Land accounts and Ecosystem Extent

DRAFT

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Contents

1 Introduction

Land accounting may refer to stand-alone applications (developed in SEEA-CF), or a component of experimental ecosystem accounting (included in SEEA-EEA). This document is intended to provide guidance on producing land data as an input to ecosystem accounts, but wherever relevant it refers to elements of the stand-alone land accounting (which is covered by guidance for the SEEA-CF), as well as other components of ecosystem accounting.

1.1 Land inputs in ecosystem accounting

Experimental ecosystem accounts need land data inputs that address:

a) land cover, which relates with ecological functions;
b) land use, which relates with economic functions; and
c) land divisions (areas) for statistical purposes.

Advancing ecosystem accounting seeks harmonized (spatially compatible) data production of the above three subjects, as well as clarification and further development of more detailed ecological functions that cannot be well explained by land cover, particularly the way these functions underpin accounting items to be further assessed as ecosystem assets and services.

Land accounting inputs are of particular importance for starting an experimental ecosystem accounting project, because they provide the means to initiate the above tasks, i.e. apply land cover types as proxy for ecosystem units (or assets); apply land use to delimit areas where ecosystem services originate; and also help to harmonize various inputs from scientific grid-data to assess condition and services, for example water run-off, habitats, carbon storage etc.

The advancement of ecosystem accounting can therefore be roughly sequenced in at least three steps: 1. Based on land-proxies and land-harmonized inputs, Tier I accounts; 2. Based on modelled thematic inputs, including land, water, carbon and other thematic subjects, Tier II; and 3. Based on measured (sampled, inventoried) data inputs for delineating detailed ecosystem asset units (proposed as Functional Ecosystem Units, FEUs, see Technical guidance note 1), Tier III.

Issues of error, uncertainty and data quality are inherent in work with proxies and data harmonization procedures. In the course of advancing the accounting system however, these proxies will be increasingly substituted by data produced specifically for the purpose and satisfying high quality standards.

Therefore, at Tier I and II, land accounting inputs, particularly land cover and use, will be applied for at least the following account estimation elements:

a) Proxy definition of ecosystem asset units in the absence of more detailed ecological information (applications as a proxy will be further explained in section 2), or when the scale of analysis has been chosen as appropriate at such an aggregate level.
b) Proxy definition and estimation of ecosystem extent measures, both in terms of an opening stock (for example area of a forest stand) and its changes

(additions and reductions of the stocks), in accordance with the land classifications included in SEEA-CF.

c) Definition of ecosystem accounting (or reporting) units, applied at a higher aggregate level (than detailed ecosystem asset unit) for a wider comparability (regional and international), corresponding to LCEU.
d) Use of land use to map the origin of (often spatially overlapping) ecosystem services that can be further linked to beneficiaries.
e) Use of land cover as a means of harmonizing data from different domains and subjects (e.g. hydrological, ecological, economic etc.). Downscaling and upscaling techniques are developed to assist such harmonization and enable common applicability addressing spatial ecosystem units. Again, when standards and methods for harmonized production of original data at sufficient quality are developed (Tier III accounts), these land-harmonization procedures may not be needed.

Apart of land cover and use, other land-related attributes may be needed for analytical and reporting purposes. Some are covered by SEEA-CF technical notes, but further specifications for ecosystem accounting are provided in section 2.

At Tier III, land accounting elements may only remain needed for statistics aggregation and reporting purposes, e.g. constructing LCEU, in which more detailed ecosystem asset units are hierarchically nested.

1.2 Scope

At Tier I, when applied as a proxy, land accounting will be the *basis for terrestrial ecosystem accounting*, it brings the spatial information component which can be linked to a number of ecological, social and economic functions pertinent to a *specific unit*/area. This helps to improve the understanding of a bigger holistic picture, depicting relations between humans, environment and ecosystems and to build integrated ecosystem accounts. Terrestrial land cover addresses freshwater and some coastal systems, but excludes marine, extensions to further coasts and sea can be pursued but to a less detailed extent (see PEGASO coastal and marine ecosystem accounts).

Key components of land accounting include *land cover types* (which may relate to broad categories of ecosystem *assets, such as forest, wetlands, grasslands* and their functions and/or *uses* (ecological, economic, social) at broader scale. Information on land ownership and tenure can be combined with land cover/use to produce accounts at a finer scale. The broader categories are well applicable for comparability; while the finer for analytical purposes, provided that bio-physical *changes* as well as economic *transactions* can be registered and their relations analysed. Ideally, the data needs to be collected at these different scales, processed and organized in a single dataset, to demonstrate both (local) *decision-support* applicability and broader *comparability* with other regions and countries.

Land accounts register the state of land cover and use at a certain time, which has also been termed *land stocks* (EEA, 2006) including the *extent* (area), type (which can be further related with indicators on condition) other properties (e.g. ownership); and changes between at least two steps in time (termed *flows* by the EEA, 2006). It may be useful to distinguish between '*naturally-driven*' and changes driven by human actions (*anthropic*).

1.3 Definitions

Key term definitions relevant to land accounting are listed below:

- Land is a unique environmental asset that delineates the space in which economic activities and environmental processes take place and within which environmental assets and economic assets are located (SEEA-CF definitions, p. 316)
- Land cover refers to the observed physical and biological cover of the Earth's surface and includes natural vegetation and abiotic (non-living) surfaces (SEEA-CF definitions, p. 316)
- Land use reflects both (a) the activities undertaken and (b) the institutional arrangements put in place for a given area for the purposes of economic production, or the maintenance and restoration of environmental functions SEEA-CF definitions, p.317)
- Land tenure is a set of rules defined by people to regulate land use (both space and its resources). This includes property rights and the way they can be changed…. (FAO's definition)
- Land cadastre is 'A comprehensive National digital dataset of land parcels including their surveyed boundaries' (Australian Bureau of Statistics - glossary), and associated attributes such as property ownership, use, value (price) etc.

Other terms that may need formal definition of land attributes for ecosystem accounting include: Real estate; Land functions; Land physiognomy; Vegetation cover, Landscape, Land use and land cover change etc.

Land use planning, management and conservation are concrete activities, which shape and define land as a surface composed of entities with distinct properties. Sometimes these entities have discrete and easily observable boundaries, for example a lake surrounded by mountain forest, sometimes – gradual transitions, such as a lake surrounded by wetlands with fluctuating water levels. Gradual transitions present a challenge for land accounting due to the mixing of two or more surface features (for example water and wetland vegetation).

Land cover *nomenclatures* and *classification* schemes are devised to express land cover surface on a map. These include rules to define and summarise the 'most important' land cover features and patterns. Transitional patterns are often addressed using thresholds to draw lines between gradual transitions (such as lowest water level for a lake surrounded by wetlands), or to define mixed classes ("lake and wetlands" as a single class, distinguished from single lake or single wetland).

The International Organization for Standardization (ISO) has introduced a standard on land cover classification, the ISO 19144-2:2012. The standard contains a common umbrella land cover classification system structure, which includes definitions, classifiers and class descriptions based on physiognomy (the access to the full ISO detail need to be purchased).

The UN FAO has developed a comprehensive Land Cover Classification System (LCCS, FAO 2000), which contains publicly accessible detailed classification concepts and user manuals.

1.4 Land accounts in globally applicable guidance[2]

The SEEA-CF contains a chapter on land accounts (called 'Asset accounts for land' section 5.6, pages 173 – 181) which provides guidance on both land cover and land use accounts preparation separately, however, the existing practical experience mostly shows evidence on combined applications or only land cover. Land use remains a more challenging subject to map, in part because of the overlapping nature of land use activities, and difficulties to summarize dominant ones.

SEEA-EEA, section 4.3 "Compiling ecosystem asset accounts" provide a short guidance on land cover accounting as an input to account for the 'extent' of ecosystem assets (the whole subject is being currently revised for the purpose of expanding this EEA guidance).

CBD's Quick-Start Package on Ecosystem natural capital accounting, (QSP-ENCA) chapter 4 "The Land Cover account" contains the most recent and exhaustive overview of land accounting concepts, methods, tools (including software), examples and globally available data inputs.

The main objective of this technical guidance document is to provide guidelines on building the land data foundation, and its applications for ecosystem accounts estimation. It includes an overview of existing national and regional applications, summary of their strengths and weaknesses, and concrete data sources, land cover and use classification and validation techniques.

