Biophysical modelling of ecosystem services and ecosystem accounting: making the marriage happier

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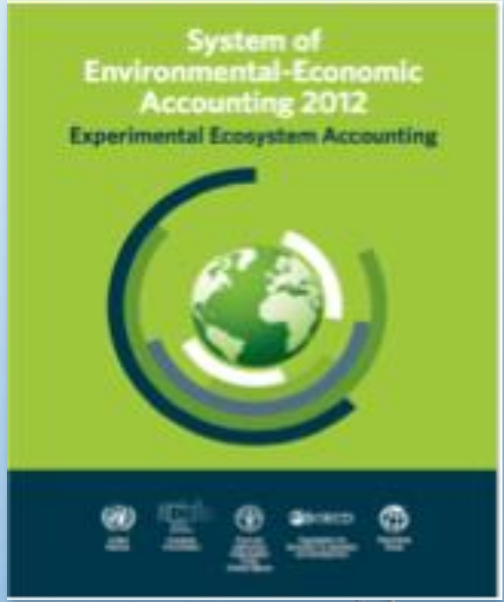
Outline of presentation

- Background
- The models
- Comparisons
- General features
- Issue – balancing supply and use of ecosystem services with biophysical models
- Questions to London Group

Ecosystem services and ecosystem accounting

- A large academic literature devoted to the study of ecosystem services
- Comparatively little on ecosystem accounting
    - SEEA Experimental Ecosystem Accounting
    - Technical Recommendations for Ecosystem Accounting
    - Papers for the SEEA – EEA update
- A range of government agencies, NGOs and academics pursuing ecosystem accounting
- Different traditions
    - Ecosystem services from academic traditions
    - Ecosystem accounting from national and ecosystem accounting traditionally done by national statistical agencies
- Marrying the two traditions together has been interesting!



Modelling of ecosystem services in accounting

- Model suites used
  - ARIES
  - InVEST
  - ESTIMAP
- Examples of continental, national and sub-national models
  - Australia
  - United Kingdom
  - United Sates of America
  - Europe

Suites of models

ARIES

- Automatically assembles most appropriate models for a region of interest, based user query
- Uses modular model components and data chosen according to context.
- An extension of ecosystem services science to renew its focus on beneficiaries and the spatial and temporal dynamics of flows.

ESTIMAP

- Collection of spatially explicit models of ecosystem services
- Developed to support policies in Europe and providing guidelines to make model customization more scientifically robust and decision relevant

InVEST

- Most widely used ES modelling tool
- Collection of 18 models for mapping and valuing ecosystem services
- Used to calculate "gross ecosystem product" in China

Modelling at national and subnational levels

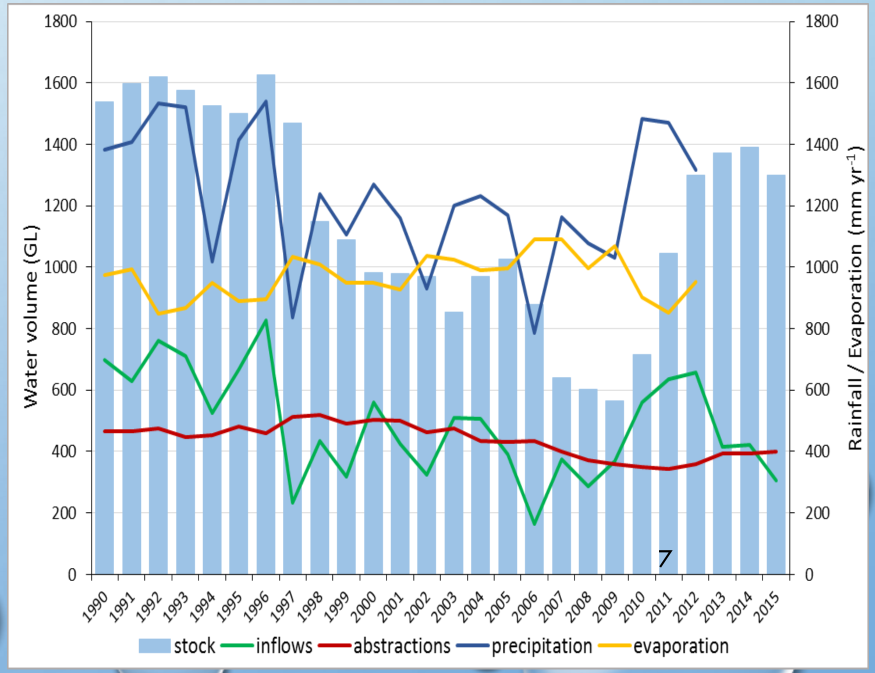
Approaches have sought to find a balance between:

- Local trust from decision makers and knowledge by the scientists applying them to a specific model or models
- Comparability of metrics, quality of underlying data, etc.
- Customizability in terms of model structure and parameterization

Australia

Australia

- Carbon storage and carbon sequestration derived from a region-specific model. The model used spatial biophysical data calibrated with site data
- Water provisioning was estimated using a spatially-explicit continental water balance model



United Kingdom

- Air pollution removal: Use of the atmospheric chemistry transport model EMEP4UK. Based on the open source EMEP model. Used the Alpha Risk Poll model ands existing morbidity and mortality data from UK local authorities.
- Noise mitigation: Use of spatial routines to estimate the economic benefits from noise mitigation by urban trees, based on existing noise mapping, calculating the benefitting residential population, and applying damage costs for noise.
- Flood prevention: Joint UK Land Environment Simulator (JULES) estimated the additional volume of flood water potentially avoided by woodland water use or retained by hydraulic roughness of floodplain woodland, compared to an alternative grass cover, with monetary values based on the estimated cost of providing for the same volume of water in a flood storage reservoir
- Outdoor Recreation Valuation tool (ORVal) have been used to calculate the benefits of greenspace for recreation.

