Cover Accounts. The Land Cover Accounts constitute the core of the EEA's database system to bridge land use, biodiversity, water, economic activity, land & habitat degradation, etc. They are constructed from the Corine Land Cover (CLC) Inventory, which is derived from a combination of satellite imagery plus ground observations at a resolution of 25 ha for land units and 5 ha for change in the years 1990 and 2000. The information is collected in a standardized way for 24 European countries, assimilated into a 1 km² grid and can be scaled up or down to any area— coastal zones, river catchments, countries, etc. *Land Cover Accounts* consist of 44 categories of land cover (natural and artificial, the latter including such things as transportation networks and other infrastructure). The change between 1990 and 2000 is tracked in a matrix of *Land Cover Flows* (See Table1) which identify the major causes of changes (human and natural) in land cover.

Beyond the CLC 2006 update in 2007, plans are under way to increase the periodicity using medium resolution satellite images for simplified monitoring between two CLC inventories; increase the resolution for specific areas such as urban zones, coastal zones or designated areas for conservation using high resolution satellite images, GIS, sampling survey results or specific databases; improve the description of elements such as transport infrastructure and rivers (imperfectly observed with the satellites used for CLC) on the basis of new geographical databases; and integrate small ecosystems using different sources and methodologies.

2. Accounts for the Ecosystem Dimension of Land.

¹ This summary is based on (EEA, forthcoming and Weber, forthcoming).

² The SEEA discusses land accounting in some detail, and land accounts have been constructed by some countries, but ecosystem accounts are mentioned only briefly, and the link to economic systems has not yet been systematically explored in an accounting framework.

The Land Cover Accounts alone are not sufficient for policy; they need to be supplemented with accounts on land use and ecosystems as well as economic information, which provide information about the processes driving land cover change, the impact of land cover change and the importance for policy issues and trade-offs. *Ecosystem accounts* expand the Land Accounts in order to record the supply of ecosystem goods and services, assessing ecosystem potentials and their integrity, health and viability. The accounts include geographical information as well as monitoring data on atmosphere and climate, the water systems, fauna and flora, and soils.

A critical starting point for Ecosystem Accounts is the construction of a Land Account matrix that tracks land cover by land use. *Land Use Accounts* identify the socio-economic functions of land and assess the services provided by land, providing a link with economic accounts, infrastructure, population, etc. The concept of land use functions includes those functions related to ecological processes.

The full framework for Ecosystem Accounting is shown in Figure 1. The physical Ecosystem Accounts consist of 3 blocks: a core stock account, which corresponds to the “basic account” concept of the SEEA, and two “supplementary accounts:”³

- A. Stocks of ecosystems and the related flows, including:
 - Terrestrial ecosystems: land cover (km², number of land units), rivers (standard-river-km, number of reaches), small features (number of units)
 - Marine ecosystem (km²) (not yet developed)
 - Inland water and Biomass
 - i. Biomass (dry matter, C, energy...) of soil, vegetation (non soil), and fauna
 - ii. Water quantity (m³)
 - iii. Nitrogen (t), flows only
 - iv. Phosphorus (t), flows only
 - Fauna & flora (number of units, of groups, volumes, tons)
 - Counts of indicators of integrity and/or diversity of the ecosystems, based on the ‘ecosystem distress syndrome’ (EDS) model⁴, that can be used to assess ecosystem health. Symptoms of distress can be grouped in a limited number of classes: nutrient cycling disruption, change in species composition, destabilisation of substrates and, for managed ecosystems, self-sustaining capacity and capacity to sustain healthy human communities. Each class of symptoms is translated in a second step into observable variables according to ecosystem types and data availability.
- B. Diagnosis of state (health, resilience, etc.) and the final assessment of ecosystem assets. This component quantifies in physical terms the amount of ecosystems (surface, volume, number, etc.) and their health. Together, these determine the sustainability of an ecosystem and its potential to deliver goods and services. The

³ The term “account” is used when the linear relation stock-flows-stock is described in full. “Count” is used when the change is not analysed in the same unit as the stocks. Counts are minimal accounts which present qualitative indicators that are essential for producing accounts of the state of the ecosystems.

⁴ Rapport D J., Whitford Walter G.: *How Ecosystems Respond to Stress - Common properties of arid and aquatic systems* in BioScience Volume: 49 Number: 3, Page: 193 -- 203 American Institute of Biological Sciences 1999

quantification will be done by attaching diagnosis elements to ecosystems described in the core account. The basic account will show the distribution of ecosystems among health/morbidity classes such as:

- Steady state (homeostasis, no noticeable alteration foreseen)
- Resilience state (ecosystems are still able to absorb or compensate disturbance, *keeping the same functions, identity and feedbacks*).
- Reversible process without compensation (degradation).
- Irreversible change (equivalent to death for living organisms)

3. Economic Accounts linked to Ecosystem Accounts

The blocks for Economic accounts would include

- Material & energy flows (including biomass, water, nutrients, residuals, etc.)
- The goods and services assessed on the basis of the land use and natural functions of the ecosystems, as well as the potential stress resulting from land use;
- A supply and use table for those elements (materials or services related to materials);
- Accounts for natural capital (structure & resilience, physical & monetary values, produced and non-produced)

Social & economic statistics would be disaggregated to land cover level where possible; otherwise a regional synthesis would be used.

Natural functions, land use functions and ecosystem services

Ecosystem services need to be defined in a way which allows consideration of trade offs between economic and non-economic use. Not all natural functions deliver services, only those which contribute to human well being, indirectly – via an economic process – or directly – the free ones. Most internal functions of ecosystems contribute to intermediate consumption for the supply of ecosystem services; they should not be accounted for a second time. Well being has to be considered in the full time perspective which means that both components of final consumption (of the year) and natural capital formation have to be accounted in an appropriate way. Land use functions reflect both economic and non-economic social values. They can be connected via supply and use tables to the agents which benefit of them. In the case of non-marketed ecosystem services, land use functions (in given places and for the communities involved) are the starting point of a comprehensive accounting.