1.5 Challenges and information gaps

Challenges remain however, and the following *needs* can be generalized:

- Need for clarification with related subjects, such as vegetation cover and types, eco-regions, habitat types, biotopes etc.; These may be closely related to land cover, and indeed fit within a unified hierarchical system, but the applied terminology, the nature of the data (including its quality, detail etc.) and data sources need explicit definitions and clarifications.
- Need to produce an agreed standardized and hierarchical classification nomenclature on land cover, to which uses, extents, conditions, and other attributes (also in standardized form) can be linked, to facilitate comparable accounts production anywhere at least on a certain aggregated level, which would be further detailed at national and local levels (see note Technical guidance note 1, on FEU). This may be a longer term process however, to be completed after certain mass of evidence from 'good ecosystem accounting practices' has been accumulated internationally
- Need for data quality and improved mapping precision especially at national levels
- Need for consistent and harmonized multi-temporal maps and related accounting inputs production
- Finally, there is a need for integrated accounting tools, where policy questions (key issues of interest) can be linked with well-defined

[2] National and regional applications are shown in section 3.

accounting categories (be it land type/stock, condition measure, use type etc.) and with well explored (proven) data sources

This note includes details on the above, as well as disambiguation with related subjects, such as vegetation cover and types, eco-regions, habitat types etc.

The guidance document on land and ecosystem accounting is in a process of development which takes into account the available international experiences, available tools and data inputs and concludes with recommendations for further experimentation.

2 Methodology

Section 2 introduces generalized principles and methods (including data sources) for working with spatial data on land for ecosystem accounting, building on the available globally applicable guidance from SEEA-CF, SEEA-EEA and QSP-ENCA, as well as the on-going experience with the SEEA-EEA pilot and associated countries.

Ecosystem accounting addresses key ecological functions, which can be related to tangible structures in the landscape. Land cover and land use bring in the structural elements, that is often the only way of drawing boundaries on the ecosystem accounting units and hence define their coverage. Since ecosystems are spatial entities, these units need to be established first as asset units, the smallest spatial area of certain homogeneous coverage and functions (proposed as FEUs in in Technical guidance note 1), and higher level delineations for statistics production and reporting, termed as LCEUs in SEEA-EEA.

Specific guidance on mapping ecosystem asset units is provided in Technical guidance note 1 (on FEUs); and guidance on various reporting and accounting units is provided in Technical guidance note 8. This section introduces guidance on developing the data needed for both of the above units, especially when needed for developing proxy inputs for the Tier I and II accounts; as well as land data used for harmonization (spatial modelling) procedures. For Tier III accounts it is possible that land elements will need to be built following (strictly) the more detailed delineations of FEUs on the ground.

A key question to bear in mind is, that the *accounting and reporting units* (LCEU) need to focus on more 'stable' or permanent landscape structures, such as topographic forms, river catchments, potential vegetation forms, ownership boundaries (in some instances), etc., while land use and land cover data used as proxy of ecosystem assets needs to reflect temporal and spatial changes that may be very dynamic, because of natural (phenology, meteorology) and human drivers of change. Therefore, there is a need to combine many sources of information that are fit for the above purposes.

Land accounts are needed to inform decision making regarding better/ optimized use and conservation of land and ecosystem resources. It is not merely for bookkeeping or information supply. Therefore, the accounts need to ensemble and summarize the information needed to inform many land management objectives.

Detailed guidelines on compilation of land accounts are available in the SEEA-CF technical notes and the CBD-QSP handbook, which are developed as stand-alone applications. In the following section, therefore most attention is directed to using land data to build the necessary elements for ecosystem accounting e.g. proxies of units and assets, harmonization processes. Since issues of data quality, error and uncertainty propagation are paramount when relying on remote sensing data products, the following notes provide suggestions for addressing some of these issues.

2.1 Building the data foundation

To develop land accounts one needs to start with developing the data foundation. It includes the spatially and temporally explicit mapping of land types, properties and

their changes according to a given (chosen, adapted or newly developed) classification nomenclature, but compatible with the recommendations of SEEA-CF and SEEA-EEA. Developing harmonized ecosystem accounting nomenclatures is a key objective of SEEA-EEA.

Typically, two types of land-data are needed: data on dynamic (changing) entities, and on permanent entities.

Permanent entities can be characterized with (relatively) stable boundaries, for example countries, territorial divisions, protected areas, as well as bio-regional entities, such as biomes, eco-regions, river catchments etc. Such entities are used (mostly) for mapping ecosystem accounting units.

Dynamic entities are those that reflect annual and multiannual changes of land features, notably expressed as land cover and land use change, but more concrete variables may have to be introduced too, for example change of land ownership, land price, land ecological functions etc. (see technical guidance note 1 on FEU).

In both cases, one part of the data will be addressing ecological or bio-physical features (as a proxy) and another one - anthropic (administrative, economic etc.).

2.1.1 Data on permanent (accounting unit) features

Data on local and higher level **administrative, statistical** and **territorial divisions** are usually publicly available from national sources. Global sources of harmonized administrative data can be accessed online, for example ESRI's World Administrative Divisions; and for statistical areas, examples can be consulted from sources like EU's NUTS, Australia's Statistical Areas. Such data is needed for statistical area-units delineation (sometimes following the boundaries of communes, municipalities, provinces, counties etc.), which conforms to principles of confidentiality. Other relevant themes of longer-term land management may be: protected areas (global source - http://www.protectedplanet.net/) and other designations (such as water provision, green corridors and belts etc.).

Well accepted **ecological** and **bio-physical classifications** (and datasets) can be accessed from global sources, including WWF's Terrestrial Ecoregions; USGS's Global Ecosystems (mapped for the Americas and Africa); potential vegetation (that can be used to assess 'pre-settlement' reference conditions, see global source: Ramankutty and Foley, 1999) etc. Nationally available source may be available in a form derived or different from the globally accepted ones, usually with higher detail, including local and regional geographic features.

Globally harmonized river catchments can be accessed from FAO's hydrosheds, by continent and global soil types from ORNL DAAC data sets (local or national sources would be preferable if existing).

2.1.2 Data on dynamic (asset) land features

Land use and land cover data will often be the only readily-available source to develop proxy of ecosystem assets over large (complete country coverage) areas and map the places where certain ecosystem services are generated. Despite being subject to error, such data may be sufficient to perform initial analysis, estimate Tier I accounts, and detect subset areas (hotspots of changes) for more detailed ecosystem accounting pilots, and advance towards national Tier II and III accounts.

Land cover may be derived from the following globally available sources:

a. FAO Global Land Cover-SHARE

The FAO product Global Land Cover-SHARE (year 2014 Beta-Release 1.0) is constructed using the best quality national and international data sources. 11 land cover classes were harmonized and reclassified according to the LCCS nomenclature and included in the SEEA-CF (see Fig. 2). The individual classes (layers) can be downloaded online in quantitative area coverage form, expressed as area per grid-cell (from 0 – 100 ha) and also a composite map of dominant classes. Validation results indicate overall Producer's accuracy of 80% (variable between 50 and 100% for the individual classes). The available product has to be tested if possible to apply for multi-temporal analysis (e.g. for countries where the original data source contains more than one year maps).

