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Integrating spatial valuation of ecosystem services into regional planning and development

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ABSTRACT

The transition of the ecosystem service framework from academic discourse into practical land use management and policy guidance is in the making. Planners and decision makers seek spatial valuation data, comprehensive examples of which are few or hindered by sectoral research traditions. We present a case of linking land use to multimethod spatial ecosystem service valuation aiming at comprehensiveness and commensurability, based on a project run parallel to regional land-use planning in the Tampere region, Finland. A spectrum of ecosystem services was scrutinized, the annual value of which was estimated at €0.8–1B. Compared to land-use planning, core areas of ecological networks proved relatively poor in terms of valuation, but hot-spots of human–nature interaction such as recreational, groundwater and landscape areas immensely valuable. Strong urban-rural trends in ecosystem service value were found, emphasizing the importance of urban nature and the context-specificity of natural capital discourse. We argue that some mismatches exist between the ecosystem service framework and its practical applicability, and that the main problem is not necessarily the transferability of tools and indicators, but the transfer of valuation and the assumptions and choices behind it. Notwithstanding its problems, the applied framework proved valuable in evaluating and guiding future land use.

1. Introduction

The past few decades have seen widespread adoption of the ecosystem approach as an overarching framework for environmental management discourse – at least in the academic sphere (Drakou et al., 2015; Polizzi et al., 2015). Its operationalization has been increasingly approached via the interrelated conceptual entity of ecosystem services (ES), and the valuation of these benefits obtained by humans from ecosystems and their functions (de Groot et al., 2012). Even though the number of studies concerning ES valuation has been constantly on the rise, the practical application of valuation has been criticized as somewhat superficial and its utility for policy guidance questionable (Primmer and Furman, 2012; Schägner et al., 2013). Perhaps due to some vagueness or unfamiliarity of the rapidly diversifying scope of ES discourse from the perspective of the "hands-on sphere", the field of ES has been increasingly approached via a more comprehensive and possibly often even more comprehensible concept of natural capital, its stocks, flows and their values (Costanza et al., 1997; Crossman et al., 2013).

Ecosystem services and natural capital are inherently spatial by nature (Boyd and Banzhaf, 2007; Schägner et al., 2013), although some services are unarguably easier to pinpoint on a map than others with the same accuracy, precision and resolution. Notwithstanding this place-bound essence, geospatial applications of ES valuation methodology have gained momentum only more recently (Maes et al., 2012a), not least due to a growing ubiquity of geographic information systems (GIS) in both study and practice (Schägner et al., 2013). However, while one of the main objectives of mapping and valuing ES is arguably visualization and communication of information into decision-making processes concerned with natural resources management (Jäppinen and Heliölä, 2015; Polizzi et al., 2015), the bridge between research and decision making is yet being built (Primmer and Furman, 2012; Bagstad et al., 2013). Current discourse on the status quo of practical ES applications has suggested a need for binding

Abbreviations: API, Application Program Interface; CICES, Common International Classification of Ecosystem Services; CLC, CORINE Land Cover; ELY, Centre for Economic; Development, Transport and the Environment; ES, Ecosystem services; LUKE, Natural Resources Institute Finland; LVVI, National outdoor recreation demand inventory; METSO, The Forest Biodiversity Programme for Southern Finland; MCE, Multi-criteria evaluation; MS-NFI, Multi-source National Forest Inventory; MSPA, Morphological Spatial Pattern Analysis; NLS, National Land Survey Finland; SYKE, Finnish Environment Institute; TEV, Total Economic Value; WSFS, Hydrological model for Finnish watersheds; WTP, Willingness to pay

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knowledge on key areas of green infrastructure and natural values with that of ES hotspots, thus enhancing the legitimacy of ES in land use related decision making (Jäppinen and Heliölä, 2015; Vierikko and Niemelä, 2016).

The recently published TEEB for Finland (The Economics of Ecosystems and Biodiversity) highlighted ES valuation as a tool for holistic land-use planning (Jäppinen and Heliölä, 2015), and the integration of spatial ES assessment data into planning, decision making and management was called for. In Finland, there is a wealth of ES-related studies, yet these often focus on mapping ES supplying structures or have had a dominantly service-specific scope, and no comprehensive and commensurate spatial valuation has been previously carried out. This may not be least due to enduring sectoral traditions in natural resources governance and research (Primmer and Furman, 2012), which may have also contributed to the relative scarcity of studies bound specifically to an ES framework (Seppelt et al., 2011). Traditions in thematically tightly-scoped research can also be seen in an imbalance of attention given to different ES – so far most emphasis has been on recreation and water ecosystems (Jäppinen and Heliölä, 2015).

