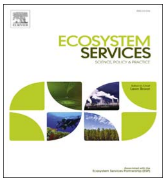
ARTICLE IN PRESS

Ecosystem Services (xxxx) xxxx–xxxx

Contents lists available at ScienceDirect

Ecosystem Services

journal homepage: www.elsevier.com/locate/ecoser



Integrating spatial valuation of ecosystem services into regional planning and development

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ARTICLE INFO

Keywords:
Ecosystem services
Valuation
GIS
Land-use planning
Natural capital

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

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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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http://dx.doi.org/10.1016/j.ecoser.2016.11.008
Received 9 May 2016; Received in revised form 3 October 2016; Accepted 18 November 2016
2212-0416/ © 2016 The Author(s). Published by Elsevier B.V.

Please cite this article as: Tammi, I., Ecosystem Services (2016), http://dx.doi.org/10.1016/j.ecoser.2016.11.008

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 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%).

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

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

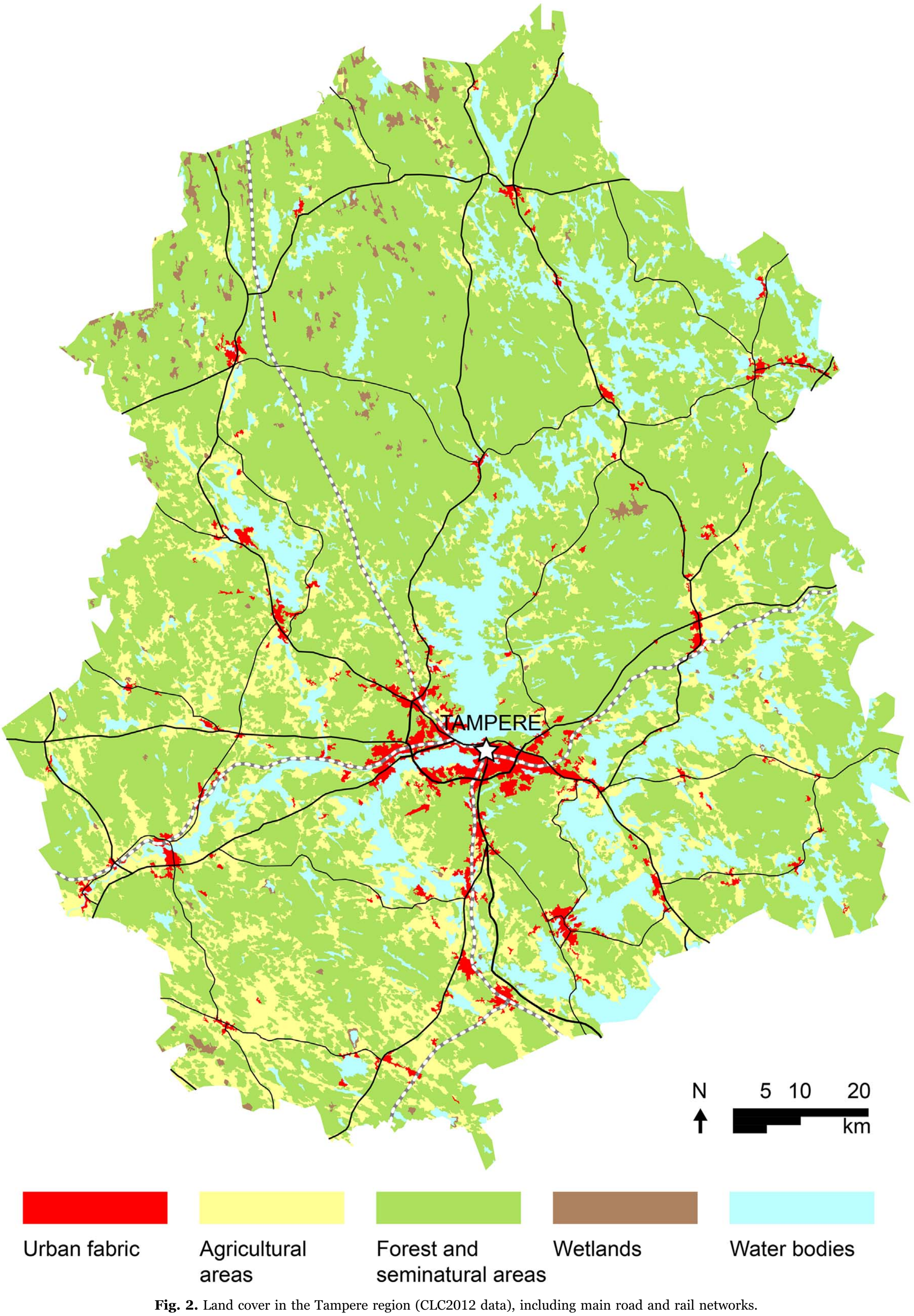

Fig. 2. Land cover in the Tampere region (CLC2012 data), including main road and rail networks.

obstacle for implementing an ES framework in decision making (Schägner et al., 2013), the selected spatial resolution was found appropriate for a regional-level context, given the heterogeneity of input data and underlying methodology. A hexagonal cell structure was chosen for the spatial database over a typical rectangular grid due to its better ability to represent and account for certain spatial continuities and connectivity in the rather complex landscape features typical to the region – especially the near-ubiquitous eskers and branching elongated lakes. The mapping was mainly carried out utilizing three interrelated open-source software: QGIS, PostGIS and R.

Valuation was aimed at combining use and non-use values to determine Total Economic Value (TEV) of ES (de Groot et al., 2010). ES were valued based on their annual flow or utilization in common monetary units, €/year, inflation-adjusted to 2015 euros. The valuation of ES was based on market price statistics mainly from within 2004–2015 or market cost approaches whenever applicable, and in other cases on value or benefit transfer from previous valuation studies. Most of the reference studies had utilized stated or revealed preference methods as the primary valuation approach. Reference case studies were dominantly Finnish and from regions with physical and socio-economic settings as similar to the study area as possible – in order to minimize context-related value transfer errors (Nelson and Kennedy, 2008; Brander et al., 2012). Its difficulties and deficiencies acknowledged, especially in regard to regulation, maintenance and cultural ES, a monetary valuation approach was chosen for its commensurable nature and its strength in providing understanding of the relativeness and preferences in resource allocation decision making (de Groot et al., 2010, 2012; Primmer and Furman, 2012), and in enabling cost-benefit analysis based impact assessment and trade-offs in land-use planning (Jäppinen and Heliölä, 2015).

2.3. Ecosystem service supply determination

2.3.1. Provision ES

Annual crop outputs (food and plants for agricultural use) from agroecosystems were determined from municipal agricultural yield statistics and mean producer prices from 2004 to 2013 (Natural Resources Institute Finland, 2014, 2015b), combined with field parcel data and hectarage from the National Land Survey's (NLS) Topographic Database. For livestock a similar approach was used, but pen location, livestock type and headcount data was provided by ELY (Centre for Economic Development, Transport and the Environment). Main reared species were taken into consideration: cattle (meat and dairy), pork, poultry (meat and eggs) and sheep. Additionally, the technical potential for biogas energy provision was estimated from major agrobiomass by-products, i.e. straw, hay (e.g. from crop rotation) and manure, their estimated methane output and the energy content thereof (Salminen and Rintala, 2002; Mäenpää, 2005; Lehtomäki, 2006; Mäkinen et al., 2006; Lehtomäki et al., 2007; Seppälä et al., 2009). Valuation was based on Nord Pool power market mean spot prices for Finland (2011–2015).

Freedom to roam is pivotal for ES use in Finland. Especially picking wild berries and mushrooms is a popular pastime and supplementary livelihood (Jäppinen and Heliölä, 2015). The most extracted berry species (80–90% of total) and thus economically important are bilberry (*Vaccinium myrtillus*), lingonberry (*Vaccinium vitis-idaea*) and cloudberry (*Rubus chamaemorus*), the latter dominantly in northern Finland (Ihalainen et al., 2005; Turtiainen et al., 2007). The spatial distribution of bilberry and lingonberry yield potential was calculated with calibrated regional yield prediction expert models for boreal forests and peatlands (Ihalainen et al., 2005; Turtiainen et al., 2005, 2007), using Multi-source National Forest Inventory spatial data (MS-NFI, 20 m resolution, Natural Resources Institute Finland, 2015a). Similar models were not yet available for fungi, although such are in development (Miina et al., 2013). Therefore, their output was estimated non-spatially based on mushroom sales and national yield estimates. Unit values were based on sales price market surveys from 2012 to 2014 commissioned by the Finnish Agency for Rural Affairs.

