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Ecosystem services in a peri-urban protected area in Cyprus: a rapid appraisal

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Abstract
Protected areas around the world are increasingly being recognized for their potential to protect various ecosystem services in addition to biodiversity. We carried out an ecosystem services (ES) assessment at the Rizoelia National Forest Park, a biodiversity hotspot in Cyprus. For ES assessment we used TESSA v.1.1 and an ES matrix-approach to map the capacity of habitat types in the area. According to TESSA the most important ES provided by the study area are aesthetic benefits, recreation/ tourism, biodiversity, global climate regulation, and environmental education. Total Carbon stock was estimated to 14247.327 tonnes and the total number of annual visits was 14471. There were no statistically significant differences in the number of visits among visitation periods but there were statistically significant differences among National Holidays, Weekends and Weekdays. We identified that plantations had the highest capacity for most groups of services particularly where their understory comprises semi-natural habitat types rich in biodiversity. This is the first study in Cyprus which provides a preliminary quantification of ES in a protected area context using widely employed tools. The paper discusses how these findings can help decision-makers to plan direct future restoration and management actions to the benefit of a wide range of stakeholders.

Keywords
ES matrix-approach, island, mapping, Natura 2000, TESSA

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Introduction

Worldwide the designation of protected areas aims to separate the components of biodiversity from natural or anthropogenic processes that threaten their persistence (Margules and Pressey 2000). This notion has been expanded over the years (see IUCN 1994, MA 2005) and while safeguarding biodiversity remains a Protected Area's (PA) primary aim, increasingly they are also considered to play a key role in the maintenance of ecosystem processes and the ecosystem services they provide (Bastian 2013; Watson et al. 2014). It is thus vital to assess the extent to which existing protected area systems represent those services. Local protected areas are an important resource for policy makers since they can be a real benefit to local populations. In an urban / peri-urban setting, the role of PAs is inextricably linked to quality of life, while at the same time they remain under intensive pressure from urban expansion and land-use/cover changes (Grimm et al. 2008). The paradox is that the negative effects of these changes to biodiversity result in turn in deterioration of ecosystem services (MA 2005), but at the same time human-induced actions may increase biodiversity of urban nature (Savard et al. 2000). The provision of ecosystem services (ES) by urban nature is considered part of a high-quality living environment (Tzoulas et al. 2007), while access to recreational services is important for public health (e.g. de Vries et al. 2003; Korpela and Ylén 2007). Thus, by identifying and assessing those benefits (ecosystem services), local policy makers can provide motivation for the establishment of protected areas beyond conservation – that of enhancing local human well-being.

ES have been defined differently by many authors (Boyd and Banzhaf 2007; Fisher and Turner 2008; Fisher et al. 2009; Seppelt et al. 2011, Burkhard and Maes 2017), with a number of classification frameworks proposed over the years (MA 2005; Haines-Young and Potschin 2013). In addition, there has been significant progress in the development of methods on ES quantification and mapping (Chan et al. 2006; Naidoo et al. 2008; Egoh et al. 2009; Eigenbrod et al. 2010; Vihervaara et al. 2010). However, most of the approaches developed for ES quantification use model-based proxies (Schulp et al. 2014) relying heavily on land cover-based assessments (Burkhard et al. 2009; 2012; Kandziora et al. 2013) in the absence of direct monitoring data on ES, and often produce maps that are too coarse in resolution to be useful at the local scale.

PA management is practised at the site-scale and thus requires practical inexpensive tools that can provide baseline information for biodiversity and ES assessment and monitoring. Although lately there has been a proliferation of ES assessment tools , site-based assessments, which are more useful to managers and practitioners, usually rely on theoretical scenarios or extrapolations from global models or require much greater technical skill and resources and are designed more for the academic user (Peh et al. 2013). As a result real site-scale approaches to ES assessment remain limited since the ES are often technically difficult and expensive to measure at that scale. The aim of this paper was to evaluate ES in a peri-urban national park in Cyprus and test the applicability of two widely used approaches namely:

a) the Toolkit for Ecosystem Service Site-based Assessment (TESSA) (Peh et al. 2013) and b) the 'ES matrix' approach (Burkhard et al. 2009) to map the potential/capacity of habitat types within the park. The specific objectives were to identify and assesse key ecosystem services provided by the park, map their spatial distributions and provide nature conservation authorities with a rapid methodology which can be applied in site-based ES assessments on the island.

Methods

Study area

Rizoelia National Forest Park (RNFP), a peri-urban Natura 2000 site close to the city of Larnaca, Cyprus (Fig. 1) is a biodiversity hotspot which has suffered intense human-related pressure over the years. Afforestation with non-native species, leisure activities and a dense road network has led to a decrease in size of two priority habitats at the European level: 1520* Iberian gypsum vegetation (Gypsophiletalia) and 5220* Arborescent matorral with *Ziziphus*.

TESSA based - Ecosystem Services Assessment

For ecosystem services (ES) assessment we used TESSA v.1.1 (Peh et al., 2013). TESSA is not computer intensive, it is inexpensive, easy to follow and easy to use for training purposes particularly for non-specialists. It focuses on the site level, is ideal for sites of biodiversity conservation importance and addresses the need to bring ecosystem services approach down to the operational scale using locally gathered information. This makes it ideal for assessing ES delivered by protected areas, producing results relevant to local decision-making and, when scaled up, for wider communication (Peh et al., 2013). Since different groups of beneficiaries value services differently, diverse stakeholder groups, i.e. local users, site managers and experts were involved. Based on a recent vegetation map (Andreou and Christodoulou 2014) of the site the mapped vegetation types were classified into broad habitat types according to TESSA (Table 1). In order to determine the most important ES delivered by the RNFP, we conducted an initial identification of its potential ES, taking into account historical information, literature data and the expert judgement by the Department of Forests (DF) officers (Table 2). We identified all the ES and their benefits delivered by the site using a table provided by TESSA. The provided benefits were all scored from 0–5, where 0=not relevant and 5= highly important (indicates the number of people benefiting). Then, the different stakeholder groups discussed and agreed on the five priority benefits (based on their scores). We used the MA (2005) framework for grouping services in order to be consistent with the chosen ES mapping method as described in the sections below.