In this paper, we present a regional case of spatially explicit mapping and valuation of ecosystem services in a Nordic context, in the Tampere region in Southwest Finland. The paper expands on outputs of a research project focusing on ecosystem services and natural capital, set in the context of land-use planning and regional development. The project was run alongside a comprehensive, strategic regional land-use planning process targeting the year 2040, thus establishing a connection to regional and local decision making. Besides green accounting, the project aimed to contribute to the evaluation and iteration of said regional plan draft (in the Finnish land-use planning system, plans have four phases: participation and assessment scheme, draft, proposal and approval), its land use policies and impacts, as well as aid in ES-related resource allocation. The paper aims to:

- Describe the use of novel GIS techniques in creating a uniform spatial framework for ES inventory.
- Derive commensurable monetary values for mapped ES and natural capital.
- Compare the spatial configuration of ES supply value to current and planned land use contexts.
- Evaluate the capability of the ES framework to answer practical needs in land-use management.

2. Materials and methods

2.1. Study setting

The study area covers the Tampere administrative region (Finnish: *Pirkanmaa*, Fig. 1) with an area of circa 14 600 km^2, of which 5% is urban, 11% agroecosystems, 69% forests or forestry lands, 1% wetland and 14% inland watercourses according to CORINE Land Cover (CLC) 2012 data (Fig. 2). The region and the spatial configuration of its ES supply are heavily characterized by being located in the intersection of different "landscape regions" – the region's southwestern–western parts being agricultural lowland, central and eastern parts a mosaic of forest, lakes and agricultural land, and the northern parts being dominantly forested and host to the region's most wetlands – due to being located on the highlands of a major drainage divide (*Suomenselkä*). Most of the region is situated on the western frontier of the so-called Finnish Lakeland – a geographical region characterized by a multitude of lakes and mosaic-like landscapes. Similarly pivotal geomorphological features from the ES perspective are the numerous eskers crisscrossing the region. Almost the entire study area is situated within the Kokemäenjoki (*Kokemäki River*) drainage basin (of which in turn most is located in the region), named after a major river traversing

Fig. 1. Location of the study area in the context of Northern Europe.

westwards through the region. As of 2015, the region, second-most populated in the country after the Helsinki region, had circa 503 500 inhabitants, the majority of whom live in the centrally located Tampere city region – the most populous inland city region in the Nordic countries. The adult population (15–74 y/o), used in multiple reference studies, was circa 370 800. According to the regional plan's population development scenario, the region will grow by an estimated 120 000 inhabitants by 2040 (+24%).

2.2. Ecosystem service mapping and valuation framework

A cross-section of ES was selected for scrutiny, from all different sections defined in the Common International Classification of Ecosystem Services (CICES 4, Haines-Young and Potschin, 2013). Alongside ES, some accompanying abiotic outputs from natural capital or natural processes were examined, in case these were strongly interconnected with biotic processes. These abiotic outputs mainly concerned energy provision. The selection of ES was based on the availability of (spatial) data and existing valuation methodology as well as the opinion of the study project's steering group consisting of 17 natural resource or land-use management experts and researchers (incl. corresponding author), but also unavoidably limited by the time frame set for the project (1 year). The mapping of ES was based dominantly on refining available spatial data, preferably open access data when applicable. Numerous spatial datasets were utilized in the study, mainly open data provided by various Finnish authorities. The main data layers included national forest inventory data, topographic databases, various spatial ES-related statistics, land-use planning data and several derivatives thereof. Several land use related aspects were examined based on data from the regional plan and background analyses thereof.

In order to enable examinations of accumulation and trade-offs between different ecosystem services, and to provide a spatial framework for commensurable valuation of ES, a spatial database was created for the region, consisting of approximately 5 900 hexagonal cells with a size of 260 ha each (roughly corresponding to the size of a 1.5 km grid cell) – the size being found here optimal for generalizing the variety of types and resolutions of the raw data as well as for "fuzzifying" some potentially sensitive spatial information regarding private livelihoods and real estate ownership. Although the coarseness of outputs from previous spatially explicit studies has been seen an