Wildlife hunting is commonplace in the region, the main hunted species being elk (*Alces alces*) and white-tailed deer (*Odocoileus virginianus*). Hunting permits are given based on quotas to game management associations, whose spatial delimitations loosely correspond to municipal boundaries. Permits for elk and other deer are given to contiguous hunting grounds of 1000 and 500 ha minimum, respectively. Suitable areas were analyzed with Morphological Spatial Pattern Analysis or MSPA (JRC, 2015) from CLC2012 data (forest and semi-natural areas), based on the ecological network analysis of the regional plan. Data on game quotas and killings acquired from the RiistaWeb Game Information database was joined to contiguous areas within each association's extent (Finnish Wildlife Agency and LUKE, 2012), weighted by the number of intersecting *Cervidae* observations, routes and pasturing grounds (data from ELY). Small game was valued non-spatially, since data for mapping this type of hunting was insufficient. Game meat values were based on official hunting statistics (FGFRI, 2014a, 2014b).

Fishing is a popular, yet declining sport. Professional fishermen are very few in the region and fishing is mainly recreational (FGFRI, 2014b), targeting species like European perch (*Perca fluviatilis*), Northern pike (*Esox lucius*), zander (*Sander lucioperca*), common roach (*Rutilus rutilus*), common bream (*Abramis brama*) and signal crayfish (*Pacifastacus leniusculus*). Mean fish catch and price data was based on 2010–2012 statistics (FGFRI, 2014b). Regional figures were derived from a larger conglomerate administrative area (*Häme*) based on the location of lakes, population and holiday housing within this area. As majority of the catch value is recreational (c. 93%) and tightly connected to holiday housing, the spatial configuration of holiday housing (summer cottages) with shore access was used as a basis for mapping. The value of fisheries is closely tied to water quality – the value declines as relative phosphorus content increases (Marttunen et al., 2012). Thus, fishery values were mapped to water bodies weighted per water quality, area and number of onshore holiday housing. Water quality data was acquired from the national lake register containing lakes and river segments over one hectare in size (SYKE, 2015).

In Finland, water extraction for household, public and economic uses are typically based on the same water sources and infrastructure – i.e. there is mainly no division between water acquisition and delivery systems for human and other uses. Main water sources nationally are ground water, surface water and artificial ground water. Water extraction was mapped for lake basins (and their immediate drainage basins) used as surface water sources, as well as for utilized groundwater aquifers and wells. Completion of the ongoing change of the main water source for the city of Tampere was assumed in mapping. Average daily extraction rates per well from 2009 to 2011 were acquired from ELY. Valuation was based on municipal water use fee averages from 2013 to 2014 and the unit values were attached to extraction facilities within corresponding municipalities. Future extraction potential was estimated as of 2040 from water supply development plans conducted by the regional council and ELY.

The annual net change in growing biomass of trees and tree-to-soil biomass inputs was modelled using a forest growth simulator (Rasinmäki et al., 2009), based on growth models by Hynynen et al. (2002). The modelling approach included different management activities, including removal of growing and dead trees for different land use classes, mimicking common Finnish silviculture management practices. The maximum sustainable removal rate of saw timber and pulpwood (spruce, pine, birch and other broad-leaved trees), as defined in the National Forest Inventory, was used in the modelling to define maximum forestry yields. The intensity of current usage was estimated based on regional statistics on forest uses (Natural Resources Institute Finland, 2015c) and applied to the modelling results as a spatially uniform ratio of the maximum. As energy wood is mainly harvested as a by-product of the aforementioned, its harvest's spatial configuration was assumed to follow that of the removal of spruce and pine especially. Wood trunk and fiber were valued according to stumpage price averages from 2004 to 2014 and energy wood according to average forest chip fuel prices from 2013 to 2014 (Statistics Finland, 2015).

2.3.2. Regulation and maintenance ES

Initial carbon stock sizes and sequestration rates in growing biomass were primarily taken from the latest MS-NFI results available.

The dataset includes biomass estimates based on satellite imagery and biomass models (Repola et al., 2007, Helmisaari and Hallbäcken, 1998; Muukkonen et al., 2006). Dry weight biomass estimates were converted to carbon estimates by multiplying by 0.5 (Liski et al., 2006). As the MS-NFI results cover only forest areas, agricultural areas as well as some forested urban areas are not covered by the data. For these areas land use class (CLC) average values were used as scaled averages compared to average forest biomass in the area. The initial carbon stock size in soil was modelled using Yasso07 soil carbon model (Tuomi et al., 2011). A retrospective 50 year simulation period with constant input of organic material per land use class was used to predict the current soil carbon stock. Data by Liski and Westman (1997) was used to get the initial value of organic soil carbon at the beginning of the simulation period. EU Emission Trading Scheme prices for carbon dioxide allowance units (2010–2014 average from the European Energy Exchange) were used as a market value proxy for annual carbon sequestration, although it should be noted that the emission trading schemes are practically devised for emissions from electricity production and other industries, while sequestration is basically a counterforce of these.

An operational, national scale nutrient loading model developed for Finnish watersheds (VEMALA) was used to analyze ES related to hydrological and nutrient cycles. The model simulates nutrient processes (e.g. load, retention and leaching) and transport on land and in water bodies. It includes two main sub-models, the WSFS hydrological model (Vehviläinen, 1994) and the VEMALA water quality model (Huttunen et al., 2016). The WSFS model enables tracking of retention to different compartments of watersheds and was used to calculate the relative role of each catchment in retention of phosphorus and nitrogen. Finest available resolution of the model, water bodies, was utilized, based on the national lake register (SYKE). Nutrient retention was valued per water body with the replacement cost method, based on water purification rates and costs for phosphorus and nitrogen in constructed wetlands (Majoinen, 2005; Maes et al., 2012a, 2012b). The value of pollination services was mapped as pollination demand according to the spatial configuration of crop and berry yields (Crossman et al., 2013), their monetary values, and their dependency rate on biotic pollination – as for insects generally and bees specifically (Robinson et al., 1989; Lehtonen, 2012).

2.3.3. *Cultural ES*

A major component of cultural ES is close-to-home recreation (85% of recreation in the region happens within 5 km from home). Data on recreational use of nature studied in the LVVI2 inventory (2009–2010) was used for recreation frequencies (Sievänen and Neuvonen, 2011). Accessibility to close-to-home recreation was mapped for green spaces at least 1.5 ha in size (Söderman et al., 2012). Population data (250 m resolution) from SYKE was allocated to green spaces defined in municipal master plans and regional plans using a probabilistic gravity model (Huff, 1964) and expert-opinion based multi-criteria evaluation (MCE), evaluating several criteria for green space attractiveness (see e.g. de Groot et al., 2010; Paracchini et al., 2014): proximity to water, density of recreational path networks, degree of naturalness, landscape values based on important landscape area inventories, density of supporting sport facilities (University of Jyväskylä, 2014), surrounding population density, and intensity of aesthetic ES (see below). Valuation was based on previous willingness to pay (WTP) studies (Tyrväinen, 2001; Lankia et al., 2013). Other nature trips were mapped for major state-owned protection areas with visitor surveys in place: the Seitseminen and Helvetinjärvi national parks and Vehoniemenharju and Siikaneva protection sites. Statistics and money generation model based data on visitor money usage (2009–2013) for the sites or similar reference sites in Southern Finland were used in valuation, alongside with survey-based estimates of the financial value of health and well-being benefits from nature (Kaikkonen et al., 2014; Vähäsarja, 2014; Metsähallitus, 2015).