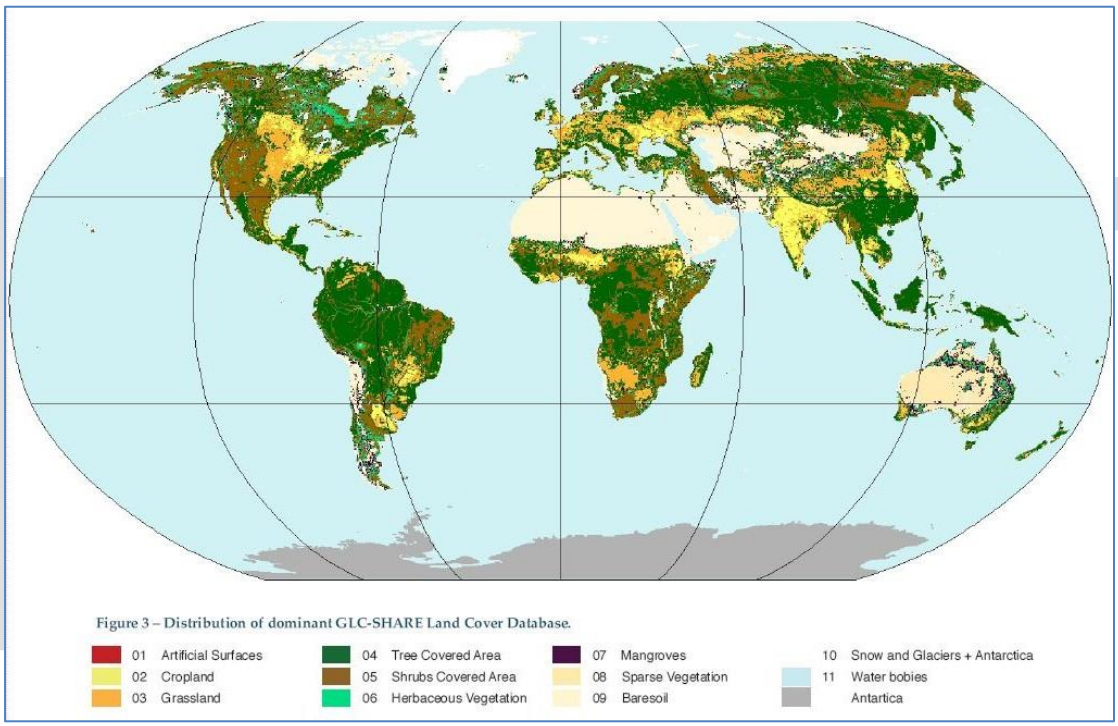


Fig. 2. Global land cover-SHARE. Source: Global Land cover network (GLCN)

The 1km grid-maps may be too coarse for spatial analysis, yet the available data may be applied to enhance its quality and spatial detail, as well to reproduce annual time-series using remote sensing imagery.

b. MODIS Land Cover

Modis Land Cover is a set of annual products based on NASA's MODIS imagery, and available at 500m x 500m spatial resolution. The product name is 'Land Cover Type Yearly L3' (version 51 is the latest), metadata can be reviewed, and spatial data downloaded from http://reverb.echo.nasa.gov/. The data is distributed as 'granules', which need to be identified by the user (online) prior to downloading. If the study area is large (e.g. a continent) considerable pre-processing will be needed to ensemble

('mosaic') and harmonize the datasets. MODIS land cover products[3] are summarised below. See nomenclatures for the five products in Annex 1.

The MODIS Land Cover Type product contains five classification schemes, which describe land cover properties derived from observations spanning a year's input of Terra- and Aqua-MODIS data. The primary land cover scheme identifies 17 land cover classes defined by the International Geosphere Biosphere Programme (IGBP), which includes 11 natural vegetation classes, 3 developed and mosaicked land classes, and three non-vegetated land classes.

The MODIS Terra + Aqua Land Cover Type Yearly L3 Global 500 m SIN Grid product incorporates five different land cover classification schemes, derived through a supervised decision-tree classification method:

- Land Cover Type 1: IGBP global vegetation classification scheme
- Land Cover Type 2: University of Maryland (UMD) scheme
- Land Cover Type 3: MODIS-derived LAI/fPAR scheme
- Land Cover Type 4: MODIS-derived Net Primary Production (NPP) scheme
- Land Cover Type 5: Plant Functional Type (PFT) scheme

V051 Land Cover Type products are produced with revised training data and certain algorithm refinements. For further details, please consult the following paper:

Friedl, M. A., Sulla-Menashe, D., Tan, B., Schneider, A., Ramankutty, N., Sibley, A., andHuang, X. (2010). MODIS Collection 5 global land cover: Algorithm refinements and characterization of new datasets. *Remote Sensing of Environment*, 114, 168–182.

Temporal analysis of land cover change may be obstructed by the data quality and course resolution, however it may be feasible to improve the available data for accounts estimation.

c. ESA's GlobCover

The European Space Agency has produced the GlobCover maps at 300 m spatial resolution for year 2005-6 and 2009 using MERIS imagery. The two temporal maps are not compatible for land use change analysis however. GlobCover applies a hierarchical classification scheme. Global and regional nomenclatures can be consulted online (see Annex II in ESA's report "GLOBCOVER Products Description and Validation Report" [4]).

d. GlobeLand30

Very high resolution global land cover maps were produced by China, known as GlobeLand30, for years 2000 and 2010, with 10 classes and 30 m resolution, based on the freely available imagery from NASA's Landsat satellite instruments. The data is available online after registration, and was also donated to the UN.

[3] https://lpdaac.usgs.gov/products/modis_products_table/mcd12q1

[4] http://due.esrin.esa.int/files/GLOBCOVER_Products_Description_Validation_Report_I2.1.pdf

1. Water bodies
2. Wetland
3. Artificial Surfaces
4. Tundra
5. Permanent snow and ice
6. Grass lands
7. Barren lands
8. Cultivated land
9. Shrub lands
10. Forests

Fig.3. GlobLand30 classification nomenclature[5]

GlobLand30 may be the most appropriate dataset for ecosystem accounting, because of its highest spatial detail and the possibility to analyze land cover change; however its quality needs to be well evaluated, since it is the newest source, among other reasons.

Land use data is usually not readily and uniformly available and therefore needs to be assembled from a number of sources, most commonly applicable would be sought from agriculture, forestry, mining, transport, industry and urban planning and administration (including parks and recreation). Protected areas administration and management (including zoning), hunting and fishing areas etc. may provide very relevant land use information too. The subject generally needs much further efforts for developing harmonized inputs (including spatial data) in land and ecosystem accounting. The European CORINE product introduced land use categories in its combine land cover and use nomenclature (see details in Section 3). Examples of mapping ecosystem services with land use include Bateman et al. (2013) and specific tools for the purpose: LUSI, Polyscape (see Jackson et al. 2013) etc.

Administrative data (including maps) on **land ownership** are likely to be available from national sources such as *Official land cadasters* or similar *land administration registers*, for example UK's Ordinance survey. Classification of Land ownerships should be developed, including private and public domains, which may overlap or differ from land use. For example, abandoned cropland may still belong to a farmer, but actually be used for nature restoration.

Land cover, land use and land ownership can change in a very dynamic way independently from each other. Therefore these three properties of land may need to be classified and mapped separately for a complete accounting application at Tier III.

Note that a **number of other themes and sources** of spatial data related to ecosystem functions or components will be very relevant for the accounting purposes (to map condition for example):

- Forest cover and deforestation - University of Maryland product "Global Forest Change
- Vegetation types, physiognomy, productivity, habitats etc.

Complete classifications on either of the above subjects, with strict definitions of their classes cannot be recommended at present, and these need to be developed for each

[5] http://www.globallandcover.com/GLC30Download/index.aspx

experimentation project as fit-for-purpose. Adherence to the SEEA-CF aggregated nomenclature on land cover and use (shown in section 2.2) should be pursued for international comparability and advancing the accounting systems. Normally, the nomenclatures of most sources of globally applicable data can be translated into the categories suggested by SEEA-CF (even if not all classes would be addressed).

2.1.3 Processing, validation and improvement of land data inputs

The available global sources of land cover can be applied for testing Tier I ecosystem accounts estimations. If these global sources are chosen for experimental accounting, the data quality and accuracy will need to be evaluated if acceptable, because of the inherent quality limitations pertaining to remote-sensing land products.

Classical validation techniques can be applied using ground truth data. The EU's LUCAS (Land Cover/Use Statistics) provides a very advanced system of collecting such data[6] for both land use and land cover (see nomenclatures in Annex 3).

Alternative methods can be considered, if such data does not exist, and neither resources to develop it. Guidance on such alternative land cover assessment and validation can be consulted in scientific literature, for example: Riemann et al. (2010); Bai (2010), etc.

If the available global sources are not adequate or of poor quality, these may be improved e.g. the detected errors corrected; or the input data re-classified; or new products can be developed. New products developed specifically for ecosystem accounting, with high precision and multi-annual time-series are needed for Tier II and III accounts. The QSP-ENCA provides an overview of most relevant techniques (see from p. 74, section 4.1.3 Land-cover mapping). Specialized institutions, such as GIS and remote sensing laboratories, would have to be involved/hired for completing the task.