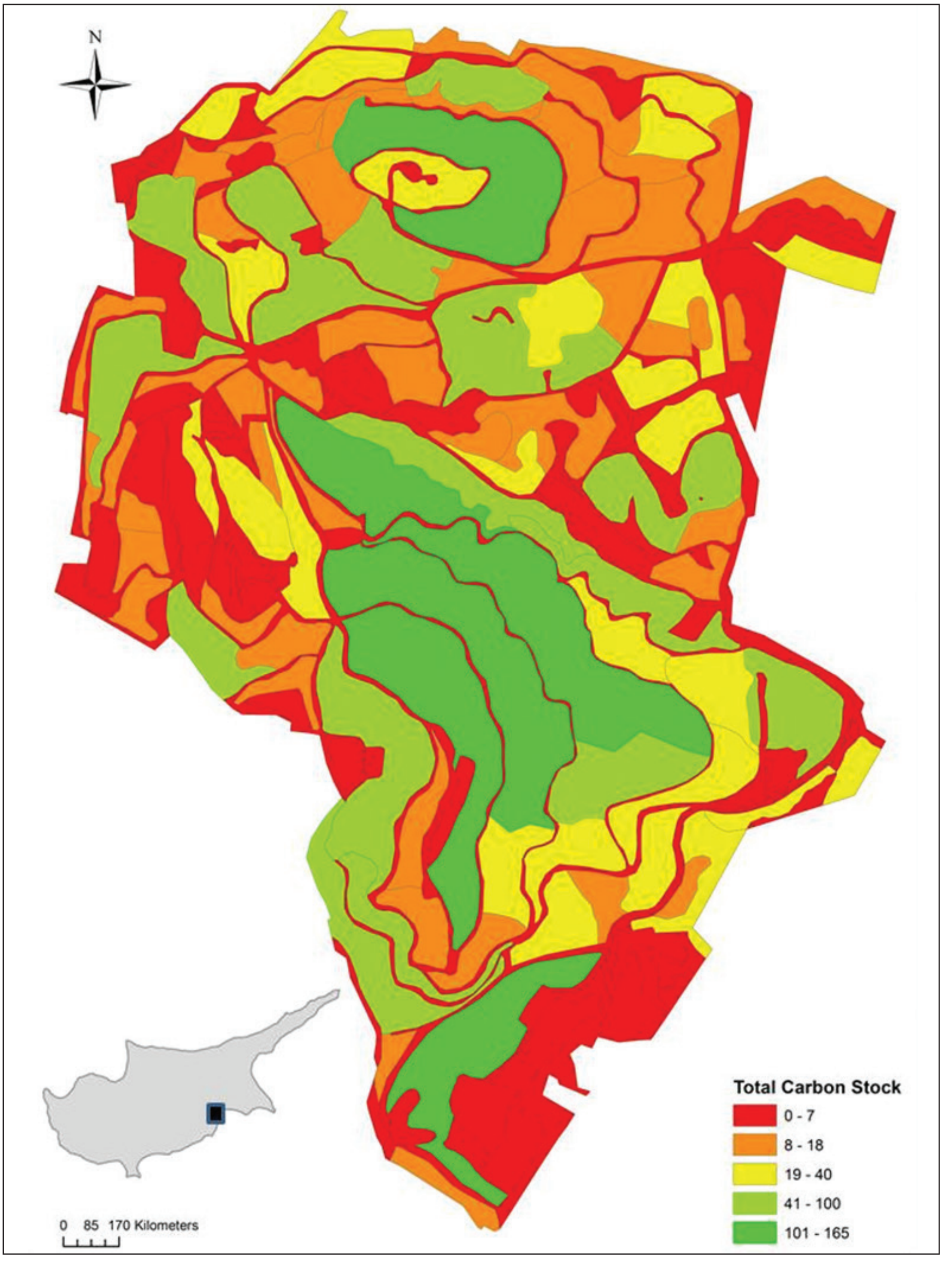

Figure 1. Location of the study area and Total Carbon Stock (tones of Carbon) derived from TESSA estimates.

Methods applied for global climate regulation assessment

Different habitats and land uses/cover have different potential influences on service of global climate regulation i.e. the exchange of carbon dioxide and other greenhouse

Table 1. Main habitat types at Rizoelia N.F.P, the corresponding habitat classification proposed by the TESSA toolkit and their extent in hectares.

	Habitat type	TESSA habitat classification	Area (ha)
Tree-dominated habitat	Needleleaf Plantation	Temperate scrub/woodland	14.57
	Broadleaf Plantation		14.09
Shrub-dominated habitat	*Sarcopoterium spinosum* phrygana (5420)		14.48
	Arborescent matorrals with *Ziziphus* (5220)		0.38
Grass Dominated	Pseudo-steppe with grasses and annuals of the Thero - Brachypodietea (6220)	Temperate grassland	0.19

Table 2. Potential ecosystem services at the current state of the site.

ES category (according to MA 2005)	ES	Benefits	Current state (score 0-5) 5= highly important	Top five services in the current state
Regulating	Global climate regulation	carbon storage in trees	4	√
	Local climate and air quality regulation	Providing shade, removing pollutants, influence rainfall	2	
	Water-related services	Water for human use	0	
		Water flow regulation	0	
		Water quality improvement	3	
	Erosion control	Avoiding landslides	2	
Provisioning	Harvesting wild goods	Foods	2	√
		Fibre	0	
		Natural medicines	0	
		Energy	0	
	Cultivated goods	Food	1	
		Fibre	0	
		Energy	0	
Supporting	Biodiversity		5	√
Cultural	Cultural/intellectual and representatives interactions	Scientific	5	
		Educational		√
		Entertainment		
		Aesthetic		√

gases between the atmosphere and the plants, animals and soils within ecosystems. Therefore, we treated separately each habitat type that was identified during the rapid appraisal stage. Field-based measurements were not possible due to lack of resources, as well as due to the protection/management regime of the area, which restricts interventions as required by the TESSA measurements. Therefore, we relied on the estimates provided in the TESSA manual for the study area which they were derived from credible values from similar sites or reliable sources mainly from the reports of the Intergovernmental Panel on Climate Change (IPCC) (Table 3). For each habitat type

Table 3. Summary of TESSA methods used for the estimation of carbon stock components