Recreational valuation of gathering berries and fungi was based on LVVI2 and the value of everyman's rights based trips (Maes et al., 2012b) – spatial distribution of recreational values was assumed to follow that of the yields since the spatial configuration of utilization is unknown. As of hunting, the recreational value was estimated at 60% of total hunting value (Aarnio and Härkönen, 2007). For fishing, WTP-based value transfer of recreational values was used (Toivonen et al., 2004). A commonplace characteristic of recreation in the Nordic region is the near-ubiquitous presence of holiday housing and the environmental benefits therefrom – swimming, other uses of water, enjoyment of scenery, being in the nature, etc. (Jäppinen and Heliölä, 2015). Holiday house locations were acquired from the Topographic Database (NLS). Two types of WTP were used in valuation – econometric estimation of travel cost (value transfer) and hedonic pricing according to the VIRVA model (Lankia, 2011; Seppälä et al., 2014). Holiday housing real estate prices were used in hedonic valuation, acquired for both cottages with and without shore access (NLS, 2014). Mean interest rates of the Bank of Finland (2000–2014) were used in deriving annual price amortization rates. In both models water quality affected the unit value.

Bequest was examined as willingness to pay for preserving natural environments. Nature protection areas (SYKE) and planned protection sites were mapped. Two distinct approaches were used to value bequest. Firstly, in Finland there is a market-based system for encouraging voluntary nature protection, especially for habitats suitable for endangered species – the Forest Biodiversity Programme METSO, 2008–2025 (METSO, 2008). METSO allows for temporary or permanent nature protection, the latter of which was used here as a reference. METSO payments to landowners are based on lost forestry-based income and the "ground value" based on biogeological forest site types. Gross wood and ground values were calculated for all nature protection areas according to METSO criteria. Where water bodies were present, these were valued according to mean water area real estate prices (NLS) from 1990 to 2012. In order to derive an annual value for the ES "flow", the value was divided by 70 years, a typical length of a silvicultural cycle in the region. Secondly, a contingent valuation approach was taken, based on WTP studies concerning the continuation of nature conservation in Eastern Finland (Kniivilä, 2004). WTP values for adult population were assigned to sites using METSO criteria as MCE weights roughly indicating site quality.

A supplementary, non-monetary mapping of aesthetic or experiential human-nature interactions was conducted. As a proxy for these services often insufficiently integrated into ES inventories (Daniel et al., 2012), geolocated nature-related imagery was “mined” from social media, using popular services Panoramio (Google) and Instagram (Facebook) (see e.g. Di Minin et al., 2015). Data was acquired from corresponding application program interfaces (API), from 2005 to 2015 (Panoramio) and 2014 (Instagram) – the different time spans due to different service ages, data quantities and API processing limits. As the services are not exclusively built for nature photography, raw data was filtered by tags corresponding to circa 200 nature-related keywords. In order to avoid a selection bias and to distinguish areas of high aesthetic interaction on average, the number of individual nature (or in-nature) photographers per grid cell was calculated. This resulted in a nature photography activity or aesthetic ES index.

2.3.4. *Abiotic provision outputs*

Potential outputs of wind power (current wind power production is virtually non-existent in the region) were based on the regional plan draft, in which potential major wind power production sites had been defined via a rigorous site exclusion and impact assessment procedure. Maximum number of wind power plants per area, nominal power outputs, annual wind information and estimated annual operating hours were derived from accompanying analyses. Feed-in tariffs were not accounted for, since these are currently practically halted for new

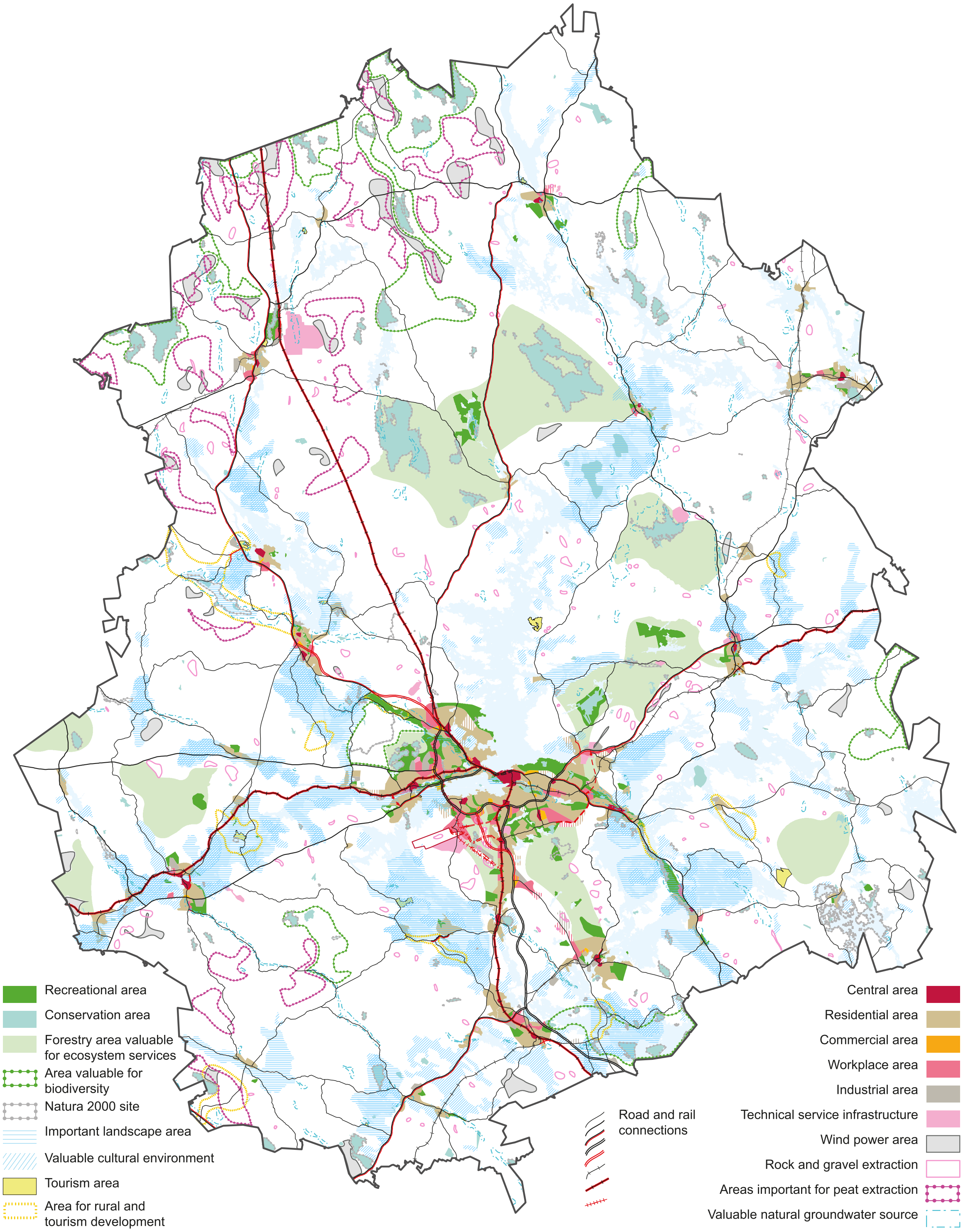

Fig. 3. A generalization of the Tampere regional plan 2040 draft. Numerous plan elements have been omitted in order to enable readability. Main urban structure and environment related elements are included.
Council of Tampere Region.

wind power plants in Finland. Hydropower usage was based on regional electricity production statistics and the locations and nominal powers of hydroelectric power plants (> 1 MW). Off-site effects were accounted for two major dams located nearby outside the region, whose reservoirs are located in the region. Since no readily suitable model for the valuation of the hydropower "production chain" was available, expert opinion was utilized. The value of power provision was divided between dam locations and reservoirs, the latter of which was split again between the lakes and their immediate catchments. Most of the major lakes in the region are regulated, and a "cascading-like" approach was used to allocate the value along the chain of lakes and watercourses, the relative importance of which for power production was estimated based on their volume and flow. Hydroelectricity and potential wind power outputs were valued according to power market prices (2011–2015 mean).