Typically, land cover and use maps have to be provided at an appropriate spatial resolution (in most cases between 30 and 100 m, maximum 500) and covering at least two steps in time, including most recent data. For reliable land use/cover change detection and analysis, consistency between the different time maps is more important than absolute accuracy.

2.2 Estimation of accounts on ecosystem extent

Once, the data foundation has been built, land accounts on extent of selected asset classes can be estimated by following accounting classification nomenclatures[7], some of which have been developed up to a certain level of international comparability (see below the SEEA examples on land cover and land use) and others that still need to be developed (through experimentation and consultation).

[6] See viewer: http://ec.europa.eu/eurostat/statistical-atlas/gis/viewer/?myConfig=LUCAS-2012.xml

[7] Accounting nomenclatures communicate with related (geographical) ones, for example International Geosphere-Biosphere Programme (IGBP) land cover classification system.

Core variables include estimates of main land types such as forest, croplands, urban lands, wetlands, grasslands and water bodies on most aggregate level. Changes registering the increase or decrease in each of the above types between two steps in time need to be mapped and estimated from at least two temporal maps. For the purpose, the temporal maps need to agree fully in terms of precision, coverage and nomenclature. The SEEA-CF provides guidance on structuring these accounts, see 'Scope of Land Cover accounts' (from page 179); and the guidance on 'Stocks, changes and flows of consumption and formation' in QSP-ENCA (page 88).

The following land accounting nomenclatures are included in SEEA CF (note that land use is divided into Land (1) and Inland waters (2):

Land cover classification (Table 5.12, p.178)	**Land use classification (Table 5.11, p. 176)**
1 Artificial surfaces (including urban and associated areas)	1.1 Agriculture
2 Herbaceous crops	1.2 Forestry
3 Woody crops	1.3 Land used for aquaculture
4 Multiple or layered crops	1.4 Use of built-up and related areas
5 Grassland	1.5 Land used for maintenance and restoration of environmental functions
6 Tree-covered areas	1.6 Other uses of land n.e.c.
7 Mangroves	1.7 Land not in use
8 Shrub-covered areas	2.1 Inland waters used for aquaculture or holding facilities
9 Shrubs and/or herbaceous vegetation, aquatic or regularly flooded	2.2 Inland waters used for maintenance and restoration of environmental functions
10 Sparsely natural vegetated areas	2.3 Other uses of inland waters n.e.c.
11 Terrestrial barren land	2.4 Inland waters not in use
12 Permanent snow and glaciers	
13 Inland water bodies	
14 Coastal water bodies and intertidal areas	

Fig. 4. SEEA-CF land cover and land use nomenclatures

The following land accounting nomenclature is suggested in CBD-ENCA guide (p.71)

Class	**Label**
01	Urban and associated developed areas
02	Homogeneous herbaceous cropland
03	Agriculture plantations, permanent crops
04	Agriculture associations and mosaics
05	Pastures and natural grassland
06	Forest tree cover
07	Shrubland, bushland, heathland
08	Sparsely vegetated areas
09	Natural vegetation associations and mosaics
10	Barren land
11	Permanent snow and glaciers
12	Open wetlands
13	Inland water bodies
14	Coastal water bodies and inter-tidal areas
15	Sea (interface with land)

Fig.5. CBD-QSP land cover nomenclature

SEEA and CBD-QSP nomenclatures are rather similar and well applicable for wide international comparability. They can also be applied for generating new (national)

land cover data, especially if no previous examples of such work exist. However, additional fine-tuning and break down of the above classes would most likely be needed to better characterize local land cover characteristic, which address also habitats and vegetation properties (see technical guidance note 1 on FEU).

In cases where the land accounting inputs were generated using nomenclatures that differ from SEEA's, the latter can be translated, but it is essential to document the exact transitions for ensuring wider comparability.

Each individual datasets, part of the accounting data foundation needs to undergo the full quality criteria assessments applicable to any type of official statistics production, including relevance, accuracy, precision, timeliness, usefulness etc.

Ecosystem accounting units are used to extract and report the accounts in a way, which suits wider regional and international comparability, yet with relevance for decision-support purposes. For example private property farmlands with different production rate may be analyzed to inform the management of water provision (or improved water quality) on a catchment scale (full guidance on accounting units is provided in Technical guidance note 8).

Further development of the SEEA land accounting nomenclatures may be appropriate to take shape in hierarchical forms (with different nomenclatures for each of the three components, cover, use and ownership), where aggregate levels would serve for international comparability and detailed ones for local/national decision-support information. In addition further links and relations may be needed, for example land use classes to be compatible with ISIC.

2.3 Estimation of land asset proxies and links to asset condition and services

For Tier I ecosystem accounts, land cover types may be applied as proxies of ecosystem assets, by introducing 'asset' attributes to each type, to approximate a 'measure of condition'. In the absence of detailed ecological data such attributes can be developed using expert knowledge and their mapping can be facilitated using commonly available sources, for example eco-regions with their bio-climatic characteristics. The origin of possible ecosystem services can be mapped, as expected on the basis of causal relationships with dominant land and use types, introduced within land cover categories.

For Tier II, more detailed assets can be mapped by linking land cover and use units with other bio-physical ecosystem characteristics, namely those derived from water, carbon, nutrients and biodiversity accounting themes, as well as others if deemed necessary. Standardized reference grid (BSU) needs to be available or developed for combined use of multiple, different courses of input data. Special data harmonization techniques will have to be applied.

2.4 Harmonization of condition-related indicators through land cover

Grid computations allow to estimate indicators of ecosystem condition from various inputs, where land cover is used as the variable to 'correct' and match selected biophysical variables from hydrology, carbon cycle and biomass, nutrient cycling,

biodiversity etc. Because of different technical specifications (for ex. resolution) and detail of the original data typically two types of transformations are applied, downscaling or up-scaling.

Downscaling is a technique applied to allocate coarse measures/estimates (including aggregate statistics) to a more detailed, spatially explicit (grid) maps. In other words it allows to 'model' the spatial behavior of an entity at landscape level using factors and suitability parameters from land cover, vegetation indices and other remote sensing products, which drive this spatial behavior, expressed as patterns and volumes, for example biomass.

Main advantage of the technique is the ability to address wide areas (such as number of countries or number of regions within a large country) in a harmonized and easily reproducible way.

Downscaling is appropriate for estimating biophysical indicators that can be linked to ecosystem condition and services, including forest stocks (from FAO's Forest Resource Assessments), harvest of crops and timber, products from grazing animals etc. Possibly more suitable inputs for ecosystem condition can be mapped using the globally available spatial data on IUCN classified species[8], for which habitat requirements are described, and the habitats can be mapped using remote-sensing products such as land cover, vegetation indices and indices on image texture/pattern.

Fully documented downscaling examples for carbon accounting are available for the European Union countries and can be obtained from the European Environment Agency.

Upscaling is a method for allocating point-data measurements and samples to spatially explicit (grid) maps, using environmental suitability factors which are expected to drive the spatial behavior the measured entity.

[8] Spatial data on IUCN species can be downloaded online: http://www.iucnredlist.org/technical-documents/spatial-data

3 Examples of land accounting from existing national and international projects on EEA

This section summarises the existing practical experiences on land accounting elements within experimental ecosystem accounting internationally.

The review includes national and international programmes and projects, which include land accounts as a component or stand-alone applications.

The following accounting elements are discussed for each project:

a) Compatibility and comparability with the land accounting classifications proposed in SEEA-CF and SEEA-EEA.
b) The land 'stocks' and 'flows' are mapped and quantified
c) Land inputs for delineation of ecosystem accounting units and assets
d) The way ecosystem conditions are assessed (using land and other attributes)
e) The way ecosystem services and assets have been addressed (e.g. in spatially explicit way, based on land accounts)
f) Estimation of aggregated or composite indicators
g) If research priorities and remaining challenges are discussed

3.1 European land and ecosystem accounts

Most of the EU-level work on ecosystem accounting has been based on CORINE land cover.

3.1.1 Data foundation

CORINE Land Cover (CLC) is a harmonized map product, based on remote sensing inventory of land cover and use features for the countries part of the European Union and associated neighbourhood countries. The land cover component is part of a wider CORINE (Co-ordination of Information on the Environment) programme, which includes similar products on biotopes, coastal erosion etc.