Habitats	Decision tree	Relevant Section	Climate section 6 Estimating total carbon stock	TESSA method	Method description
Tree-dominated habitats	Climate section 2	Trees were planted-Complete Climate sections 6-10	Above-Ground live Biomass (AGB) carbon stock	IPCC- tier 1 - Method climate method 2 Estimating above-ground live biomass carbon stock using IPCC tier 1 estimates	To calculate the total above-ground live biomass of each habitat at the site, multiply above-ground live biomass by the area (ha) of the habitat. To calculate the total above-ground live biomass of each habitat at the site, multiply above-ground live biomass by the area (ha) of the habitat. To calculate the total above-ground live biomass carbon stock (t C) of your habitat, multiply the total above-ground live biomass by a conversion factor of 0.5 for tree-dominated, forest plantations, woody savannahs, perennial crop-dominated habitats and urban parks, or by 0.47 for grass dominated habitats, wetlands and urban lawn.
			Below-Ground Biomass (BGB) carbon stock	IPCC conversion factors – Climate Method 5: Estimating below-ground biomass carbon stock using IPCC conversion factors	Below-ground biomass carbon stock was estimated using a ratio of below ground-ground biomass to above ground biomass (R) for particular vegetation types (IPCC 2006): Temperate conifers (TC; 0.40), Temperate *Eucalyptus* spp., (TE; 0.44), semi-arid grassland (SAG; 2.8) and Shrubland (S; 2.8).
			dead organic matter carbon stock	IPCC tier 1 estimates-Climate Method 6. Estimating dead organic matter (litter and dead wood) carbon stock using IPCC tier 1 estimates.	The default value for the Needle leaf evergreen plantation is 20.3. To calculate the total litter carbon stock of each habitat, this value is multiplied by the area (in ha) of the habitat (14.566).
			soil organic carbon stock in mineral and organic soils –	Climate Method 7: Estimating soil organic carbon stock in mineral and organic soils. This section provides information on how to calculate soil carbon stocks in either organic or mineral soils.	Soil on the Rizoelia site is mineral. The default mineral soil classification should be used with Tier 1 methods because default reference C stock and stock change factors were derived according to these soil types. Therefore the IPCC (2006), for the default reference soil organic carbon stock = 38 tonnes C ha-1.Total area size = 47.8632ha

Habitats	Decision tree	Relevant Section	Climate section 6 Estimating total carbon stock	TESSA method	Method description
Grass-dominated habitats	Climate section 3	Complete Climate sections 6,7,9,10	Above-Ground live Biomass (AGB) carbon stock	IPCC- tier 1 - Method climate method 2 Estimating above-ground live biomass carbon stock using IPCC tier 1 estimates	To calculate the total above-ground live biomass of each habitat at the site, multiply above-ground live biomass by the area (ha) of the habitat. To calculate the total above-ground live biomass of each habitat at the site, multiply above-ground live biomass by the area (ha) of the habitat. To calculate the total above-ground live biomass carbon stock (t C) of your habitat, multiply the total above-ground live biomass by a conversion factor of 0.5 for tree-dominated, forest plantations, woody savannahs, perennial crop-dominated habitats and urban parks, or by 0.47 for grass dominated habitats, wetlands and urban lawn.
			Below-Ground Biomass (BGB) carbon stock	IPCC conversion factors – Climate Method 5 Estimating below-ground biomass carbon stock using IPCC conversion factors	Below-ground biomass carbon stock was estimated using a ratio of below ground-ground biomass to above ground biomass (R) for particular vegetation types (IPCC 2006): Temperate conifers (TC; 0.40), Temperate Eucalyptus spp., (TE; 0.44), semi-arid grassland (SAG; 2.8) and Shrubland (S; 2.8).
			dead organic matter carbon stock	IPCC tier 1 estimates-Climate Method 6. Estimating dead organic matter (litter and dead wood) carbon stock using IPCC tier 1 estimates	No existing tabulated data from IPPC (2006). It is assumed that there are no significant litter and dead wood carbon pools for grass-dominated habitats.
			soil organic carbon stock in mineral and organic soils –	Climate Method 7: Estimating soil organic carbon stock in mineral and organic soils. This section provides information on how to calculate soil carbon stocks in either organic or mineral soils.	
			Soil Organic Carbon Stock in Mineral soils	IPCC Tier 1 soil carbon inventory method:	The first step is the definition of the climate domain of the sites. According to the Annex 3A.5 in Chapter 3 of IPCC (2006), for the default climate classification scheme maps, Cyprus is classified as warm temperate dry. The second step concerns the soil type of each habitat type. The FAO Soils Map of the World was used to identify the soil types on the site as cambisols. Next step is the definition of the habitat types in the area and to multiply the area of each habitat type with the default reference soil organic carbon stock for the area, which is 38 tonnes C ha^{-1}.

Table 4. Summary of TESSA methods used for the estimation of greenhouse gasses emissions and results.

Estimation of the greenhouse gases (CO_2, N_2O, CH_4) emitted by the plants, soil and animals over time (positive flux).	TESSA method	Results
1. Carbon Dioxide (CO_2) emissions	Climate Method 9	CO_2 soil emissions from the site can be considered insignificant because the Rizoelia site has mineral soils. Therefore the emission of carbon dioxide from the Rizoelia site is negligible.
2. Methane emissions	Climate Section 10	Methane emissions from the site can be considered insignificant because the Rizoelia site has no grazing.
3. Nitrous oxide emissions	Climate Section 11	Nitrous oxide emissions from the site can be considered insignificant because the Rizoelia site has no fertilisers added, is not a drained peatland and is not grazed.
The carbon sequestered (taken in from the atmosphere) over time by the plants and soil (negative flux)	Climate section 6	Represented as C sequestered in above ground biomass vegetation over 1 year.

Table 5. Summary of total carbon estimation results per habitat type.

