



Editorial

Human-nature nexuses: Broadening knowledge on integrated biosphere-technosphere modelling to advance the assessment of ecosystem services



1. Introduction to the Special Issue

The value of ecosystem functions and biodiversity, and the associated capacity of ecosystems to supply services in support of human well-being necessarily depends upon the long-lasting and durable interaction among all ‘earth’ spheres, from the natural to the industrial and human ones, see e.g. [Costanza et al. \(2017\)](#). Investigating and understanding these interactions requires the creation of interdisciplinary knowledge and cross-fertilization processes among disparate fields of research, which, however, may turn into integrated modelling challenges that need to be addressed.

Overcoming these hurdles will allow to reach consensus on how to assess synergies and trade-offs among ecosystem services (ES) in complex integrated systems. In this regard, identifying first, and then trying to model the complex and interlinked *human-nature nexuses* is one affordable strategy to assess the specific relationships between technosphere and geobiosphere. The use of multiscale integrated models ([Turner et al., 2016](#)) seems a promising option for characterizing the relationships among these spheres, since adopting an integrated solution prompts towards the holistic description of their interactions and feedbacks ([Boumans et al., 2015](#)). Nevertheless, the feasibility and credibility of such multifaceted modelling frameworks are necessarily influenced by the accuracy and representativeness of their outputs, which in turn depend on the balance between simplification and complexity in the system models themselves. Accordingly, a major challenge to address is still the difficulty of collecting and harmonizing a large amount of diverse data and information into a unique, integrated model, in particular with regard to georeferenced information, ecological/biophysical data common for biosphere processes, and the socioeconomic variables typical of the technosphere processes.

Such an integrated approach is suitable to support not only environmental and nature conservation policies, but also human well-being, and can certainly contribute to current initiatives of accounting, monitoring and mapping of ES such as MAES (Mapping and Assessment of Ecosystems and their Services; [Maes et al., 2016](#)), SEEA (System of Environmental-Economic Accounting; [UN, 2014](#)) and TEEB (The Economics of Ecosystems and Biodiversity; [TEEB, 2010](#)). Or, more in general, to the sustainable development of technosphere production systems considering a life cycle perspective (covering all steps of production from material extraction to final disposal), according for instance to a life cycle sustainability assessment (LCSA) approach ([Guinée, 2016](#)). In this context,

the concept of ES turns out to be at the interface among several underpinning research and decision-making questions: assessing the value of ES may mean attempting to understand and quantify the very nature of coupled ecological-economic systems (see system diagram in [Costanza et al., 2017](#)).

While scientific effort intensifies in this domain, a number of challenges still underlie the implementation of integrated modelling frameworks for the assessment and monitoring of ES. This is also true with regard to the analysis of future scenarios, the definition of effective indicators to assess environmental synergies and trade-offs, the consideration of economic and social aspects, and eventually the interaction among different disciplines, such as methods of life cycle assessment, spatial analysis and ecological modelling, to name a few.

2. Aim of the Special Issue

The goal of publishing this Special Issue in *Ecosystem Services* (entitled: “Human-Nature nexuses: broadening knowledge on integrated biosphere-technosphere modelling to advance the assessment of ecosystem services”) was therefore to contribute to the advancement of knowledge on the theoretical and operational practices for modelling and assessing the relationships among the components of complex biosphere-technosphere systems, at different spatio-temporal decisional scales.

This ambitious task was facilitated by means of the ES concept and the multi-scale and multi-objective features underpinning the assessment of ES, which could offer a common approach to inspire the development of novel interdisciplinary initiatives. Hence the *call for papers* was mainly dedicated to the proposal of innovative approaches that could integrate the ES assessment with modelling tools that typically focus on the evaluation of environmental and socioeconomic issues associated with products life cycle systems. As a result, studies published in this Special Issue attempted to address at least one of the following challenges:

- Integration between the ES concept and life cycle assessment frameworks through theoretical, quantitative and/or qualitative approaches;
- Establishment of proof-of-concepts, case studies or methodological developments showing the potential to use integrated modelling approaches to improve the sustainability assessment of coupled ecological-economic systems, with focus on ES.

3. Structure and papers of the Special Issue

As outlined in Table 1, 14 articles constitute this Special Issue and examine a large variety of concepts, objectives, methods and tools to link existing environmental accounting and assessment practices to the modelling and valuation of ES. The Special Issue opens with a critical review paper that identifies and discusses the main aspects to be considered when implementing the ES concept into relevant decision-making tools (Maia de Souza et al.,

2018). This study, as other papers in the Special Issue (Blanco et al., 2018, van Zelm et al., 2018) particularly focus on the life cycle assessment (LCA) tool and its links to ES. As anticipated in the previous sections, the focus on LCA is justified by the overarching scope that this method can offer for the environmental impact assessment of production systems, and its current wide application for sustainability analysis at different spatial scales of ideally any type of marketable good or service. In this regard, the LCA method, which typically focuses on environmental issues, represents a

Table 1
Summary of the goal and scope of each paper published in this Special Issue.