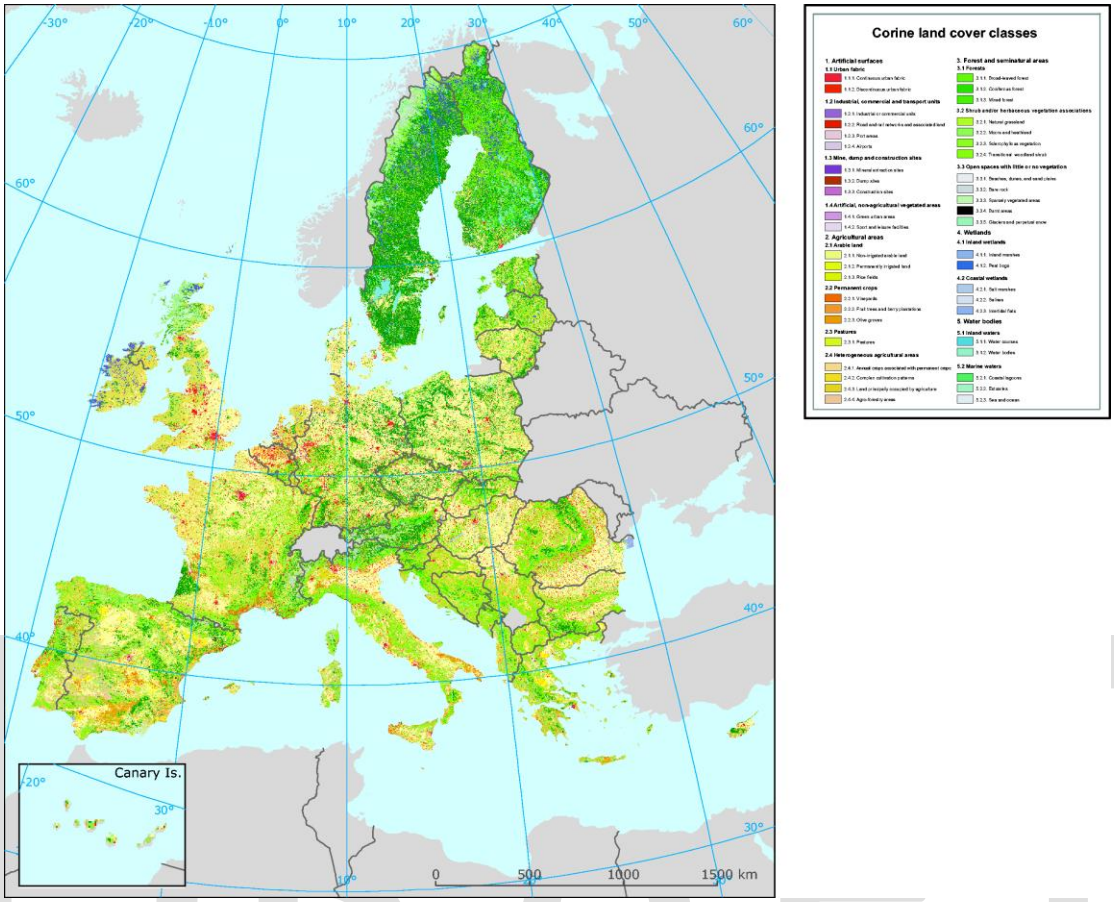


Fig. 7. One of CORINE's distinctive features is that land cover and land use are combined in a single nomenclature, structured hierarchically in three levels (level one contains 5 classes, level two – 15 and level three – 44), shown on Figure 8.

Level 1	Level 2	Level 3
1. Artificial surfaces	1.1 Urban fabric	1.1.1 Continuous urban fabric
		1.1.2 Discontinuous urban fabric
	1.2 Industrial, commercial and transport units	1.2.1 Industrial or commercial units
		1.2.2 Road and rail networks and associated land
		1.2.3 Port areas
		1.2.4 Airports
	1.3 Mine, dump and construction sites	1.3.1 Mineral extraction sites
		1.3.2 Dump sites
		1.3.3 Construction sites
	1.4 Artificial, non-agricultural vegetated areas	1.4.1 Green urban areas
		1.4.2 Sport and leisure facilities
2. Agricultural areas	2.1 Arable land	2.1.1 Non-irrigated arable land
		2.1.2 Permanently irrigated land
		2.1.3 Rice fields
	2.2 Permanent crops	2.2.1 Vineyards
		2.2.2 Fruit trees and berry plantations
		2.2.3 Olive groves
	2.3 Pastures	2.3.1 Pastures
	2.4 Heterogeneous agricultural areas	2.4.1 Annual crops associated with permanent crops
		2.4.2 Complex cultivation patterns
		2.4.3 Land principally occupied by agriculture with significant areas of natural vegetation
		2.4.4 Agro-forestry areas
3. Forests and semi-natural areas	3.1 Forests	3.1.1 Broad-leaved forest
		3.1.2 Coniferous forest
		3.1.3 Mixed forest
	3.2 Shrub and/or herbaceous vegetation associations	3.2.1 Natural grassland
		3.2.2 Moors and heathland
		3.2.3 Sclerophyllous vegetation
		3.2.4 Transitional woodland scrub
	3.3 Open spaces with little or no vegetation	3.3.1 Beaches, dunes, sand plains
		3.3.2 Bare rock
		3.3.3 Sparsely vegetated areas
		3.3.4 Burnt areas
		3.3.5 Glaciers and perpetual snow
4. Wetlands	4.1 Inland wetlands	4.1.1 Inland marshes
		4.1.2 Peat bogs
	4.2 Coastal wetlands	4.2.1 Salt marshes
		4.2.2 Salines
		4.2.3 Intertidal flats
5. Water bodies	5.1 Continental waters	5.1.1 Water courses
		5.1.2 Water bodies
	5.2 Marine waters	5.2.1 Coastal lagoons
		5.2.2 Estuaries
		5.2.3 Sea and ocean

Fig. 8. Hierarchical nomenclature of CORINE Land cover

On European scale data has been produced up to the third level at three time steps, 1990, 2000 and 2006 (2012 is under development), but individual country or regional applications have elaborated higher detail levels, for example Spain's Andalucian land use and vegetation cover with 112 classes equivalent to at level five of CORINE land cover.

3.1.2 Estimation of land accounts

The European Environment Agency has been producing *land accounts* for the EU countries based on the CLC. A specific methodology was developed to classify land accounting categories in *stocks* and *flows*, it is published in 'Land accounts for Europe 1990–2000' (by Weber and Heines-Young, European Environment Agency). Stock accounts (areas per CORINE class) are summarized in the following broader categories.

Code	Broad cover type	Aggregated CLC classes by Code
1	Artificial surfaces	CLC 1
2A	Arable land and permanent crops	CLC 2.1+2.2+2.4.1
2B	Pastures and mosaic farmland	CLC 2.3+2.4.2+2.4.3+2.4.4
3A	Forests and transitional woodland shrub	CLC 3.1+3.2.4
3B	Natural grassland, heathland, sclerophylous vegetation	CLC 3.2.1+3.2.2+3.2.3
3C	Open space with little or no vegetation	CLC 3.3
4	Wetlands	CLC 4
5	Water bodies	CLC 5

Fig.9: Broad land cover classes used to classify CORINE land cover data for land accounts. Source: 'Land accounts for Europe 1990–2000'

Land flows were created by analyzing all the possible transitions between the 44 classes and summarizing them into 75 meaningful transitions at 3 hierarchical levels, with 9 categories of land cover/use change shown in Fig.9, and the full detail can be consulted in 'Land accounts for Europe 1990–2000'.

The classification of changes was derived from the cross tabulation of the 44 level 3 Corine land cover classes, which produced 1936 possible pairings of all potential initial and final cover classes. Of these, 44 represented no change (i.e. they were arranged along the leading diagonal of the matrix), and 1892 represent a potential type of transformation. In order to make the matrix of change easier to handle the changes were aggregated into 50 types of flows, which themselves could be grouped into just nine major categories of change. The latter represented level 1 in the resulting nomenclature of change. They are:
LCF1 Urban land management
LCF2 Urban residential sprawl
LCF3 Sprawl of economic sites and infrastructures
LCF4 Agriculture internal conversions
LCF5 Conversion from forested and natural land to agriculture
LCF6 Withdrawal of farming
LCF7 Forests creation and management
LCF8 Water bodies creation and management
LCF9 Changes of land cover due to natural and multiple causes.