	RNFP Habitat Type	TESSA Habitat Classification	Area (ha)	C_AGB	C_BGB	C_Soil	C_dead	Total Carbon stocks (tC)
	Needle-leaf Plantation	Temperate scrub/ woodland	14.56	349.58	139.83		295.69	
	Other Trees Plantation	Temperate scrub/ woodland	14.08	338.05	148.74		no data	
	5420	Temperate scrub/ woodland	14.47	347.47	972.92		no data	
	5220	Temperate scrub/ woodland	0.38	9.19	25.73		no data	
	6220	Grass- Dominated/ Temperate grassland	0.18	0.20	0.57		0	
	Non-vegetated	n/a	45.60	no data	no data		no data	
	Synanthropic	n/a	1.42	no data	no data		no data	
Total			**90.73**	**1044.51**	**1287.81**	**11619.30**	**295.69**	**14247.32**

(tree-dominated and grass- dominated) we assessed factors, which might affect global climate regulation: the carbon stored in the plants (above-ground biomass; below-ground biomass), dead organic matter and soil and the greenhouse gases emitted by the plants, soil and animals over time. The methods given by TESSA and used for carbon stock estimation and gas emissions are given in Table 3 and Table 4 respectively, while the results are summarized in Table 5. The methodology used by TESSA provides with decision trees to help users determine the most appropriate method for estimating carbon stock and gas emissions based on a number of questions related to study area characteristics and data availability.

Methods applied for Nature-based tourism and recreation

TESSA methodology takes into account two different aspects of recreation and nature-based tourism ecosystem services delivery i.e., the total number of visits to the site, and the associated expenditure. Census Recreation Method 1, is given as a means to measure the volume of nature-based tourism and recreation, while Recreation Method 2 for the economic value.

Recreation Method 1 was used to measure the volume of nature-based tourism and recreation, (Peh et al. 2013). Particularly, Recreation Method 1 is essentially a census of visitors, where a count of the people visiting the site (at the visiting entrances) over an entire year takes place (Peh et al. 2013). The initial assumption was that visits are over 100 per year so a census was conducted in order to estimate the total number of annual visits. Counting of visits took place from April 2014 until February 2015 divided in three periods (March-May, June-October and November-February) to examine the effect of seasonality on visitation. In each period, seven census surveys (21 in a total) were conducted during weekends, weekdays and national holidays. Counting points were located at RNFP's entrances (North and South) and surveys took place from 7:00 to 19:00. In order to identify people which were visiting the site for nature-based tourism or recreation we asked all visitors directly. At the same time we used Recreation Method 2 (Peh et al. 2013) for estimating tourism and recreation economic value. A short questionnaire was prepared to capture visitors' spending on the area and was distributed to 246 visitors. The Questionnaire requested information regarding gender, ethnicity, frequency of site visits, duration of trip and amount spent during travel and on the site.

ES 'matrix' approach

We used the ES 'matrix' approach (Burkhard et al. 2009; 2012), which links ES to appropriate geo-biophysical spatial units, to map the potential/capacity of habitat types to deliver ecosystem services. The ES matrix approach is based on a normalisation of ES indicator values to a relative scale ranging from 0–5 for their supply, flow and/or demand ranking. "0" represents no relevant ES supply or demand, while at the other end of the scale, "5" represents the maximum ES indicator value (Burkhard and Maes 2017). We assessed the maximum potential quantity of a service provided per unit area of each habitat type/land cover type in the RNFP under natural conditions using the scale of 0–5 (Appendix 1).

The scores assigned to each habitat and function were derived through brainstorming sessions (experts judgement) between local experts from the Department of Forests (DF) and the Department of Environment (DE), experts from two national Universities and literature searches. Scores retained represent the consensus of these sessions. We did not evaluate provisioning services since activities related to these services are not allowed or in the area encouraged. However, we have accounted for occasional biomass resulting from fuel wood extracted during invasive species removal.

Mapping ES

In order to map the spatial extent of carbon related components at the RNFP, we used the habitat types as spatial units within which we attributed the values for each of the four carbon components and the total carbon stock, as derived from TESSA estimates (Fig. 1).In addition, we mapped supporting services, regulating and maintenance, and cultural services per habitat type based on the ES 'matrix' approach.

Results

The most important habitat types at the site and their current extent are given in Table 1. According to the Rapid Appraisal analysis the most important ecosystem services delivered by the study area refer to Aesthetic benefits/inspiration, Recreation/tourism, Biodiversity, Global climate regulation, and Environmental education. Aesthetic benefits/inspiration and Recreation/tourism are included in the broad category of Nature-based recreation and Global climate regulation referred mainly to the Carbon related services.

TESSA based ES assessment

Global climate regulation

The total carbon stock at the RNFP was calculated by adding the carbon stocks for each habitat at the site [Above-Ground Biomass (C_ABG), Below-Ground Biomass (C_BGB), Soil (C_Soil) and Dead organic matter (C_dead)] to derive the total carbon stock at the site (expressed as tonnes of carbon) (Table 5). The total annual greenhouse gas flux for the site was insignificant and it was excluded from the calculations (Table 4).

Nature-based recreation - tourism and recreation economic value

The total number of annual visits (TANV) in RNFP was 14471. Particularly, TANV for periods A (March-May), B (June-October) and C (November-February) was 3834, 4734 and 5903 respectively. There were no statistically significant differences (One-way ANOVA; Sig. = 0.459) in the number of visits among visitation periods (March-May, June-October, and November-February). On the contrary, there were statistically significant differences (one way ANOVA; Sig.= 0.009) among National Holidays, Weekends and Weekdays. Specifically, multiple comparisons using Least Significant Difference t test (LSD) showed that the highest differences in the mean number of visitors are between National Holidays and Weekdays. There were also significant differences between National Holidays and Weekends. The results indicated that the number of visits increased significantly during public holidays. The economic survey revealed that

75.4% of the respondents spent less than 5 euros (mainly for fuel) during their trip to the study area. However, most of the respondents stated that there would be willing to spend more should there be facilities provided in the park.

Mapping ecosystem services

In terms of supporting ES we identified that plantations, despite considered of low biodiversity value, (Needle-leaf Plantation, Temperate scrub/woodland) have the highest capacity (compared to the natural and semi-natural habitats of the site) to provide ES, particularly in places with priority habitat types to their understory. Mapping regulating services capacity corroborated the importance of plantations compared to other habitat types due to the dominant life-form. Apart from roads, habitats comprising exclusively synanthropic vegetation communities scored low in general, except for the cases that these occur in mixture with the *Ziziphus lotus* habitat type (higher score). In addition, the conifer plantations of RNFP were perceived more important for recreation in a peri-urban setting; hence, scored higher at the cultural services compared to other habitat types (Fig. 2). When the sum for all groups of services was calculated, the results demonstrated that some plantations within the RNFP attained the highest value in places where their understory comprises one or more of the habitat types 1520*, 6220* and 5420.

