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Integrated modelling of ecosystem services and energy systems research

Matthew Agarwala (1,2,3), Andrew Lovett (1), Ian Bateman (3), Brett Day (3), Paolo Agnolucci (4), and Guy Ziv (5)

(1) School of Environmental Sciences, University of East Anglia, Norwich, UK, (2) Geography and Environment Department, London School of Economics, London, UK, (3) Society, Environment and Economy Institute, University of Exeter, Exeter, UK, (4) Bartlett School Env, Energy & Resources, University College London, London, UK, (5) School of Geography, University of Leeds, Leeds, UK

The UK Government is formally committed to reducing carbon emissions and protecting and improving natural capital and the environment. However, actually delivering on these objectives requires an integrated approach to addressing two parallel challenges: de-carbonising future energy system pathways; and safeguarding natural capital to ensure the continued flow of ecosystem services. Although both emphasise benefiting from natural resources, efforts to connect natural capital and energy systems research have been limited, meaning opportunities to improve management of natural resources and meet society's energy needs could be missed.

The ecosystem services paradigm provides a consistent conceptual framework that applies in multiple disciplines across the natural and economic sciences, and facilitates collaboration between them. At the forefront of the field, integrated ecosystem service – economy models have guided public- and private-sector decision making at all levels. Models vary in sophistication from simple spreadsheet tools to complex software packages integrating biophysical, GIS and economic models and draw upon many fields, including ecology, hydrology, geography, systems theory, economics and the social sciences. They also differ in their ability to value changes in natural capital and ecosystem services at various spatial and temporal scales. Despite these differences, current models share a common feature: their treatment of energy systems is superficial at best.

In contrast, energy systems research has no widely adopted, unifying conceptual framework that organises thinking about key system components and interactions. Instead, the literature is organised around modelling approaches, including life cycle analyses, econometric investigations, linear programming and computable general equilibrium models. However, some consistencies do emerge. First, often contain a linear set of steps, from exploration to resource supply, fuel processing, conversion/generation, transmission, distribution, and finally, end energy use. Although each step clearly impacts upon natural capital, links to the natural environment are rarely identified or quantified within energy research.

In short, the respective conceptual frameworks guiding ecosystem service and energy research are not well integrated. Major knowledge and research gaps appear at the system boundaries: while energy models may mention flows of residuals, exploring where exactly these flows enter the environment, and how they impact ecosystems and natural capital is often considered to be 'outside the system boundary'. While integrated modelling represents the frontier of ecosystem service research, current efforts largely ignore the future energy pathways set out by energy systems models and government carbon targets. This disconnect means that policy-oriented research on how best to (i) maintain natural capital and (ii) meet specific climate targets may be poorly aligned, or worse, offer conflicting advice.

We present a re-imagined version of the ecosystem services conceptual framework, in which emphasis is placed on interactions between energy systems and the natural environment. Using the UK as a case study, we employ a recent integrated environmental-economic ecosystem service model, TIM, developed by Bateman et al (2014) and energy pathways developed by the UK Energy Research Centre and the UK Government Committee on Climate Change to illustrate how the new conceptual framework might apply in real world applications.