Peat extraction is a major component in the region's energy

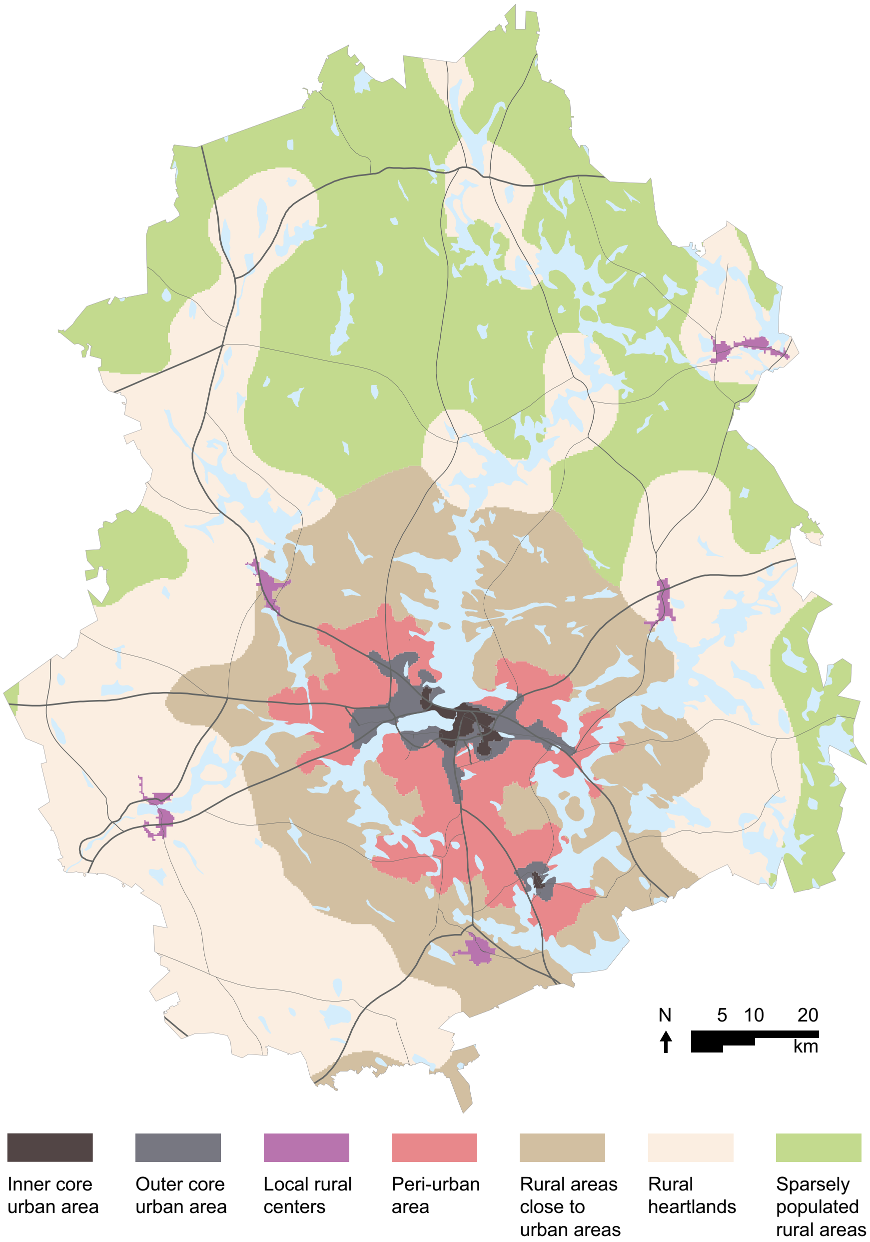

Fig. 4. Urban–rural spatial typology in the Tampere region. Major lakes and road networks have been added. Helminen et al., 2014 (modified)

production (especially in fuel mixes with wood in combined heat and power generation) and peat is also used in large quantities for agricultural purposes. Mapping major peat extraction sites was also based on the regional plan. The estimated volume of annually extractable peat for each area was derived from per-site total estimates, divided by a typical 20-year site life cycle. An energy content of 0.9 MWh per loose cubic meter of milled peat was used as a reference (Alakangas, 2000). Valuation was based on mean energy (heat) production price statistics from 2009 to 2013 (Statistics Finland, 2015). Iivonen (2008) was used for valuing major non-energy uses of peat.

2.4. Linking ES into land use and management contexts

In order to gain an understanding of the linkages between land use, its management and ES, the results of spatial ES valuation were compared to different environment-related land use categories of the regional plan 2040 draft (Fig. 3), as well as to current land use according to CLC2012 level 1 data. The land use types examined from the regional plan were: core areas of ecological networks (areas important for ES and core areas of biodiversity), all nature protection areas (> 1 ha), areas belonging to the Natura 2000 network, recreational areas, groundwater areas, nationally or regionally valuable landscape areas and valuable cultural landscapes. The core areas of ecological networks were based on an analysis made for the regional plan on regionally important green core areas and the connections between them. The analysis had been conducted using MSPA, spatial MCE of qualitative ecological spatial data, and methods of participatory mapping (see e.g. Tammi and Kalliola, 2014). ES were aggregated into spatial delineations of current and planned and use based on whether or not a specific ES is supplied at specific land use type (e.g. wild berries are supplied basically only at forest or wetlands) or is legally utilizable at specific areas defined in the land use plan (e.g. forestry is practically forbidden in protection areas).

A municipal level aggregation of ES values was originally carried

Table 1
Current and potential annual rates and values for ES and abiotic natural outputs in the Tampere region. The potential value is mainly used for comparative purposes, since changes in the supply and demand balance due to realization of said potentials and their probable impact on unit values have not been accounted for. NS=non-spatially valued ES.

Ecosystem service	Current rate p.a.	Value (M€/a)	Potential rate p.a.	Potential value (M€/a)	Mean unit value
Provision	**NA**	**380**	**NA**	**515**	**NA**
Cultivated crops	0.6–37 t/ha	48.5 + 22.3 NS	NA	NA	130–590 €/t
Reared animals	28 Mkg meat, 0.12 Mm^3 milk, 1.5 Mkg eggs	93.5	NA	NA	1.4–2.7 €/kg (meat), 0.4 €/l (milk), 1 €/kg (eggs)
Wild plants for nutrition	0.5–1.5 Mkg	0.6–2.0+1.1 NS	15 Mkg (berries), 12 Mkg (fungi)	19.8+35 NS	1.3€/kg (berries), 2.9e/kg (fungi)
Wild animals for nutrition	7 100 (*Cervidae*)+2.3 Mkg (fish, 15% freed)	2.7 (deer)+1.5 (other game) NS+5.7 (fish)	8 000 (*Cervidae*)+2.3 Mkg (fish)	3.1 (deer)+1.5 small game (NS)+7.0 (fish)	6.5 €/kg (deer), 2.7 €/kg (fish)
Surface water	16.8 Mm^3	16.8	21.2 Mm^3	21.2	1.0 €/m^3
Ground water	18.7 Mm^3	22.5	23.7 Mm^3	28.4	1.2 €/m^3
Fibers from wood	3.7 Mm^3	110	5.2 Mm^3	159	17.1 €/m^3 (fiber), 53.3 €/m^3 (saw wood)
Bioenergy (wood)	1.3 Mm^3/2 600 GWh	54	1.8 Mm^3/3 600 GWh	76	21 €/MWh
Bioenergy (agro-)	NA	NA	496 GWh (plant), 136 GWh (animal)	18.9 (plant), 5.20 (animal)	38 €/MWh
Regulation and maintenance	**NA**	**79–96**	**NA**	**79–96** (+83 incl. all CO_2 sequestration)	**NA**
CO_2sequestration	3.4	31	12.7	31 (114)	9.0 €/t CO_2
Nutrient retention	54–61 t P, 0.9–1.2 Mt N	43–54	NA	NA	410 €/kg P, 25 €/kg N
Pollination (demand-based)	NA	4.1–9.9 (incl. domestic needs) +1.1 (honey)	NA	NA	310 €/ha (crop yield contribution), 6.8 €/ha (berries).
Cultural	**NA**	**306–434**	**NA**	**306–434**	**NA**
Close-to-home recreation and nature trips)	Close-to-home trips 33.6 M+2.8 M NS, nature trips 0.09 M	118–144+9.7–12 NS (close-to-home), 9.3–17 (nature trips)			3.5–4.3 €/close-to-home trip, 103–194 €/nature trip
Recreational values from holiday housing and waters (e.g. boating)	38.4 d/a or 18 trips/user/a (cottages). 20.8 trips/pers, 4.2 M trips (boating etc.)	83–120 (holiday housing) +42–58 (boating etc.)	NA	NA	111–203 €/trip (WTP), 2 780–5 050 €/cottage (hedonic, 80% of plot & 30% of building value)
Recreational value from hunting-gathering	10 000 hunters, 23.5 hunting days p.a. 168 000 fishers, 15.3 fishing days p.a.	6.3 (hunting)+12–33 (fishing) +12.9 (berries)+9.5 (fungi)	NA	NA	9.3 €/trip (everyman's rights), 60% of total hunting/fishing value, 69.4 €/a (fishing, WTP)
Bequest	NA	2.9 (METSO)–21.5 (WTP)	NA	NA	39 €/m^3 (wood)+150–580 €/ha (ground), 58 €/a/pers. (WTP)
(Aesthetic) nature interactions	3.2 photos/user, 18 000 photos/a, 0.3 users/km^2	NA	NA	NA	NA
Abiotic (non-ES)	**NA**	**44**	**NA**	**117**	**NA**
Hydropower	150 MW/548 GWh	21–24	NA	NA	38 €/MW h
Wind power	~ 0 GW h	0	1.7 TWh	63	38 €/MW h
Peat extraction	1.1 Mm^3/1.0 TWh (energy)+0.3 Mm^3 (other)	23	1.3 Mm^3/1.2 TWh (energy)+0.5 Mm^3 (other)	30	19 €/MW h, 16 €/m^3
Total	**NA**	**760–910**	**NA**	**900–1 130 (incl. current use)**	**NA**
Total incl. abiotic	**NA**	**810–960**	**NA**	**940–1 180 (incl. current use)**	**NA**