Discussion and conclusions

This is the first study of a complete site-based ES assessment in a protected area setting in Cyprus and as such, it has the potential to support environmental management and policy. The results corroborated the importance of RNFP for ES provision, in addition to biodiversity support, with direct and indirect benefits to the local community. Among the most important findings of this study are the results on recreation as a service in the study area, since it is higher than ever recorded in the past with annual visits (TANV) reaching a total number of 14471, with most of them during days off work in the period November to February. Recreation activities in the study area are less associated with nature-based activities like wildlife and forest appreciation. Only 21% of the respondents gave as main reason of their visit the appreciation of nature.

High visitor numbers may result in conflict between nature conservation and recreation in peri-urban parks (Borgstrom 2008; Sterl et al. 2008; Wagner et al. 2005; Zaikanov and Kiseleva 2008). Recreational services have economic importance (Tyrväinen and Miettinen 2000) while they are also important for tourism, as nature-related activities often influence the decisions of foreign tourists to travel to Cyprus. Protected areas, if properly managed, can provide, among other benefits, a source of income to local communities. In the case of RNFP visitors live and work locally, therefore contribute relatively small amounts to the local economy while there are no extra facilities

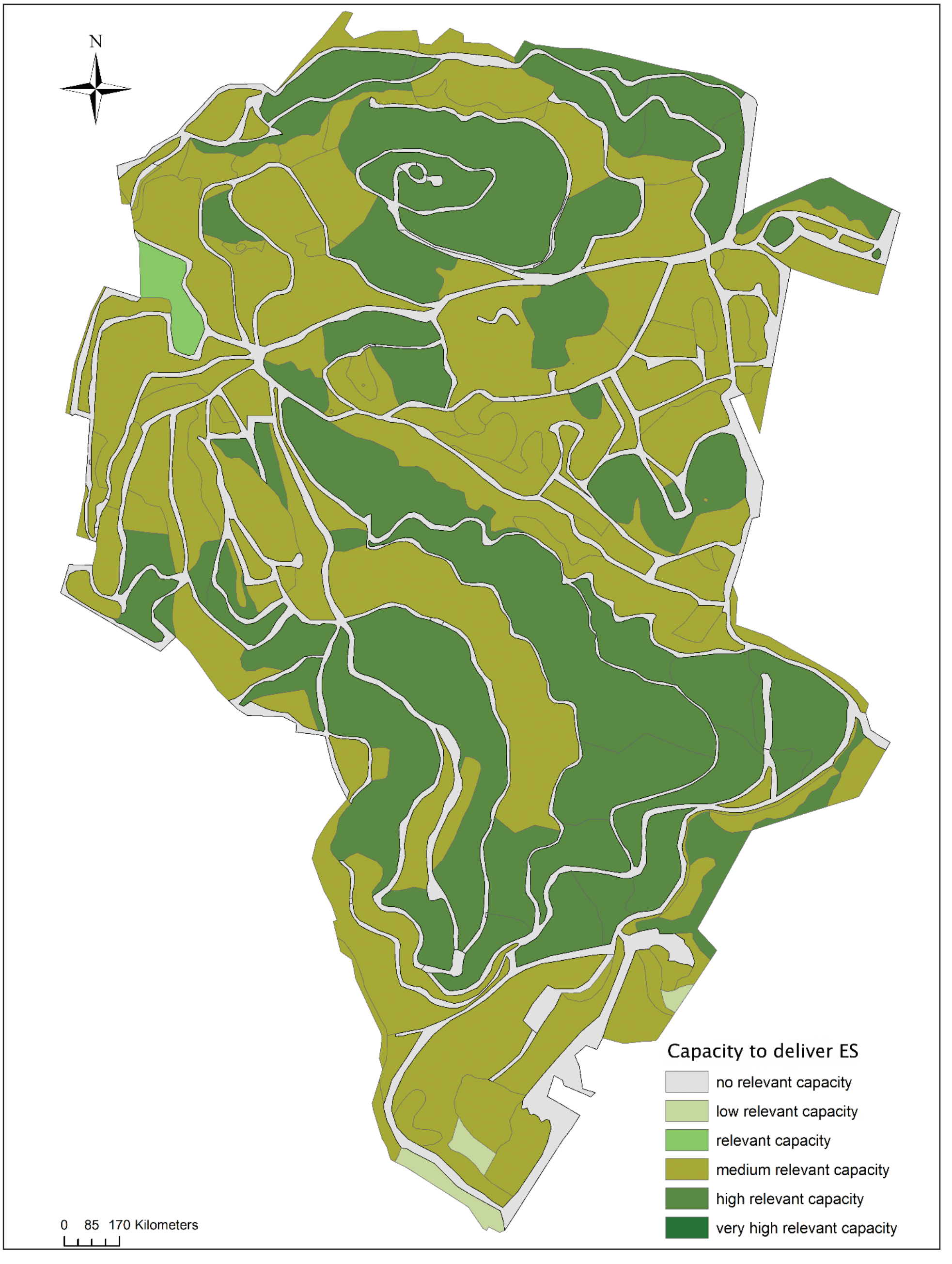

Figure 2. Capacity of habitat types in the study area to deliver ES (based on ES matrix approach described in the text).

on site where money could be spent on. Within a peri-urban park, green areas and tree plantations can function as carbon sinks (McHale et al. 2007), although urban vegetation only sequestrates a small part of annual CO_2 emissions of a city (Jansson and

Nohrstedt 2001; Lebel et al. 2007). In fact, urban parks can function as carbon sources because management and the use of parks produce multiple amounts of CO_2 emissions compared to the carbon sequestration capacity of a green area (Oliver-Sola et al. 2007). Although urban carbon sinks, do not necessarily have a significant impact on the global carbon balance, urban green areas can have local importance as carbon sinks.

In the study area, apart from the Mediterranean grass-dominated habitat (6220*), the above-ground carbon stock measurements did not show variability. On the other hand, the highest below-ground carbon biomass was estimated in the Mediterranean scrub habitats (5220* and 5420). The lack of tabulated data for scrubs or broadleaf evergreen woodland was the main limitation for the implementation of the TESSA approach, which led to the underestimation of litter and dead organic material carbon stocks for all habitat types, except the Needle-leaf plantation. Another underestimation refers to the contribution of the extensive root systems, particularly in the cases of known phreatophytes like *Ziziphus lotus* (Gorai et al. 2010). Despite this limitation, in the absence of resources for extensive fieldwork, TESSA provides a consistent, inexpensive, rapid tool for ecosystem services appraisal at local level, which can be easily applied by practitioners and understood by stakeholders (Peh et al. 2014; Blaen et al. 2015). The tool becomes even more valuable in protected areas, including Natura 2000 sites, where often restrictions apply for land use and conservation management, which might influence the provision of services.