Land use functions and ecosystem stress

Land use can create stress on natural systems; the EDS identifies 4 main types of anthropogenic stress:

- physical restructuring which fragments or destroys critical habitats, causes substrate instability and disrupts nutrient cycling;
- introduction of exotic species, intentionally or accidentally;
- discharge of residuals and toxic substances, which contributes to eutrophication and the build up of toxic substances in food webs.
- over-harvesting.

The land use accounts identify stressors in relation to the previous health diagnosis of the account of ecosystem state, taking into account carrying capacities and threshold values as well as possible synergies with natural disturbances. In the full system of Land and

Ecosystem Accounts, the observed stress can then be linked to the economic accounts (supply & use table) as well as to a range of statistics on agriculture, forestry, population, transport and others.

At this stage, the choice of economic valuation methods to be used for ecosystem services and assets is still open for discussion. The ambition here is to support many possible approaches in an open way. Clearly, there is a focus on the capital based approaches and the assessment of the ecosystem wealth, but this is not exclusive. As long as the market does not provide appropriate prices, alternate valuations probably make sense. Also, the approach of land and ecosystem accounts implicitly assumes that even though some elements cannot be monetized they are part of the natural capital and should be quantified in one way or another to be part of the decision making process and assessment of trade-offs.

Currently, the EEA – a European organization based on a wide network of national environmental agencies and research institutions and with partnerships with other European institutions such as the Joint Research Centre, Eurostat or the European Space Agency – has started introducing concepts of land and ecosystem accounting in several fields of activity related to biodiversity, water, biomass and nutrients, landscape analysis. A few case studies are currently run for large wetlands such as the Danube Delta in Romania or Doñana in Spain and natural grasslands. Transversal developments are as well taking place in relation to the fragmentation of rivers systems and more broadly of ecological networks or on the integration of current monitoring by Earth observation satellites of the variability of the ecosystem productivity into the geographical patterns of the land accounts, or the re-sampling of biodiversity data for ecosystem health assessments. The establishment of a matrix of land use functions x ecosystem goods and services is as well on next year work plan.

References

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Table. Land cover in 1990 and 2000, Land consumption and Land formation – sum of 24 European countries

	Artificial areas	Arable land & permanent crops	Pastures & mosaics	Forested land	Semi-natural vegetation	Open spaces & bare soils	Wetlands	Water bodies	Total
Land cover 1990	161860	1174325	820109	1030635	264932	52593	46915	45854	3597223
Consumption of initial land cover									
lcf1 Urban land management	737	15	19	0	8	0	0		780
lcf2 Urban residential sprawl		1923	1867	200	145	8	3	2	4149
lcf3 Sprawl of economic sites and infrastructures	77	2728	1595	665	451	35	22	53	5627
lcf4 Agriculture internal conversions		17252	10062						27314
lcf5 Conversion from other land cover to agriculture	273		935	1796	1734	155	96	50	5039
lcf6 Withdrawal of farming		2393	2860						5253
lcf7 Forests creation and management	254			35803	5166	1048	1063	3	43337
lcf8 Water bodies creation and management	191	252	253	117	190	17		21	1042
lcf9 Change due to natural and multiple causes	311	44	15	1317	1323	1041	229	252	4534
<i>Total consumption of initial land cover</i>	<i>1843</i>	<i>24608</i>	<i>17607</i>	<i>39899</i>	<i>9018</i>	<i>2304</i>	<i>1413</i>	<i>381</i>	<i>97074</i>
Formation of new land cover									
lcf1 Urban land management	780								780
lcf2 Urban residential sprawl	4149								4149
lcf3 Sprawl of economic sites and infrastructures	5627								5627
lcf4 Agriculture internal conversions		15695	11619						27314
lcf5 Conversion from other land cover to agriculture		2450	2590						5039
lcf6 Withdrawal of farming			1124	2792	1244	23	70	0	5253
lcf7 Forests creation and management				42547	766	24			43337
lcf8 Water bodies creation and management						21		1021	1042
lcf9 Change due to natural and multiple causes				4	2167	1790	313	260	4534
<i>Total formation of new land cover</i>	<i>10556</i>	<i>18144</i>	<i>15333</i>	<i>45343</i>	<i>4177</i>	<i>1858</i>	<i>383</i>	<i>1280</i>	<i>97074</i>
Land cover 2000	170572	1167861	817835	1036079	260090	52147	45885	46754	3597223
<i>Net formation of land cover (formation-consumption)</i>	<i>8712</i>	<i>-6463</i>	<i>-2275</i>	<i>5444</i>	<i>-4842</i>	<i>-446</i>	<i>-1030</i>	<i>899</i>	
<i>Net formation of land cover as % of initial year</i>	<i>5.4</i>	<i>-0.6</i>	<i>-0.3</i>	<i>0.5</i>	<i>-1.8</i>	<i>-0.8</i>	<i>-2.2</i>	<i>2.0</i>	
<i>Total turnover of land cover (formation+consumption)</i>	<i>12399</i>	<i>42752</i>	<i>32940</i>	<i>85242</i>	<i>13195</i>	<i>4162</i>	<i>1796</i>	<i>1661</i>	<i>194148</i>
<i>Total turnover of land cover as % of initial year</i>	<i>7.7</i>	<i>3.6</i>	<i>4.0</i>	<i>8.3</i>	<i>5.0</i>	<i>7.9</i>	<i>3.8</i>	<i>3.6</i>	<i>5.4</i>

Figure. Land and ecosystem Accounting Framework