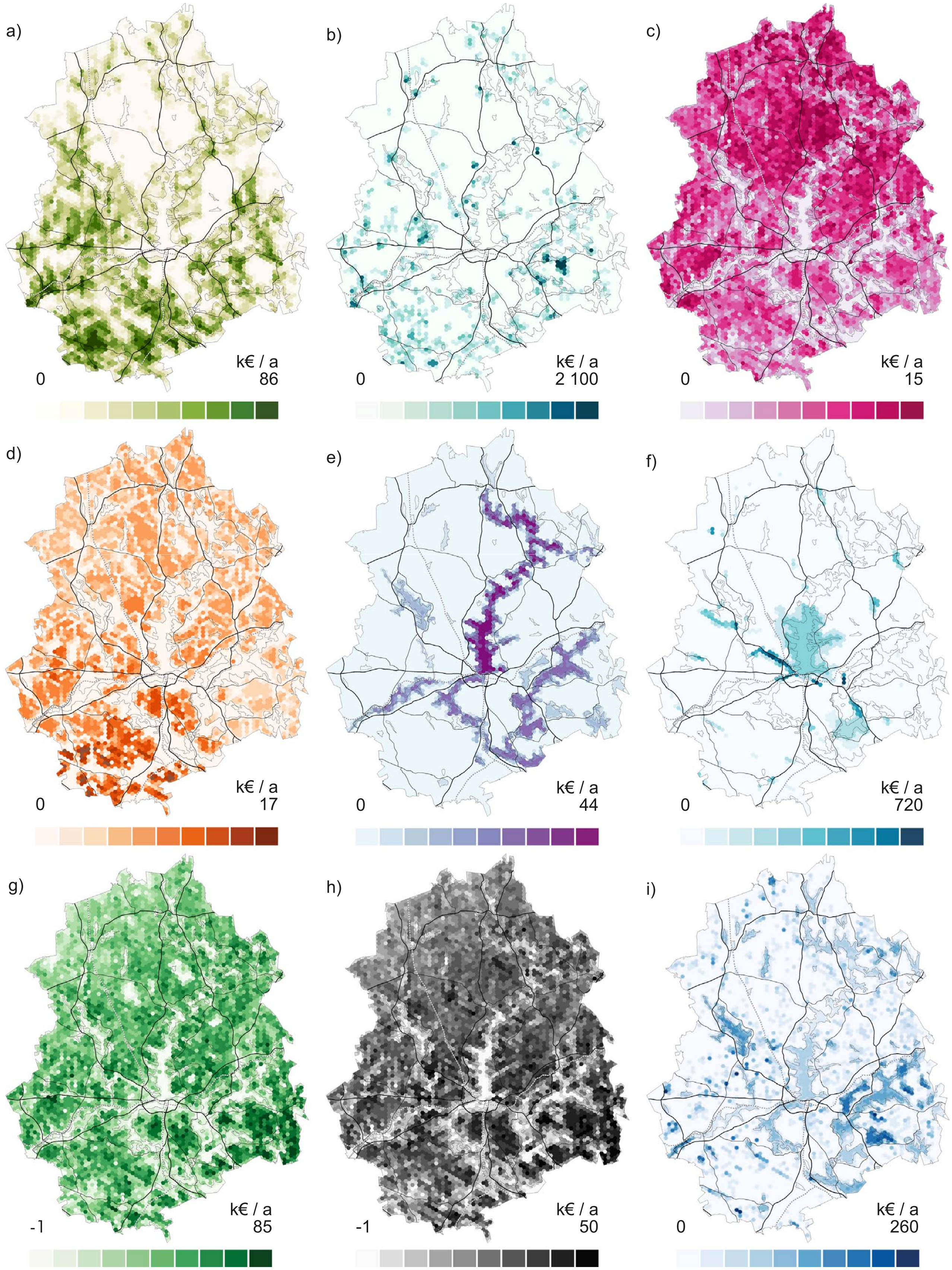

Fig. 5. a. Annual ES TEV supply in the Tampere region: a) cultivated crops incl. plant biomass based energy potential, b) reared animals incl. manure based energy potential, c) yield potential for bilberry and lingonberry incl. recreational value from current utilization, d) *Cervidae* hunting incl. recreational value, e) professional and recreational fishing incl. meat and recreational value, f) ground and surface water usage, g) supply of saw timber, pulpwood and energy wood, h) carbon sequestration, i) retention of phosphorus and nitrogen in water bodies. (width: 2 columns). 5b. Annual ES value (TEV) supply in the Tampere region: j) insect pollination of crops and wild berries, k) close-to-home recreation, nature trips and recreational values from holiday housing incl. uses of waters, l) bequest, mapped by market-cost pricing and WTP (in brackets), m) aesthetic nature interactions (non-monetary), described by the number of individual nature photographers per grid cell, n) abiotic provision of hydropower, peat (energy and other uses) and wind power (potential), o) ES total (excl. abiotic outputs), p) total provision ES, q) total regulation and maintenance ES, r) total cultural ES. (width:2 columns).