#	Reference paper	Article type	General aim	Application/case study
1	Maia de Souza et al.	Review Article	To identify and discuss the main aspects to be considered when implementing the ecosystem services (ES) concept into decision-making tools, such as life cycle assessment (LCA), with a focus on the current state-of-the-art of the assessment of ES influenced by biofuel production.	Analysis of the challenges and opportunities (related to factors like environmental context, feedstock and supply chain management, and spatial and temporal scales, and policy instruments and involvement of stakeholders) in context specific ES assessment associated with biofuel production.
2	Blanco et al.	Research Paper	To provide an operational framework for the incorporation of ES as a midpoint impact category in LCA, using commonly accepted definitions of ES.	Demonstration of the framework through a case study of water extraction by mining industries in the north of Chile.
3	van Zelm et al.	Research Paper	To provide spatially explicit characterization factors (CFs) for life cycle impact assessment (LCIA) of erosion due to crop production, as a function of crop and management practice, on a global scale.	The CFs are provided for seven crops cultivated globally for biofuel and food production purposes, namely cassava, corn, rapeseed, soybean, sugarcane, sunflower, and wheat, with a country scale resolution.
4	Mancini et al.	Review Article	To analyze a biophysically-based (alternative to a monetary-based) approach for the assessment of ecosystem services, formulated on the use of the Ecological Footprint (EF) accounting method.	Comparison of Economic valuation and EF assessments of forest land type ecosystem services performed over 200 world countries.
5	Almeida et al.	Research Paper	To present an Emergy-based evaluation of the supply and indirect use of net primary production (NPP) and of a subset of regulating services directly connected with NPP in urban parks.	The city of São Paulo, Brazil, is used as a case study.
6	Giannetti et al.	Research Paper	To investigate and express the relationships between the use of natural resources and economic processes (i.e. the human-nature nexuses), by quantifying the resources supporting national economies and the ecosystems, using the Emergy methodology.	An insight on how human-nature nexuses in Brazil changed over time (from 1981 to 2011) is provided.
7	Saladini et al.	Research Paper	To evaluate how the Techno-Ecological Synergy (TES) framework, which incorporates the role of natural capital in engineering assessment and design, can benefit by using the Emergy approach for the quantification of both demand and supply of ecosystem services.	Application of the TES framework based on Emergy to an integrated techno-ecological system represented by a biodiesel production plant, analysing the demand and supply of water provision, carbon sequestration and air regulation services over two alternative technological and ecological options (establishment of a forest for carbon sequestration and air pollutants absorption and a constructed wetland for treating wastewater).
8	Campbell	Research Paper	To present a biophysical-based method for assessing social preferences for ecosystem services, the “eco-price”, suggesting that considering the revealed preferences of society is preferable in most situations.	The method is applied to typical forests and wetlands in Maryland (the State of Maryland is part of the Chesapeake Bay watershed, and encompasses the northern portion of the Bay).
9	Li et al.	Research Paper	To map the human influence intensity (HII) based on a state-of-the-art methodology to assess human pressures on the land, which takes into account the conservation of ecological service functions and biodiversity.	Time series (1990–2010) and spatial assessments conducted at county and 1 km scales in the Tibetan Plateau, China.
10	Ziv et al.	Research Paper	To assess the trade-offs and synergies between the use of ecosystem services and conservation goals across “Special Protection Areas” (SPAs) of the European Union’s Natura 2000 network.	Analysis conducted on 3757 European SPAs designated under Article 4 of the EC Birds Directive (Annex I), which cover 540,479 km ² across 9 biogeographical regions.
11	Pinke et al.	Research Paper	To assess the value of wetland-related ecosystem services, and compare them to the monetary value of the profitability of land use and the additional costs of grain producer system on land at risk from groundwater inundation.	Integrative land use planning in the floodand drought-prone Hungarian Plain, east of the Tisza River (Hungary).
12	Łaskiewicz et al.	Research Paper	To evaluate the impact of urban green space availability on residential duration across different socioeconomic status groups, using econometric modelling.	Use of geolocalized residential quality survey data of N = 860 residents from the city center of Lodz (Poland).
13	Anzaldúa et al.	Short communication	To introduce the ES evaluation framework developed in the DESSIN project (https://dessin-project.eu/) to the wider scientific community, and to promote its use and further development as a tool for conducting local-level applications of the Ecosystem Services Approach.	Brief conceptual illustration of the applicability of the DESSIN evaluation framework to both demo sites and mature case study sites across Europe, which encompass freshwater ecosystems.
14	Gerner et al.	Research Paper	To demonstrate the suitability of applying a structured and integrated ecosystem services evaluation to an extensive river restoration project, according to the DESSIN approach.	Case study estimating the impact of the restoration of the Emscher River (located in the “Ruhr Metropolitan Area” within the federal state of Northrhine-Westphalia, Western Germany) and its tributaries on the provision, use and benefit of ES.

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