The land *stock* and *flow* accounts cover two periods of time 1990 – 2000 and 2000 – 2006, and a third period 2006 – 2012 will be available soon.

Land 'condition' assessments have been approached by estimating spatial indicators from selected land cover classes, e.g. urban, agricultural and natural and semi-natural following specific data transformation techniques, which consists of estimating number of hectares per grid cell of 1km x 1km, and also applying spatial smoothing (fully explained in 'Land accounts for Europe 1990–2000'). An indicator called Green Landscape Background aggregates all land-cover types (namely, 2A, 2B, 3A, 3B, 3C, 4 and 5 in table Fig.9), which are expected to contain certain ecologically-favorable functions. A step further in assessing ecosystem condition was approached

by combining the green background information with two more indicators: on protected areas coverage and landscape fragmentation by roads, railways and urban areas. This indicator is called Net Landscape Ecological Potential (nLEP, created by Weber and Spyropoulou, 2006).

Ecosystem accounting units were created on the basis of the CLC, by extracting dominant land types (dominance defined as land type coverage exceeding either 34 or 50% of a grid-cell) and this land information was further combined with administrative divisions, river catchments and elevation zones. The resulting units are called Socio-ecological Landscape Units (SELU, Weber and Ivanov, 2011).

3.1.3 Development of simplified ecosystem capital accounts

Simplified ecosystem capital accounts were developed by the European Environmental Agency, following the publication of an experimental framework for ecosystem capital accounting (EEA, 2011). Data inputs on land, water, carbon-related and biodiversity related themes were tested for estimation of spatially explicit time-series of accounting inputs, all harmonized at 1km reference grid.

Downscaling and up-scaling techniques were applied to process carbon-related inputs, using CORINE land cover and SPOT vegetation indices. The accounts includes opening stock of biomass and soil organic carbon for year 2000, and annual flows until 2010. The annual flows present the major volumes of carbon exchanges: primary production, ecosystem respiration, carbon exports through harvests and imports through manure and sludge. These allowed to estimate two balancing items: net ecosystem production (which is the balance between the vertical carbon transfers, e.g. from and to the atmosphere) and balance between lateral imports and exports. The two balancing items were summed up to estimate net annual carbon balances.

Accounts on species and habitats of European conservation importance were estimated using data from the 'Article 17 Reports' generated by the EU25 countries. These data were published in connection with their first assessment under the EU's Habitat Directive, covering the period 2001 – 2006 (new reports were delivered in 2013). They vary, however, in their quality and spatial detail, which makes their interpretation difficult. A downscaling procedure was therefore applied to enhance and harmonize the species and habitats distributions and counts in a way allowing for international comparison at a landscape level.

The above land, carbon and habitat/species accounting themes allow to estimate composite indicators of ecosystem condition.

3.2 Mapping and Assessment of ecosystems and their Services (MAES) in Europe

The MAES programme[9] was set up by the European Commission to support the European Union (EU) member states to achieve a high-level policy target under EU's Biodiversity Strategy 2020, to have the countries' ecosystems and their services mapped and assessed by 2014. The working approach is broadly based on the recommendations of SEEA-EEA, it proposes a typology of European ecosystems (largely based on CORINE land-cover) and ecosystem services according a baseline and scenarios of change.

Even if few of the 28 member states have reported MAES results (towards the end of 2014), ample methodological guidance has been developed on European level. It includes an common analytical framework, a Europe wide map of ecosystem types; and set of indicators for identifying ecosystem services associated with broad pilot themes e.g. agriculture, nature, forest, freshwater, marine. The identification of ecosystem services follows CICES (v4.3) nomenclature. Natural capital accounting is addressed as a separate pilot within MAES in which also a number of countries are involved, an overview of progress is available (report from Jan. 2014).

3.3 Mediterranean coastal land accounting

The European land accounting methodology was adapted (simplified) for developing land accounts for the African and Middle-East countries of the Mediterranean basin where urban sprawl on the coast and related loss of natural and semi-natural habitats is of a main concern. This work was done within the EU-funded project PEGASO.

Land cover maps were produced specifically for the purpose (see Fig. 10), because the existing global maps were not suitable for analyzing urban land use changes in the area. Medium resolution remote sensing imagery (MODIS) was acquired from NASA's data provision services (http://reverb.echo.nasa.gov/) and classified (maximum likelihood supervised classification in ArcMAP) to map 16 classes of land cover addressing most pressing issues of land use change especially in coastal areas (such as dense and dispersed urban sprawl, intensive and extensive agriculture, forests, wetlands and water bodies).

[9] Action 5 on **Mapping and Assessment of Ecosystems and their Services (MAES)** under target two of the EU 2020 Biodiversity Strategy foresees that:
"Member States, with the assistance of the Commission, will map and assess the state of ecosystems and their services in their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020".

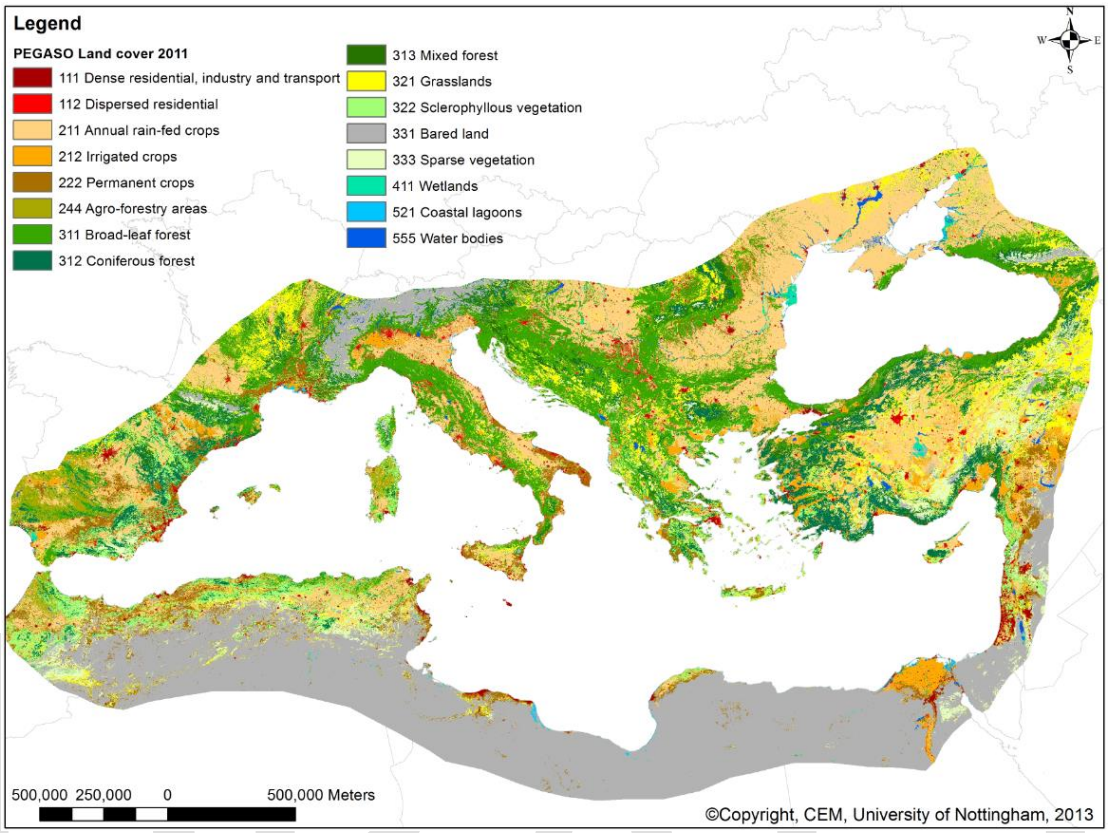


Fig 10. PEGASO Land Cover for year 2011

Land accounts were produced for the years 2000 and 2011 for accounting units defined by the intersection of the countries administrative divisions and three buffers of increasing distance from the coast-line, 1, 10 and 50 km.

There is interest to further refine and update the land accounting methodology by UNEP's MAP programme for the Mediterranean Sea. Reports containing details on the Mediterranean land accounting work can be consulted online (chapter 2).