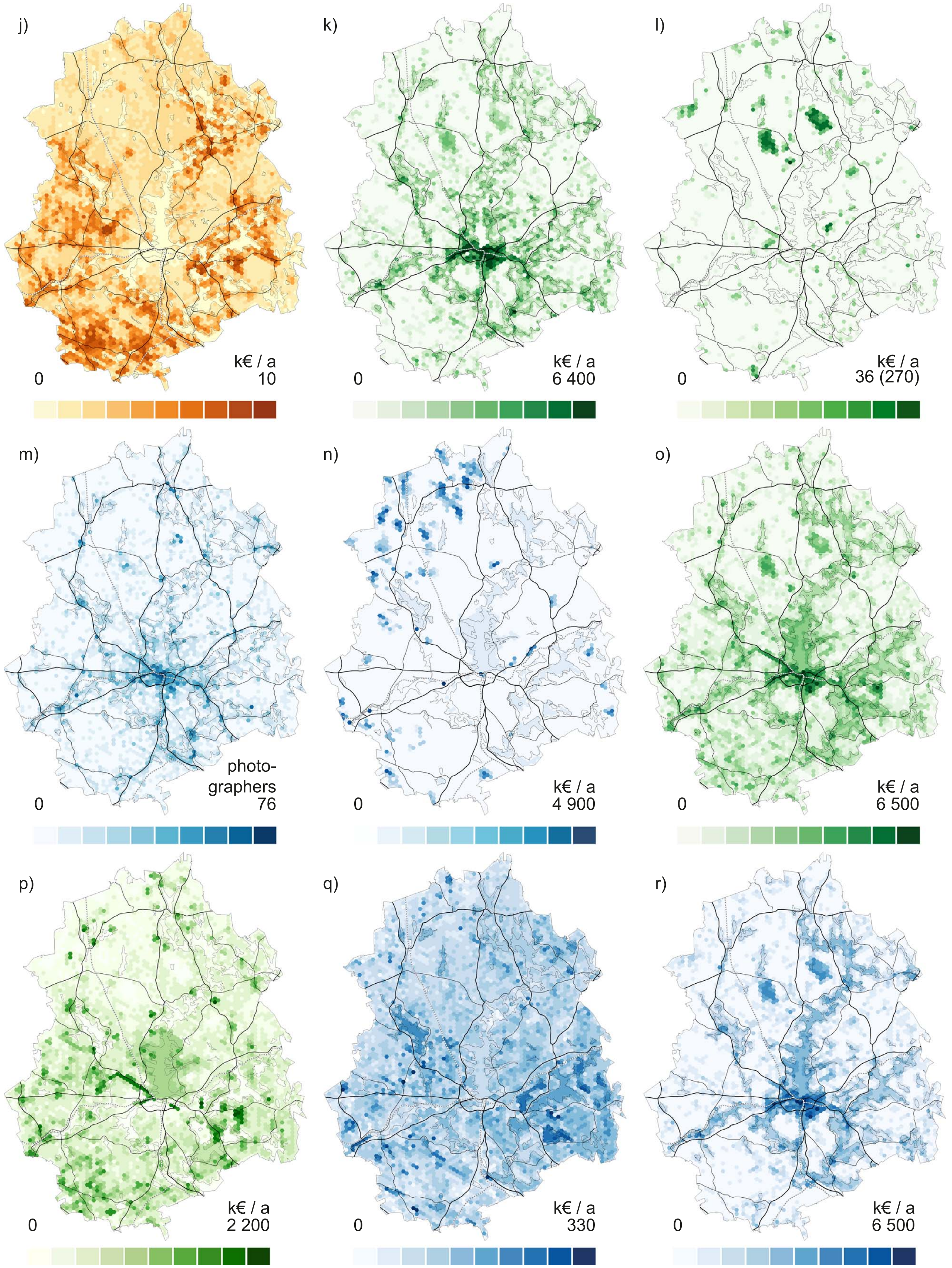

Fig. 5. (*continued*)

Table 2
Comparison of ES values with current land cover as described by CLC2012 level 1 data. ES-specific values were calculated as averages in case a range of values was present or several valuation methodologies were utilized. Immediately utilizable ES potentials or services, whose current utilization rate is unknown were included in the analysis, arriving at a total ES value of c. 916 M€/a. It should be noted that due to the resolution of the data and its underlying modelling methodology, artificial surfaces include some urban nature and semi-natural areas, which are especially valuable from the perspective of cultural ES. Similarly, many ground water areas consist usually of a combination of artificial, semi-natural and natural surfaces, and in agricultural areas animal rearing often intersects with artificial surfaces from the land cover perspective.

CLC2012 class	Total area (km^2)	Provision ES (M €/a)	Reg. and maintenance ES (M €/a)	Cultural ES (M €/a)	Total ES (M €/a)	Total ES (€/a/ha)
Artificial surfaces	710	28.2	1.68	54.5	84	1 197
Agricultural areas	1 700	148	3.81	23.5	175	1 060
Forest and semi-natural areas	10 030	226	29.6	173	430	428
Wetlands	120	2.33	0.32	4.12	6.8	549
Water bodies	2 100	22.8	44.7	153	220	1 049
Total	14 660	427	80	408	916	625

out in order to aid in future local ES implementations, but was found to lack explanatory power because of numerous municipal mergers, due to which the municipalities often comprise functionally vastly different areas – from urban cores to wilderness. Therefore an alternative approach independent of administrative boundaries was chosen. ES values were compared against a multi-source functional urban–rural typology created at SYKE as a tool for zonal planning and development independent of administrative contexts (Fig. 4, Helminen et al., 2014). The typology, ranging from inner urban cores to sparsely populated rural areas, combines socioeconomic, demographic, traffic and commuting data as well as urban structure and land use information and indicators derived from these. Both absolute and relative ES statistics were calculated for the different typology classes.

3. Results

3.1. Spatial valuation of ecosystem services

The annual value of ES in the Tampere region scrutinized here is circa 760–910 million euros, or 835 million euros on average (Table 1). Including abiotic outputs the value reaches approximately 810–960 million euros per annum (average 885 M€). When considering the potential rates examined here in addition, the total annual value reaches circa 0.9–1.2 billion euros. However, these values should be considered a lower boundary of ES TEV (see e.g. Costanza et al., 1997), since neither the selection of ES nor valuation were exhaustive. Spatially the utilization of ES is heterogeneous (Fig. 5a, b). Logically many ES follow the landscape settings (e.g. SW crop yields and pollination, S–SE forest growth and carbon sequestration or NW abiotic outputs and potentials from peat and wind power), or the combination of these and settlement patterns (e.g. fishing in largest lakes surrounded by most holiday housing, water usage from lakes and eskers around the city region or recreation dominantly around the urban core and holiday housing clusters). Some ES show more complex patterns rooted in for example historical ES utilization or mixtures of biogeographic and anthropogenic factors (e.g. animal rearing or nutrient retention in lakes) and some have a clear linkage to ES user movement or human-made decisions (e.g. aesthetic interactions or bequest).

3.2. Comparing ES with current and planned land use and spatial typologies

The linkage between ES and land use reveals clear patterns between extensive and intensive forms of land use in relation to ES value supply and utilization (Table 2), with highest relative rates in areas of high anthropogenic influence, while total values follow the overall landscape composition and its extensive forms of land use, especially forestry and agriculture. When comparing ES values to land-use planning, similar trends highlighting the human–nature interface arise (Table 3). Areas with high use frequencies, such as recreational or groundwater areas, seem by far the most valuable in terms of relative annual ES flow, followed by valuable landscape areas, which often encompass a mixture of agricultural, forestry and recreational uses. An ES value divide exists between protection sites (incl. Natura 2000) and core areas of the ecological network (areas important for biodiversity and areas important for ecosystem services) – mainly due to a higher presence of bequest and recreational uses, as mapped here. The anthropocentrism of the ES framework becomes evident when comparing ES values to the urban–rural typology (Fig. 6). Simply put, the higher the population density, the stronger the ES demand, and in low population density areas, the per capita ES value rises dramatically. One should note that

Table 3
Comparison of (currently utilized) ES values with land use types from the regional plan 2040 draft. Values of ES that were subject to more than one type of valuation methodology were calculated as averages of these. Note that some of the different area types can be overlapping, e.g. areas belonging to the Natura 2000 network often – but not always – include nature protection areas. For recreational areas two different delineation approaches were used, excluding and including adjacent water areas, since the water element played a major role in the valuation function for recreational areas.