The second part of this assessment included an expert-based evaluation and mapping of the capacity of various habitat types to support a range of services which is now widely accepted in ES science (Jacobs et al. 2015), despite its reported challenges (Burkhard et al. 2009; 2012; Eigenbrod et al. 2010). Although, Rizoelia NFP is a biodiversity hotspot hosting three priority habitat types of European importance, the study highlighted that plantations in the area, despite their low biodiversity value, are equally important in terms of their capacity for ecosystem services supply. Therefore, in addition to biodiversity conservation, competent authorities should also manage the area in the future in a way that maximizes the provision of these services. This is now facilitated by the present first evaluation of the area's potential, and the explicit spatial nature of the approach for visualizing the extent of services in the park (Tallis and Polasky 2009). What is equally important in terms of management is shifting from solely biodiversity delivery to ES delivery and the need to identify trade-offs between ES. The relationship between biodiversity and ecosystem services is a complex one (Mace et al. 2012) and has sparked a debate among conservationists on whether management interventions can achieve both ES and biodiversity related targets (see Reyes et al. 2012). In order to quantify the complex inter-relations between ecosystem services, drivers and pressures there is a need to take into account these different components and identify trade-offs (Haines-Young and Potschin 2007; Haines-Young et al. 2012; Haines-Young 2012; Sharp et al. 2016). The ES matrix approach is an evolving one and since it is quite general, there is a lot of scope for improvement. However, this rapid expert driven approach is a good early indication of what it can be supported by the park in terms of ecosystem services, their general patterns and how they can be assessed given more time and resources. It is interesting to note that the mapping results for carbon sequestration using TESSA, corroborates experts-based assessment; the latter aiming at assessing the magnitude of provision/capacity and therefore the importance of certain habitat types (like plantations) for regulating and maintenance services delivery in the study area, was carried out independently.

The study demonstrated the importance of site-based assessment for ecosystem services delivered in protected areas, pointing out a gap at the national level for a rigorous approach in such assessments in parallel to other national studies at the European level and in accordance with the obligations of Cyprus under the EU biodiversity strategy for 2020. These types of assessments are precursors to economic valuation of ecosystems services and the identification of their direct financial benefits to the local communities (Defra 2007, TEEB 2010, UK-NEA 2011).

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References

Andreou M, Christodoulou CS (2014) Monitoring plan for the habitat type *5220: Arborescent matorral with *Ziziphus*, at the Rizoelia National Forest Park. Frederick University, Nicosia, 1–19.

Bastian O (2013) The role of biodiversity in supporting ecosystem services in Natura 2000 sites. Ecological Indicators 24: 2–22. https://doi.org/10.1016/j.ecolind.2012.05.016

Blaen PJ, Jia L, Peh, KSH, Field RH, Balmford A, MacDonald MA, Bradbury RB (2015) Rapid assessment of ecosystem services provided by two mineral extraction sites restored for nature conservation in an agricultural landscape in eastern England. PloS ONE 10(4): p.e0121010 https://doi.org/10.1371/journal.pone.0121010

Borgstrom ST (2008) Challenges of urban nature conservation. Licentiate thesis 2008:1, Department of Systems Ecology, Stockholm University, Stockholm.

Boyd J, Banzhaf S (2007) What are ecosystem services? The need for standardized environmental accounting units. Ecological Economics 63: 616–626. https://doi.org/10.1016/j.ecolecon.2007.01.002

Burkhard B, Kroll F, Müller F, Windhorst W (2009) Landscapes' Capacities to Provide Ecosystem Services – a Concept for Land-Cover Based Assessments. Landscape Online 15: 1–22.

Burkhard B, Kroll F, Nedkov S, Müller F (2012) Mapping ecosystem service supply, demand and budgets. Ecological Indicators 21: 17–29. https://doi.org/10.1016/j.ecolind.2011.06.019

Burkhard B, Maes J (Eds) (2017) Mapping Ecosystem Services. Pensoft Publishers, Sofia, 374 pp. https://doi.org/10.3897/ab.e12837

Chan KM, Shaw MR, Cameron, DR, Underwood EC, Daily GC (2006) Conservation planning for ecosystem services. PLoS Biology 4(11): 379. https://doi.org/10.1371/journal.pbio.0040379

de Vries S, Verheij RA, Groenewegen PP, Spreeuwenberg P (2003) Natural environments—Healthy environments? An exploratory analysis of the relationship between greenspace and health. Environmental Planning A 35: 1717–1731. https://doi.org/10.1068/a35111

Defra (2007) An introductory guide to valuing ecosystem services, Defra, London, 1–65.

Egoh B, Drakou E, Dunbar D, Maes J, Willemen L (2012) Indicators for mapping ecosystem services: a review. Joint Research Centre, Institute for Environment and Sustainability, Luxembourg, 1–107.

Eigenbrod F, Armsworth PR, Anderson BJ, Heinemeyer A, Gillings S, Roy DB, Thomas CD, Gaston KJ (2010) The impact of proxy-based methods on mapping the distribution of ecosystem services. Journal of Applied Ecology 47: 377–385. https://doi.org/10.1111/j.1365-2664.2010.01777.x

Fisher B, Turner RK (2008) Ecosystem services: classification for valuation. Biological Conservation 141: 1167–9. https://doi.org/10.1016/j.biocon.2008.02.019

Fisher B, Turner RK, Morling P (2009) Defining and classifying ecosystem services for decision making. Ecological Economics 68: 643–653. https://doi.org/10.1016/j.ecolecon.2008.09.014

Gorai M, Maraghni M, Neffati M (2010) Relationship between phenological traits and water potential patterns of the wild jujube *Ziziphus lotus* (L.) Lam. in southern Tunisia. Plant Ecology & Diversity 3: 273–280. https://doi.org/10.1080/17550874.2010.500337

Grimm NB, Faeth SH, Golubiewski NE, Redman CL, Wu J, Bai X, Briggs JM (2008) Global change and the ecology of cities. Science 319: 756–760. https://doi.org/10.1126/science.1150195

Haines-Young R (2011) Exploring ecosystem service issues across diverse knowledge domains using Bayesian Belief Networks. Progress in Physical Geography 35: 681–699. https://doi.org/10.1177/0309133311422977

Haines-Young R, Potschin M (2013) Common International Classification of Ecosystem Services (CICES): Consultation on Version 4, August-December 2012. EEA Framework Contract No EEA/IEA/09/003.