United States of America

Two approaches were used in pilot ecosystem accounts

- a series of independently applied, bespoke models for accounts in the South-eastern U.S. and
- the development of novel models hosted in a common code repository for the development of national-scale urban ecosystem accounts.

The object of the latter is to facilitate faster re-computation of ecosystem accounts by future analysts, as opposed to the "kindness of strangers" approach that asks various researchers to rerun their models every time accounts are recomputed is less likely to be sustainable.

Europe

Spatially explicit biophysical models:

- Water purification GREEN (Geospatial Regression Equation for European Nutrient losses)
- Other models for nature-based recreation, pollination and flood control
- Additional models are currently being developed for soil retention and habitat maintenance

Separate ecosystem potential and service demand to assess what are drivers of changes in the actual flow (e.g. higher actual flow is caused by enlargement and/or enhancements of the ecosystems supplying the service or by an increased demand for that service

- Allows assessing and locating unmet demand, i.e. where there is a need for a service, but the ecosystem is not providing it.

INCA applications also show that biophysical mapping differs from biophysical modelling

Comparison table

Biophysical modelling approach	Pros	Cons
ARIES	• Offers very rapid ES assessment through ARIES Explorer tool, high level of expert-level customizability through ARIES Modeler tool • Artificial intelligence approach selects the most appropriate data and models for use in each application, plus provenance for transparency • ”Global yet customizable” modelling approach offers the ability to compile ecosystem accounts in data-scarce regions • Provides infrastructure to make data and models interoperable and reusable, advancing global SEEA EEA efforts	• Benefits of data & model interoperability, path to achieve it are poorly understood by most scientists • Models for incorporating beneficiaries/ ecosystem service use are not yet fully built out
ESTIMAP	• Endorsed by Joint Research Centre to underpin ecosystem accounting in the European Union • Model customizability is possible (Zulian et al. 2018)	• Models are written in different programming languages, so are difficult for external users to apply
InVEST	• Most widely used ecosystem services modelling tool • Very well documented • Large user community	• Relatively limited use to date in ecosystem accounting • Limited accounting for beneficiaries/ecosystem service use
Custom ES models	• Often well known and trusted by scientists and decision makers in the contexts in which they are applied	• Limited comparability between ecosystem accounts compiled for different regions when using widely varying modelling

General features of biophysical models

Biophysical models show the potential supply, which is broadly in line with the concept of ecosystem capacity (and exceeding capacity leads to degradation or depletion).

- Physical flows are available for people to use. But this does not mean that the flows are used
- Ecosystem services are the flows that are used by people.

Biophysical modelling provides the physical flows, capacity or potential uses and additional data are needed to estimate use of ecosystem services

- ARIES address this by having models of economic and social actors.

Issue: balancing supply and use

Physical modellers want the total supply to be constrained to the amount of physical flows but some physical quantities can be used more than once or in more than one service (how do physical flows relate to services?)

- A PSUT would record all use, everything in and everything out.
  - E.g. for water the physical use of water can be greater than the volume of flows calculated by modelling. Water used for hydro power can then be used for irrigation
- Accounting for land use
  - For growing multiple crops in a year, should you count the land area twice?
  - Multi-story buildings in urban areas, should you divide the floor space by area for all those using the building
- The growth of trees in plantations is:
  - a volume of timber produced as well as carbon sequestration
- The total volume in these trees is an inventory in the SNA and is a carbon storage service in SEEA EEA

Conclusions

A wide range of models is available to estimate physical flows related to ecosystem services. No one model or suite of models has emerged usable in all or even most circumstances.

For ecosystem accounting, the models most likely to used are locally developed models, probably due to two reasons:

(1) Local models are likely to be more accurate than generic models and

(2) Local models are more familiar than the than generic models to those developing the accounts, scientists and decision makers in countries

Two of the model suites reviewed – ARIES and ESTMAP – allow for more detail models to be used instead of global models when and where they are available.

Use of FAIR Data Principles

FAIR Data Principles

The development of the modelling for ecosystem accounting should adopt the FAIR Data Principles proposed by Wilkinson et al. (2016). That is to maximize its value, scientific data should be

- Findable
- Accessible
- Interoperable
- Reusable

Questions for the London Group to consider

- Does the paper reflect your experiences with use of modelling for ecosystem accounting?
- Which models have you used and what is your experience of the models available?
- Do you have other comments or suggestions?