3.2 Australian land accounts

The Australian Bureau of Statistics is producing annual Australian Environmental and Economic Accounts (AEEA) on national level (catalogue number 4655). These accounts include 'stock' estimates for major land cover classes (see below) and changes between them. The latest 2014 accounts release can be accessed as a (pdf) report and (excel) data-cubes.

The previous release (2013, Towards Australian Environmental and Economic Accounts) included a chapter (number 6) on Experimental land and ecosystem accounting, where several regional initiatives are introduced, including the Experimental land accounts for Victoria and Queensland (see catalogue series 4609).

On national level Experimental land accounts have been compiled for Australia using two maps that cover the periods January 2001 to December 2002 and January 2010 to December 2011. The map product are called Dynamic Land Cover, beta version (DLCv2, see AEEA, 2014, p 24), developed by Geoscience Australia. This map product has 25 land classes, based on the international standard classification of land

cover, ISO-19144-2:2012, Land Cover Meta Language, but adapted to Australia's land characteristics. The imagery source is NASA's MODIS, specifically the 16-day EVI composite at 250 m resolution[10].

Fig. 12. National Dynamic Land Cover Dataset of Australia (source: Geoscience Australia)

Land cover accounts were estimating by aggregating the 25 classes into seven categories, as shown below.

[10] From 'Product description: 'The MODIS time series for each pixel was analysed using an innovative technique which reduced each time series into 12 coefficients based on the statistical, phenological and seasonal characteristics of each pixel. These coefficients were then clustered using a support vector clustering algorithm and the resultant classes were labelled using agreed National data supplied from catchment scale land use mapping and the National Vegetation Information System (NVIS).'

Australian Dynamic Land Cover	AEEA presentation
Built Up Areas	Built Up Areas
Rainfed Cropping Rainfed Pasture	Rainfed cropping and pasture
Alpine Grasses - Open Hummock Grasses - Open Sedges - Open Tussock Grasses - Open Hummock Grasses - Sparse Tussock Grasses - Sparse	Grasses and Sedges
Trees - Closed Trees - Open Trees - Scattered Trees - Sparse	Trees
Irrigated Cropping Irrigated Pasture	Irrigated cropping and pasture
Shrubs - Closed Shrubs - Open Chenopod Shrubs - Open Shrubs - Scattered Shrubs - Sparse Chenopod Shrubs - Sparse	Shrubs
Extraction Sites Inland Water bodies Salt Lakes Wetlands	Other

Fig. 13 Concordance between Australian Dynamic Land Cover and presented categories (source: http://www.abs.gov.au/)

3.3 Victorian experimental ecosystem accounts (VEEA)

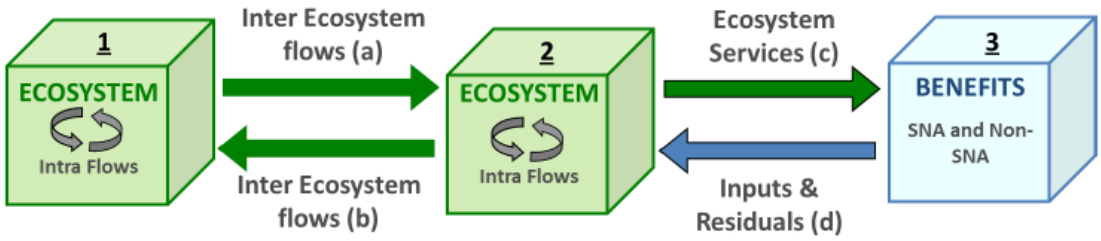
Experimental land and ecosystem accounts for the state of Victoria (Australia) were published in 2013. This publication is based on more than 10 years of state-wide ecosystem asset management activities, addressing the maintenance and restoration of ecosystem *services*[11] on private and public lands. The process of designing effective ecosystem management actions, supported by proper information tools and knowledge base has enabled the development of an operational *ecosystem management and accounting system*.

The main elements of this system are:

- A data-base, which integrates (links) numerical bio-physical (ecological and landscape) data with possible management actions and over specified time horizons, with expected improvement options.
- A software tool, called EnSYM, designed to harmonize input data, simulate ecosystem management actions and assess their benefits, through a number of biophysical models
- An Ecosystem services payment scheme, called EcoMarkets which was designed to provide the needed services in most cost-effective and efficient manner.
- Environmental metrics (unpublished), designed for different ecosystem types, e.g. wetlands, croplands, forests, where ecosystem conditions and related

[11] Services are defined in broader terms here, not only those of direct benefit to people, but also services supporting rich biodiversity and functioning ecosystems in a broader sense

services can be assessed in biophysical terms in relation to the performed management actions.



Applying the Victorian environmental markets approach to ecosystem accounting uses a "bottom-up" methodology by (i) quantifying all intra-ecosystem flows using a measure of asset condition; (ii) quantifying the volume of inter-ecosystem flows as a function of the asset condition and its context in the landscape; and (iii) quantifying the volume of ecosystem services as a function of the inter-ecosystem flows and a measure of "significance" representing an anthropocentric preference for the flows.

Figure 6. Scheme of Victorian experimental ecosystem accounts

Experimental land and ecosystem accounts could be produced using the data, knowledge base and information tools that were developed for supporting the most effective policies and activities in Victoria. There accounts include:

- **Ecosystem Asset Accounts** – classified according to *Major vegetation groups*, with account on their extent and condition in year 2005 with changes in reference to pre-settlement times (ca 1750) (see VEEA, page 5).
- **Asset Flow Accounts** – estimated for all natural vegetation on private and public lands, with natural- and human-induced changes in terms of extent during the period 1994 and 2004 (see VEEA, page 14). Total increase of 0.31% from the opening stock, versus 0.16% decrease shows a positive balance for the 10-year period, however another 0.13% was changed from public to private land tenure.
- **Physical Flow Accounts** – address inter-ecosystem services (provisioning, regulation and cultural) that benefit economic and other activities. The flows of ecosystem services are estimated as a function of the asset condition, extent and landscape context.

3.4 Measuring ecosystem goods and services (MEGS) in Canada

Mapping ecosystem good and services (MEGS) was a two-year project led by Statistics Canada and Environment Canada, involving a number of national institutions: Agriculture and Agri-Food Canada, Fisheries and Oceans Canada, Natural Resources Canada, Parks Canada and Policy Horizons Canada. A report titled 'Measuring ecosystem goods and services in Canada' (further referred as MEGS, 2013) was published in Nov. 2013**,** including a pdf version**.**

A *MEGS statistical infrastructure* was developed (see Appendix A in MEGS 2013), a key component of which is the *MEGS geodatabase*, where many spatial datasets relevant to land cover and land use were gathered and harmonized. Accounting concepts and principles were drawn in accordance to SEEA-EEA, as well as TEEB and WAVES.

Land accounts were developed at national level.