Haines-Young R, Potschin M, Kienast F (2012) Indicators of ecosystem service potential at European scales: mapping marginal changes and trade-offs. Ecological Indicators 21: 39–53. https://doi.org/10.1016/j.ecolind.2011.09.004

Haines-Young R, Potschin M (2007) The Ecosystem Concept and the Identification of Ecosystem Goods and Services in the English Policy Context. Review Paper to Defra, Project Code NR0107, 1–21.

IUCN (1994) Guidelines for Protected Area Management Categories. IUCN, Gland, Switzerland and Cambridge, UK.

Jacobs S, Burkhard B, Van Daele T, Staes J, Schneiders A (2015) 'The Matrix Reloaded': A review of expert knowledge use for mapping ecosystem services. Ecological Modelling 295: 21–30. https://doi.org/10.1016/j.ecolmodel.2014.08.024

Jansson A, Nohrstedt P (2001) Carbon sinks and human freshwater dependence in Stockholm County. Ecological Economics 39:361–370. https://doi.org/10.1016/S0921-8009(01)00224-5

Kandziora M, Burkhard B, Müller F (2013) Mapping provisioning ecosystem services at the local scale using data of varying spatial and temporal resolution. Ecosystem Services 4: 47–59. https://doi.org/10.1016/j.ecoser.2013.04.001

Korpela KM, Ylén M (2007) Perceived health is associated with visiting natural favourite places in the vicinity. Health & Place 13: 138–151. https://doi.org/10.1016/j.healthplace.2005.11.002

Lebel L, Garden P, Banaticla MRN, Lasco RD, Contreras A, Mitra AP, Sharma C, Nguyen HT, Ooi GL, Sari A (2007) Management into the development strategies of urbanizing regions in Asia: implications of urban function, form, and role. Journal of Industrial Ecology 11: 61–81. https://doi.org/10.1162/jie.2007.1185

MA (2005) Ecosystems and Human Well Being: a Synthesis. Island Press, 137 pp.

Mace GM, Norris K, Fitter AH (2012) Biodiversity and ecosystem services: a multilayered relationship. Trends in Ecology & Evolution 27:19–26. https://doi.org/10.1016/j.tree.2011.08.006

Margules CR, Pressey RL (2000) Systematic conservation planning. Nature 405(6783): 243–253. https://doi.org/10.1038/35012251

McHale MR, McPherson EG, Burke IC (2007) The potential of urban tree plantings to be cost effective in carbon credit markets. Urban For Urban Green 6: 49–60. https://doi.org/10.1016/j.ufug.2007.01.001

Naidoo R, Balmford A, Costanza R, Fisher B, Green RE, Lehner B, Malcolm TR, Ricketts TH (2008) Global mapping of ecosystem services and conservation priorities. Proceedings of the National Academy of Sciences of the United States of America 105: 9495–9500. https://doi.org/10.1073/pnas.0707823105

Oliver-Sola J, Nunez M, Gabarrell X, Boada M, Rieradevall J (2007) Service sector metabolism: accounting for energy impacts of the Montjuıc urban park in Barcelona. Journal of Industrial Ecology 11: 83–98. https://doi.org/10.1162/jie.2007.1193

Peh KSH, Balmford A, Bradbury RB, Brown C, Butchart SH, Hughes FM, Stattersfield A, Thomas DH, Walpole M, Bayliss J, Gowing D (2013) TESSA: a toolkit for rapid assessment of ecosystem services at sites of biodiversity conservation importance. Ecosystem Services 5: 51–57. https://doi.org/10.1016/j.ecoser.2013.06.003

Peh KSH, Balmford A, Field RH, Lamb A, Birch JC, Bradbury RB, Brown C, Butchart SH, Lester M, Morrison R, Sedgwick I (2014) Benefits and costs of ecological restoration: Rapid assessment of changing ecosystem service values at a UK wetland. Ecology and Evolution 4: 3875–3886. https://doi.org/10.1002/ece3.1248

Reyers B, Polasky S, Tallis H, Mooney HA, Larigauderie A (2012) Finding common ground for biodiversity and ecosystem services. BioScience 62: 503–507. https://doi.org/10.1525/bio.2012.62.5.12

Savard J-PL, Clergeau P, Mennechez G (2000) Biodiversity concepts and urban ecosystems. Landscape Urban Planning 48:131–142 https://doi.org/10.1016/S0169-2046(00)00037-2

Schulp CJE, Lautenbach S, Verburg PH (2014) Quantifying and mapping ecosystem services: demand and supply of pollination in the European Union. Ecological Indicators 36: 131–141. https://doi.org/10.1016/j.ecolind.2013.07.014

Seppelt R, Dormann CF, Eppink FV, Lautenbach S, Schmidt S (2011) A quantitative review of ecosystem service studies: approaches, shortcomings and the road ahead. Journal of Applied Ecology 48: 630–636. https://doi.org/10.1111/j.1365-2664.2010.01952.x

Sharp R, Tallis HT, Ricketts T, Guerry AD, Wood SA, Chaplin-Kramer R, Nelson E, Ennaanay D, Wolny S, Olwero, N, Vigerstol K, Pennington D, Mendoza G, Aukema J, Foster J, Forrest J, Cameron D, Arkema K, Lonsdorf E, Kennedy C, Verutes G, Kim CK, Guannel G, Papenfus M, Toft J, Marsik M, Bernhardt J, Griffin R, Glowinski K, Chaumont N, Perelman A, Lacayo M, Mandle L, Hamel P, Vogl AL, Rogers L, Bierbower W (2016) InVEST User's Guide. The Natural Capital Project, Stanford University, University of Minnesota, The Nature Conservancy, and World Wildlife Fund.