Land use	Area (km^2)	Provision ES (M€/a)	Reg. and maintenance ES (M€/a)	Cultural ES (M€/a)	Total ES (M€/a)	Total ES value incl. abiotic outputs (M €/a)	ES €/a/ha	ES incl. abiotic €/a/ha
Areas important for biodiversity	698	12	3.9	11	27	27	389	394
Areas important for ecosystem services	980	21	4.7	12	37	37	380	382
Protection areas	372	1.3	2.1	29	32	33	866	875
Natura 2000 areas	348	1.0	2.1	25	29	29	820	830
Recreational areas	167	4.2	0.8	17–27	22–32	23–33	1 380–1 980	1 440–2 040
Valuable landscapes	1 431	56	11	55	121	129	847	900
Cultural landscapes	911	44	5.6	20	70	72	765	788
Groundwater areas	337	30	1.4	13	44	45	1 310	1 340

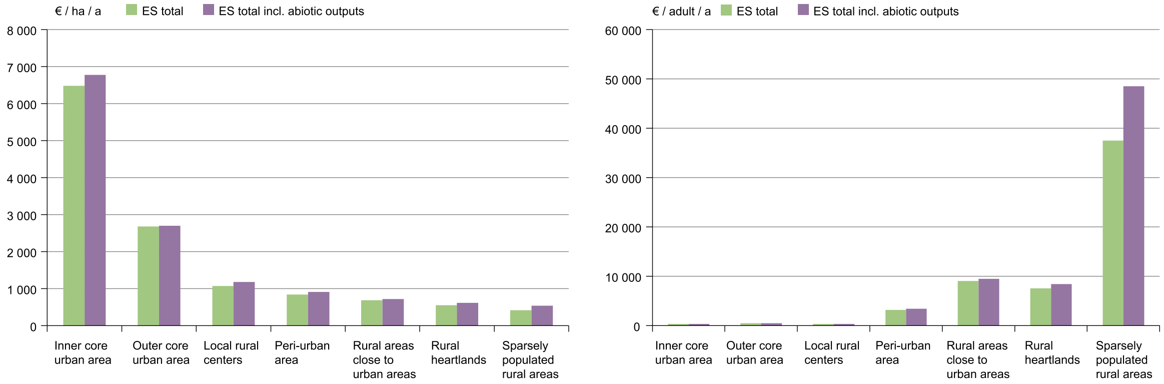

Fig. 6. Comparison of ES value mapping with an urban–rural spatial typology (Helminen et al., 2014). The graphs describe ES value (€/a) both including and excluding abiotic outputs a) per hectare and b) per person (15–74 y/o).

ES supply and demand go often strongly hand-in-hand in our case area, since there is little scarcity of supplying ecosystem structures due to the relative ubiquity of nature in Finnish cities – but this is not always nor everywhere the case.

4. Discussion and conclusions

4.1. Assessing uncertainty

Capturing ecosystem functions in monetary values triggered skepticism early on (Vatn and Bromley, 1994), and valuation remains tricky. We formed a moderate estimate for the lower boundary of ES value supplied (and utilized) by the region. However, since ES often form dynamically in complex chains of ecosystem functions at different spatial levels, a relatively fixed-scale approach aimed at producing localizable, practically applicable data, will miss some of the ES dynamics, especially regulation services typically relevant and observable at larger scales (de Groot et al., 2010). Converting these services to monetary values remains difficult partly due to problems in identifying the providing ecosystem structures. This is partly evident in our results, which emphasize provision and cultural services that can be pinpointed and monetized in a relatively straightforward manner. Care should be taken when considering the relatively low value of regulation and maintenance ES and their potentially providing structures (major forests and wetlands). Then again, the values that can be most easily monetized may also be most relevant and influenceable in practical land-use planning. The regulation and maintenance ES that may be easiest valued in future research, could be local services such as visual screening or microclimate and air quality regulation provided by vegetation, which again would increase the relative value of urban and semi-natural environments.

The maximum simultaneous TEV remains fuzzy. Care was taken in avoiding double counting of ES values (Costanza, 1997), but take for instance carbon sequestration and forest growth, which correlate strongly. Sequestration rates were estimated against the “unutilized” part of forest growth, but unleashing the potential TEV of sequestration would require significant reductions in forestry. The Pareto optimality of the ES use spectrum remains unclear and is likely to fluctuate according to societal changes. Critical interpretation should be also practiced when comparing current and potential ES flows, which are partly dependent on realized land use plans, partly “immediately utilizable”. Although newest available valuation references were used, the availability of price time series used in value transfer varied between different ES. A temporal misalignment may have widened the error margin, since prices can fluctuate notably due to e.g. climatic, political and macroeconomic changes. Aggregating results to different spatial delineations from a single-resolution ES inventory creates uncertainty in quantitative comparisons. Parts of the spatial database located on the region's borders lacked some ES TEV due to edge effects caused by the grid delineation, which was softened by partial extrapolation. The spatial delineation of ES scrutiny is also a somewhat philosophical question, especially with WTP and off-site effects (see e.g. Seppelt et al., 2011). Here we estimated that the region's inhabitants are willing to pay for, say, bequest ES, but there surely are people outside the region willing to pay for its nature protection. Choices made on defining the ES beneficiaries inevitably affect the valuation, and narrowing down the uncertainty would require in-depth ES user base analysis.

The generalizability and transferability of ES assessments are context-dependent – the danger of generalization errors exists in value transfer (Nelson and Kennedy, 2008; Brander et al., 2012). The results of this study could be satisfactorily transferred to at least boreal-hemiboreal settings with similar societal conditions, but the further one moves away from circumstantial similarity, the stronger the uncertainty. Many of the distinguished ES hot-spots were connected to locations special due to their biogeomorphology or cultural-historical significance that would be nearly impossible to identify using for example generalized land cover based models. There, on the other hand, lies the strength of multimethod ES assessment frameworks. Here we combined ad hoc approaches with different types of existing spatial modelling processes, aiming at the golden mean between sufficient customizability and practical usability. Concerning questions of the generality of ES tools, indicators, and the feasibility of their implementation into practical land-use management (Primmer and Furman, 2012), we argue that problems are faced especially when dealing with values, since these are strongly rooted in societal contexts – yet seem to be among the most sought-after information. The tools, approaches or indicators tested here are however not strictly context-specific, but a lot depends on the quality and quantity of ES-related data at hand for the planner.

4.2. ES from a land-use planning and policy perspective

Before case study onset, the regional planning process had been surrounded by discourse on interactions between urban and rural areas, where land-use planning was criticized of concerning mainly the former, and comprehensive consideration of natural capital in planning and development was called for. This call came especially from declining rural areas where possibly a feeling of neglect towards their potential was felt. Our results underline a few aspects to this discourse. Firstly, a rather linear decline in ES/ha value from urban to rural settings was seen – prime ES hot-spots tended to be located in urban settings. This is perhaps not surprising considering ES are benefits gained by humans from ecosystems – and need people to enjoy these benefits. Also, historically population centers tended to form around favorable environmental settings – and the demand for cultural ES only seems to emphasize this relationship. Next, one should consider intensity versus extensiveness (see e.g. de Groot et al., 2010, 2012). In absolute figures, ES value declined from rural towards urban areas. Of course, rural areas were tenfold compared to urban ones. ES such as food and forestry outputs are highly valuable, but require vast spaces and “flow” slowly – compare for example hourly water usage or daily recreation to a 70-year boreal silviculture cycle. These slowly regenerated natural capital stocks are highly valuable (e.g. forest stocks were valued at c. €4B at current prices, or carbon storages of c. 700 $MtCO_2$ at €6.3B using emission trading prices), but the flows are experienced gradually over time and space.

Low population density in extensive rural areas elevated the per-capita ES value tremendously. This may bring an interesting viewpoint into land use discourse. A common housing preference of (young) Finnish adults has been a detached house at the urban–rural intersect, at a commutable distance to the city yet close to nature for restorative purposes (Korpela et al., 2001). This nature-bound housing preference could be possibly translated loosely into a preference of ES abundance over having to share the ES "commons"; the most rural areas generated 120–150 times more ES flow value per capita compared to their most urban counterparts. At the same time, the relative importance of abiotic provision outputs versus ES decreased along the rural–urban gradient, mainly due to the fact that many abiotic outputs cannot be generated in urban areas. However, in the discourse surrounding the study, stakeholders from rural settings seemed to lean more on traditional natural resource viewpoints, while their urban counterparts dominantly promoted an ES framework. Potential linkages between such place-based land use discourse differences and ES versus natural capital viewpoints would require further verification. We recommend that the focus in implementing an ES framework in land-use planning should be placed at urban and peri-urban green (and blue) spaces. In our case region, we expect the demand for ES to grow hand in hand with population growth. Due to e.g. infill development, the increasingly valuable urban ES refuges may be threatened and should be put under the magnifying glass in land-use planning.