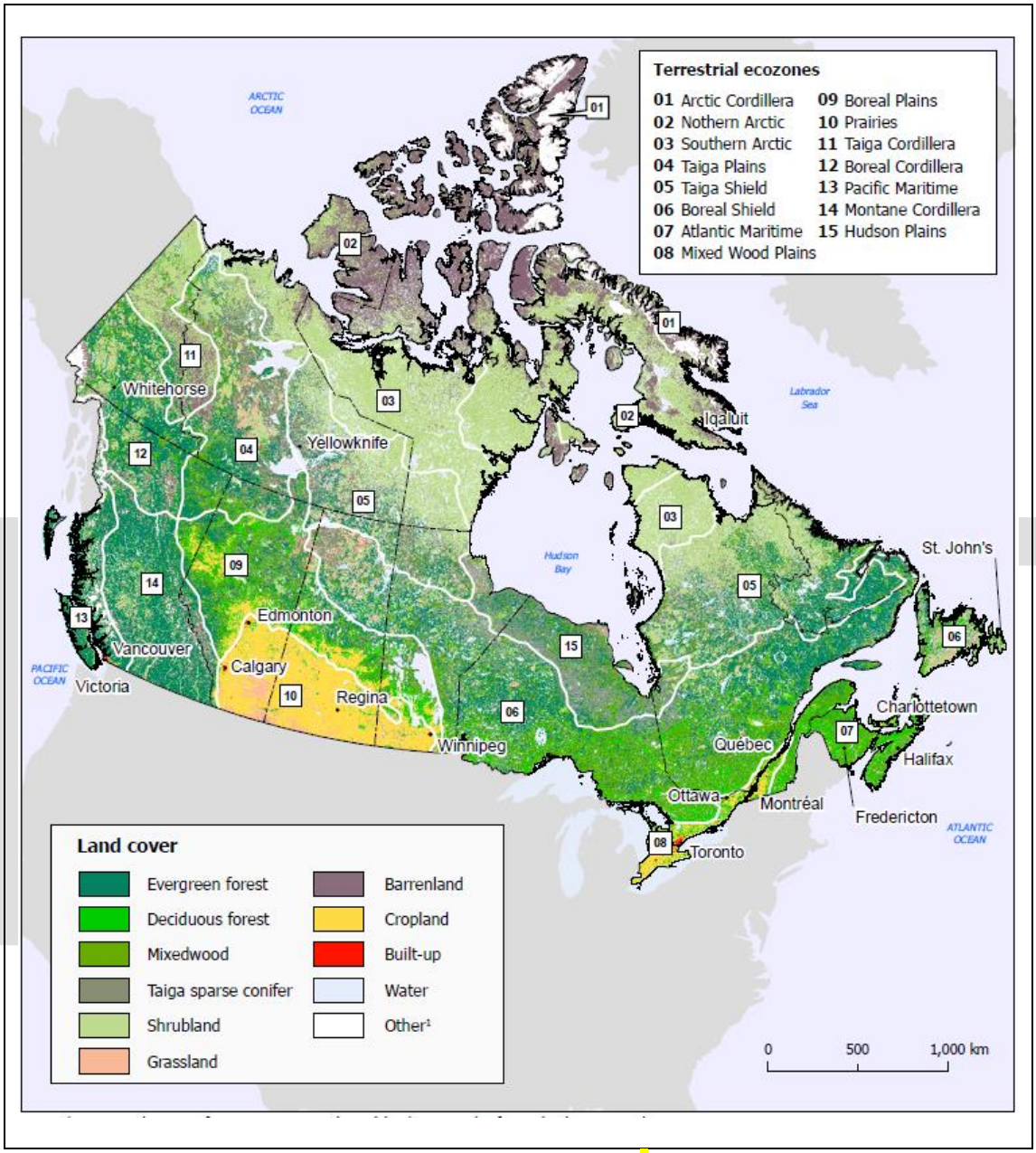


Fig. 11. CCRS Land cover (source: Statistics Canada, 2013)

Main national-level land cover dataset was developed by Canada Centre for Remote Sensing (CCRS) using NASA's MODIS imagery at 250 m resolution, but including 25 classes (further referred as CCRS land cover). Annual land cover maps are produced for the period 2001 – 2011 and included in the MEGS database. The 250m grid-cell is defined as the Basic spatial unit (BSU) for analysis. Land cover ecosystem unit (LCEU) concept, proposed by SEEA-EEA was elaborated by adding the dimensions of terrain elevation and ruggedness to map a more relevant statistical proxy of terrestrial ecosystems in Canada.

Land stocks are classified following the CCRS nomenclature. Land flows classification is approached through CICES where only final good and services are addressed, however MEGS deemed necessary also certain intermediate ones.

Ecosystem quality or 'condition' was addressed through measures of productivity, the ecological potential of the landscape, various aspects of biodiversity including the status and trends of species and others. Five measures of ecosystem quality: landscape type (three categories: *natural or naturalizing areas, agricultural land areas and settled areas*); natural land parcel size, distance to natural land parcel, barrier density and human population density were applied to assess the degree of human modification of the landscape at sub-drainage level.
Valuation of Ecosystem services was tested on case-by-case basis.

Several research priorities were defined, including improvement of spatial detail for land cover, and improved accuracy for ecosystems of particular importance; development of appropriate indicators for ecosystem quality, condition and potential; improved characterization of ecosystem goods and services from coastal and marine ecosystems, valuation of service flows; improved asset classification and mapping of their boundaries.

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5 Annexes

Annex 1. MODIS land cover products and their nomenclatures[12]

Class	IGBP (Type 1)	UMD (Type 2)	LAI/fPAR (Type 3)	NPP (Type 4)
0	Water	Water	Water	Water
1	Evergreen Needleleaf forest	Evergreen Needleleaf forest	Grasses/Cereal crops	Evergreen Needleleaf vegetation
2	Evergreen Broadleaf forest	Evergreen Broadleaf forest	Shrubs	Evergreen Broadleaf vegetation
3	Deciduous Needleleaf forest	Deciduous Needleleaf forest	Broadleaf crops	Deciduous Needleleaf vegetation
4	Deciduous Broadleaf forest	Deciduous Broadleaf forest	Savanna	Deciduous Broadleaf vegetation
5	Mixed forest	Mixed forest	Evergreen Broadleaf forest	Annual Broadleaf vegetation
6	Closed shrublands	Closed shrublands	Deciduous Broadleaf forest	Annual grass vegetation
7	Open shrublands	Open shrublands	Evergreen Needleleaf forest	Non-vegetated land
8	Woody savannas	Woody savannas	Deciduous Needleleaf forest	Urban
9	Savannas	Savannas	Non-vegetated	
10	Grasslands	Grasslands	Urban	
11	Permanent wetlands			
12	Croplands	Croplands		
13	Urban and built-up	Urban and built-up		
14	Cropland/Natural vegetation mosaic			
15	Snow and ice			
16	Barren or sparsely vegetated	Barren or sparsely vegetated		
254	Unclassified	Unclassified	Unclassified	Unclassified
255	Fill Value	Fill Value	Fill Value	Fill Value

[12] https://lpdaac.usgs.gov/products/modis_products_table/mcd12q1

Annex 2: Global GlobCover legend (level 1)

11 Post-flooding or irrigated croplands
14 Rainfed croplands
20 Mosaic Cropland (50-70%) / Vegetation (grassland, shrubland, forest) (20-50%)
30 Mosaic Vegetation (grassland, shrubland, forest) (50-70%) / Cropland (20-50%)
40 Closed to open (>15%) broadleaved evergreen and/or semi-deciduous forest (>5m)
50 Closed (>40%) broadleaved deciduous forest (>5m)
60 Open (15-40%) broadleaved deciduous forest (>5m)
70 Closed (>40%) needleleaved evergreen forest (>5m)
90 Open (15-40%) needleleaved deciduous or evergreen forest (>5m)
100 Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)
110 Mosaic Forest/Shrubland (50-70%) / Grassland (20-50%)
120 Mosaic Grassland (50-70%) / Forest/Shrubland (20-50%)
130 Closed to open (>15%) shrubland (15%) grassland
150 Sparse (>15%) vegetation (woody vegetation, shrubs, grassland)
160 Closed (>40%) broadleaved forest regularly flooded - Fresh water
170 Closed (>40%) broadleaved semi-deciduous and/or evergreen forest regularly flooded - Saline water
180 Closed to open (>15%) vegetation (grassland, shrubland, woody vegetation) on regularly flooded or waterlogged soil - Fresh, brackish or saline water
190 Artificial surfaces and associated areas (urban areas >50%)
200 Bare areas
210 Water bodies
220 Permanent snow and ice

Annex 3: LUCAS Land cover and land use classes

LUCAS Land cover

A10	Built-up areas
B10	Cereals (+ triticale)
B20	Root crops
B30	Non permanent industrial crops
B40	Dry pulses, vegetables and flowers
B50	Fodder crops
B70	Fruit trees & berries
B80	Other Permanent Crops
C10	Broadleaved and evergreen woodland
C20	Coniferous woodland
C30	Mixed woodland
D10	Shrubland with sparse tree cover

D20	Shrubland without tree cover
E10	Grassland with sparse tree/shrub cover
E20	Grassland without tree cover
E30	Spontaneous vegetation
F00	Bare Land
G10	Inland water bodies
G20	Inland running water
G30	Coastal water bodies
G50	Glacier, permanent snow
H10	Inland wetlands
H20	Coastal wetlands

LUCAS Land use

U110	Agriculture (+ Kitchen garden + Fallow land)
U120	Forestry
U130	Fishing
U140	Mining, Quarrying
U150	Hunting
U210	Energy production
U220	Industry & Manufacturing
U310	Transport, communication, …
U320	Water & waste treatment
U330	Construction
U340	Commerce, Finance, Business
U350	Community Services
U360	Recreation, Leisure, Sport
U370	Residential
U400	Unused