Sterl P, Brandenburg C, Arnberger A (2008) Visitors' awareness and assessment of recreational disturbance of wildlife in the Donau-Auen National Park. Journal for Nature Conservation 16: 135–145. https://doi.org/10.1016/j.jnc.2008.06.001

Tallis H, Polasky S (2009) Mapping and valuing ecosystem services as an approach for conservation and natural-resource management. Annals of the New York Academy of Sciences 1162: 265–283. https://doi.org/10.1111/j.1749-6632.2009.04152.x

TEEB (2010) The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB, 1–36.

Tyrväinen L, Miettinen A (2000) Property prices and urban forest amenities. Journal of Environmental Economics and Management 39: 205–223. https://doi.org/10.1006/jeem.1999.1097

Tzoulas K, Korpela K, Venn S, Yli-Pelkonen V, Kaźmierczak A, Niemela J, James P (2007) Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. Landscape and Urban Planning 81: 67–178. https://doi.org/10.1016/j.landurbplan.2007.02.001

UK National Ecosystem Assessment (2011) The UK National Ecosystem Assessment Technical Report. UNEP-WCMC, Cambridge, 1464 pp.

Vihervaara P, Kumpula T, Tanskanen A, Burkhard, B (2010) Ecosystem services–A tool for sustainable management of human–environment systems. Case study Finnish Forest Lapland. Ecological Complexity 7: 410–42. https://doi.org/10.1016/j.ecocom.2009.12.002

Wagner S, Sterl P, Arnberger A (2005) Disturbance of avifauna caused by water sports activities in Austria's Danube Floodplains National Park. Wildlife Biology in Practice 1: 60–76.

Watson JE, Dudley N, Segan DB, Hockings M (2014) The performance and potential of protected areas. Nature 515(7525): 67–73. https://doi.org/10.1038/nature13947

Appendix I

Matrix for the assessment of the different habitat types capacities to deliver selected ecosystem goods and services (adapted from Burkhard et al. 2009). The assessment scale ranges from 0–5 as described below. In the rows between the assessments (yellow colour), sums for the individual ecosystem services groups were calculated.

Equivalent Land Cover Types	Habitat Types / Land cover types	Supporting Services	Abiotic heterogeneity	Biodiversity	Biotic waterflows	Metabolic Efficiency	Exercy Capture (Radiation)	Reduction of nutrient loss	Capacity Storage	Provisioning Services	Crops	Livestock	Fodder	Wild Food	Timber	Fuel Wood	Energy (Biomass)	Biochemical/Medicine	Regulating Services	Local climate	Global climate	Flood protection	Groundwater recharge	Air quality	Erosion	Nutrients	Water Purification	Pollution	Cultural services	Recreation &Aesthetic values	Intrinsic Biodiversity Value
Industrial or commercial units	Buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road and rail networks	Roads	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Green urban areas	Plantations	21	2	1	3	3	4	4	4	2	0	0	0	0	0	2	0	0	23	3	1	4	2	2	4	4	1	2	6	5	1
	Plantations+ 1520	24	2	4	3	3	4	4	4	2	0	0	0	0	0	2	0	0	23	3	1	4	2	2	4	4	1	2	9	5	4
	Plantations+ 5420	23	2	3	3	3	4	4	4	2	0	0	0	0	0	2	0	0	23	3	1	4	2	2	4	4	1	2	8	5	3
	Planta-tions+6220	24	2	4	3	3	4	4	4	2	0	0	0	0	0	2	0	0	23	3	1	4	2	2	4	4	1	2	9	5	4
	Plantations+ synanthropic	22	2	2	3	3	4	4	4	2	0	0	0	0	0	2	0	0	23	3	1	4	2	2	4	4	1	2	7	5	2
Non-irrigated arable land	Cultivation	17	2	1	3	3	3	1	4	0	0	0	0	0	0	0	0	0	5	2	1	1	1	0	0	0	0	0	1	0	1
Natural grassland	1520	24	3	5	2	2	2	5	5	0	0	0	0	0	0	0	0	0	16	2	3	1	1	0	3	3	3	0	6	1	5
	6220+1520	20	3	5	2	2	2	3	3	0	0	0	0	0	0	0	0	0	16	2	3	1	1	0	3	3	3	0	6	1	5
	6220+5420	20	3	5	2	2	2	3	3	0	0	0	0	0	0	0	0	0	16	2	3	1	1	0	3	3	3	0	6	1	5
Sclerophyllous vegetation	5420	21	3	4	2	3	3	4	2	0	0	0	0	0	0	0	0	0	16	2	1	1	1	0	3	3	3	2	6	2	4
	5420+1520	20	3	5	2	2	3	2	3	0	0	0	0	0	0	0	0	0	19	2	1	1	2	0	4	4	3	2	7	2	5
	5420+5220	22	3	5	4	2	3	2	3	0	0	0	0	0	0	0	0	0	20	2	1	2	3	0	3	3	4	2	7	2	5
	5420+6220	18	3	3	2	2	3	2	3	0	0	0	0	0	0	0	0	0	19	2	1	1	2	0	4	4	3	2	5	2	3
	5420+ Plantation	22	4	3	3	3	4	2	3	0	0	0	0	0	0	0	0	0	20	2	2	2	2	1	3	3	3	2	5	2	3
	6220+1520	19	3	4	2	2	3	2	3	0	0	0	0	0	0	0	0	0	17	2	1	1	2	0	3	3	3	2	6	2	4
	5420+ synanthropic	17	3	3	2	2	2	2	3	0	0	0	0	0	0	0	0	0	14	2	1	1	2	0	2	2	2	2	5	2	3
Sparsely vegetated areas	Synanthropic	10	3	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	3	1	0	1	1	0	0	0	0	0	1	0	1
	Synanthropic+ 5220	20	3	5	2	2	3	2	3	0	0	0	0	0	0	0	0	0	23	2	2	2	3	0	4	4	4	2	7	2	5
	Synanthropic+ 5420	18	3	3	2	2	3	2	3	0	0	0	0	0	0	0	0	0	16	2	1	1	2	0	3	3	2	2	5	2	3
	Synanthropic+ 6220	18	3	3	2	2	3	2	3	0	0	0	0	0	0	0	0	0	16	2	1	1	2	0	3	3	2	2	5	2	3

0	no relevant capacity of the habitat type to provide this particular ecosystem service
1	grey green = low relevant capacity,
2	light green = relevant capacity
3	yellow green = medium relevant capacity,
4	blue green = high relevant capacity and
5	dark green = very high relevant capacity