Our results indicate that there is indeed a need to bind knowledge on “key green and blue areas” with that of ES hot-spots (Jäppinen and Heliölä, 2015), since these may often be relatively separate. Large forest and wetland areas, considered core areas of ecological networks in the regional plan, did not exhibit particularly strong ES value. There are probably a few reasons behind this. The ES framework approaches valuation from a human perspective, yet in the regional plan ecological networks had been considered mainly from the perspective of fauna and flora. It is thus not necessarily surprising that ES value doesn't seem very high in remote parts of the ecological network, often infrequently utilized by humans. Although, their value is often related to biodiversity or regulation and maintenance ES – which were not exhaustively covered by our analysis. As for recreation, the lack of value in these areas was partly caused by the fact that little spatial information exists on their recreational use. However, only an estimated 7% of recreational trips (excl. holiday housing) are made to these areas (valued here non-spatially). The value difference is partly technical by nature; due to no-overlap rules in the land use plan, protection sites within core green areas are technically enclaves and thus didn't contribute to the value of the core areas. Nevertheless, results from the CLC comparison support the observation of low values. A smaller, similar value difference was observed between Natura 2000 areas and other protection sites. The former are often used exclusively for conservation, while the set of protection areas as a whole contains many areas used simultaneously for both conservation and recreation, thus exhibiting higher value here. Regardless of large forests and wetlands seeming relatively weak from the perspective of annual ES flow, they contain massive natural capital stocks, as pointed out above. Future research should aim towards devising a reliable means of commensurating natural capital stocks and ecosystem services, as these are often brought up simultaneously in planning discourse, yet may differ notably even spatiotemporally. To put it otherwise, how should slow and fast ecosystem services really be compared?

4.3. Putting ES into future land-use management

Regional level ES assessments seem most common so far (Seppelt et al., 2011; Crossman et al., 2013) – but why? According to our experience there may be a few key reasons behind this. Firstly, statistics and reference studies suitable for ES mapping and valuing as well as spatial data are often produced at a regional administrative level. Much related at least in Finland is the fact that people's everyday movement is increasingly regional by extent, not limited to local settings. As ES values are often heavily connected to the location of the beneficiaries (Paracchini et al., 2014), the people, local-scale implementations may be unable to account for the big picture of ES user mobility. Thirdly, a regional approach offers possibly a suitable level of generalization between local and national levels, which may often prove too precise with the current knowledge or too coarse to be useful in practical implementations, respectively. A useful nuance of the Tampere region is the fact that it is mostly part of the same major drainage basin. Indeed, a drainage basin based spatial delimitation for ES approaches has been previously found valuable in mapping ES supply, especially when hydrological and nutrient cycles and other regulation and maintenance services are concerned (Valtanen et al., 2015; Vierikko and Niemelä, 2016).

Finally, a reason brought up during the project for the lack of local-scale ES implementations was simply a lack of resources at the municipal level. There are indeed a few obstacles to satisfactory ES framework implementation in practical land-use management, and often these can be tracked down to time and money, specifically the lack thereof. Decision-making processes are often criticized for their short-sightedness and desire for benefits in the short-term over the long-term. This is reflected in land-use planning processes, and if an ES assessment is made to support these to begin with, its comprehensiveness and rigor are often compromised by insufficient resourcing, which prevents the planner from properly familiarizing with ES indicators, data, models and tools. This in turn calls for an era of open information. For instance Schägner et al. (2013) have noted that mapping and storing ES values in spatial databases has the advantage of making site-specific valuation data readily available for decision makers and policy evaluation. We argue that ES data should be readily available for everyone (see e.g. de Groot et al., 2010), in order to promote the contributions of ES to human well-being as well as to encourage further ES implementations and data refinement. The ecosystem approach challenges planners and decision makers to use best available scientific knowledge, and the open data principle can only help in overcoming this challenge.

We wanted to uproot sectoral modelling traditions and plant them into the CICES framework (Haines-Young and Potschin, 2013). From the perspective of practical implementation the framework needed bending, especially in the case of regulation, maintenance and cultural ES. The problem was often a seemingly artificial separation of abiotic and biotic services from an everyday perspective. We find this problematic since ecosystems themselves consist of biotic–abiotic interactions – an issue already discussed in CICES itself and recently by van der Meulen et al. (2016). For instance, recreational or aesthetic experiences can be derived from both living organisms and the ground below them, nutrient retention in lakes is a combination of biotic and abiotic structures and processes (e.g. sedimentation and erosion), and visual screening is achieved by combining physical and biological structures. Similar examples are trying to find their place in CICES. It is often the case that planners and decision makers want information on both biotic and abiotic aspects, and to examine these separately can be even dangerous since there are strong feedbacks from one to the other. For example the utilization of hydropower in our case region has created obstacles to fish migration (and fishing-related ES) and nutrient flows, and rock extraction has had major effects on recreation, water balances and the overlying land cover – basically removing the ES supplying structures. The production boundary between ecosystem services and goods remains somewhat diffuse in practical applications, which here seemed to drift towards a mixture of CICES and the SEAA Central Framework or the concept of "natural flows", already highlighted by Haines-Young and Potschin (2013). The big picture of ES-related flows is complex, and proper cost-benefit analyses would need to consider non-ecological flows or inputs (Boyd and Banzhaf, 2007), the surface of which was merely scratched here. Similarly, the concepts of ES provision potential, supply, potential and sustainable supply, demand and potential demand can have several, often ambiguous interrelated interpretations (Jäppinen and Heliölä, 2015), and their mixed use is often unavoidable in practice due to the contextual frameworks from which the analyses stem from. Which of these concepts is most relevant in planning practice, remains yet unclear.

Notwithstanding its problems, the ES framework provided a workable foundation for spatial ES valuation. The results of the study already affected the Tampere regional plan 2040 proposal, altering the plan towards a more comprehensive guidance solution for ecosystem service hot-spots. The key issue here was a spatially explicit inventory and valuation framework, which could be directly compared with land-use planning data and the plan itself and thus be used as a foundation for delineating plan features and reformulating the accompanying regulations. A common characteristic of strategic level land-use planning is the time it takes for a plan to be realized, thus monitoring and assessing the aftermath of implementing an ES framework remains to be seen. However, the task of regional planning has partly been seen as delivering information further down the planning hierarchy and raising awareness on land use -related issues under discussion. Our approach succeeded in generating stakeholder interest for locally utilizing the gained information in future development projects. The study raised notable media interest, and has affected and aided already several large and small scale planning processes from impact assessments to bio- and circular economy projects to participatory landscape planning, not only within the region but in different parts of the country. In some other regions work is currently planned or underway to assess ecosystem services mimicking the methodology and analytic processes described here. From what we have observed so far, most interest has been generated by three aspects: relativity of ES values, comprehensiveness of their scrutiny, as well as mapping and valuing non-market services – especially cultural and experiential ES. When it comes to indicators of the latter, we anticipate a growing interest towards data generated by the ES beneficiaries themselves, that is, “crowdsourced” ES-related information, be it stated or revealed preferences obtained via social media or other means of participatory data collection.

Drawing on our experience, we conclude that there is a place for ES-based approaches and tools in land-use planning and development, but the practical planning sphere may require clarification and synthesis of the widening scope of ES, natural capital and environmental economics discourse. In practice, there is seldom a single framework to go forward with, but the suitable pieces of the ecosystem service puzzle need to be assembled. The same applies to ES tools and indicators – it seems unrealistic that any single data source or tool would fulfill the information needs of those initiating an ES planning scheme. Our work described here consisted largely of sewing existing or refined pieces of information together. This would suggest that in such contexts where for instance authorities or research institutes already have multiple ES-related data collection, reporting or sharing mechanisms in place, the main focus of future work enabling the implementation of ecosystem service frameworks into sustainable land-use management, should be put into integrating existing, separate sources of information in a manner that would readily combine the spatial and value components of ES-related information – this again would allow for more effortless and even semi-automated ecosystem service monitoring and assessment processes. The utility of ES assessments to policy guidance had been previously questioned (Primmer and Furman, 2012). Nevertheless, we argue that by comprehensively incorporating both spatial and value dimensions to ES analyses and communicating the information via visualizations and data openness, immediate changes in land use may not appear, but awareness of the issue will emerge and gradually reach different levels of planning – and hopefully the implementation of the plans, eventually.

Acknowledgement

The ecosystem service project in which the authors of this paper participated, "Pirkanmaan ekosysteemipalvelut", was supported by the European Regional Development Fund programme for Western Finland 2007–2013 (Project A32791). We would like to thank Anne Mäkynen, Miina Vainio, Riina Känkänen and Thomas Banafa for their support.

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