

Stewardship of Urban Ecosystem Services

Understanding the Value(s) of Urban Gardens in Barcelona

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Abstract The notion and assessment of ecosystem services (ES) values is becoming an established part of the discourse regarding urban green space performance. Yet, underlying factors enabling ES values are still poorly understood. We assume the production of ES value crucial for environmental stewardship in cities, and aimed in this study to uncover their key enabling factors. This study has been developed on a broad data base including a survey (n=201), interviews (n=46), field observation and remote sensing from 27 urban gardens in Barcelona, Spain, including municipal 'allotment gardens' and 'civic gardens' emerging from bottom-up

initiatives. In a first step, we distinguished different urban gardens types regarding the ES values they provide. In a second step, we tested specific garden characteristics including (a) user profiles, (b) biophysical garden properties, and (c) institutional settings for their specific importance to trigger ES values. Results showed ES values to significantly differ with the types of gardens. For example, classical allotment gardens are more likely to provide recreational values, while emerging civic gardens are more likely to produce place-making and social cohesion. A main finding from our study is the importance of social and institutional garden characteristic as enabling factors of ES values. Results indicate, for example, a correlation between childhood experiences and a higher appreciation of ES. Our results further indicate that civic gardens with broader property rights and decision-capacities are more likely to enhance stewardship action. In providing a differentiated understanding of the ES value(s) of urban gardens, this study highlights the potential for green space planning in cities to steer the stewardship of urban gardens by providing institutional and physical space for civic gardening initiatives.

Key words Cities • Social-ecological systems • Civic ecology • Green commons • Green infrastructure • Nature-based solutions • Urban regeneration

Key findings

- *Social and institutional properties significantly influence the perception of ES values in urban gardens*
- *We found garden size, management, property rights, gender, education and origin to enable ES values*
- *Land use and gardeners' age have not been found to significantly influence ES values*
- *Community management and enhanced property rights stipulate place identity and social cohesion*
- *Our results indicate a correlation between childhood experiences and stewardship action*

Introduction

Stewardship of ecosystem services (ES) is one of the greatest challenges for landscape and urban planning in the 21st century (Rockström et al., 2015; UN, 2014:15). The global urbanization trend (Seto et al., 2011) is decreasing people's awareness for human dependency on healthy ecosystems (Colding & Barthel, 2013; Gómez-Baggethun & De Groot 2010; Miller et al., 2005), and impinging upon environmental stewardship (Andersson & Barthel, 2016). Recent advances in assessing the value of urban ES (e.g., Gómez-Baggethun et al., 2013; Haase et al., 2014) are counteracting this trend by sensitizing for the importance of environmental stewardship action to maintain and restore multifunctional urban green spaces for human well-being.

Among different green spaces in cities, urban gardens have shown to be hubs for civic engagement and environmental stewardship in cities (Bendt et al., 2013; Colding & Barthel, 2013) that inspire civic restoration and community-based green space tending (Connolly et al., 2013; Krasny & Tidball, 2009a). A number of studies has helped shedding light on the specific ES values, which can be understood as an expression of people's needs and preferences in relation to nature and others (Chan et al., 2016), that motivate individuals or groups of people to engage in the stewardship action of community gardening (Hynes & Howe, 2002; Guitart et al., 2012, Breuste & Artmann, 2014; Langemeyer et al., 2016). Chan et al. (2016) distinguished ES values into intrinsic, instrumental and relational values, the latter produced individually as well as collectively. Engaging in stewardship action rewards — and thus motivates — gardeners with several direct benefits (Langemeyer et al., 2016; Calvet-Mir et al. 2016). Benefits include emotional, practical and social values (Dunnett & Quasim, 2000) as well as enhanced food security (e.g. Barthel & Isendahl, 2013), recreational benefits (e.g. Hawkins et al., 2011; van den Berg et al., 2010), educational benefits (e.g. Breuste & Artmann, 2014; Doyle & Krasny, 2003), social cohesion (e.g. Armstrong, 2000), and sense of place and community (e.g. Andersson et al., 2007; Andersson et al., 2014). A recent study by Camps-Calvet et al. (2016) lists as many as 20 different ES that make urban

gardens valuable for people. The study found relaxation, 'biophilia', the satisfaction of blooming life, (Wilson, 1984) and place-making, generally considered to be process of civic or community-based urban regeneration (Healey, 2007; Noori & Benson, 2016), among the most appreciated ES.

Multiple ES values urban gardens provide to city dwellers qualify them as potential nature-based solutions to urban challenges (Cabral et al., 2017; Kabisch et al., 2016). Community gardening can for example enhance social inclusion (Anguelovski, 2013), stimulate healthier diets (Litt et al., 2011), lower the risk of obesity (Zick et al., 2013) and help urban people to reconnect to nature (Krasny & Tidball, 2009a). Urban gardens are also important components of larger urban green infrastructure networks that provide niche habitats and ecological connectivity (Breuste, 2010; Langemeyer et al., 2016). Yet, urban gardens are by no means homogenous, and rapidly changing urban conditions are leading to the emergence of new varieties and approaches to urban gardens (Caputo et al., 2016). Classical 'allotment gardens' (publicly owned land formally dedicated to gardening) are complemented by new forms of 'community gardens' or 'civic gardens' emerging from *ad-hoc* gardening initiatives which do not necessarily follow top-down planning approaches (Camps-Calvet et al., 2016; Caputo et al., 2016; Zammit & Erjavec, 2016). It is thus likely that these garden types provide different values and to fit different needs of urban societies. Thus, drafting green infrastructure policies that enable the broad potential of urban gardens in providing benefits to people requires understanding the production of ES values in different types of urban gardens.

In general terms, ES values have been described as originating from the complex interactions within coupled social-ecological systems (e.g. Andersson et al., 2014). Properties of urban social-ecological systems that are generally assumed to enable ES values include ecological and physical elements, beneficiaries' social and demographic properties as well as the institutional context (e.g. Chan et al. 2012; Gómez-Baggethun & Kelemen 2008; Kremer et al., 2016; Primmer et al., 2014; Scholte et al., 2015). To

our knowledge, only two studies have examined factors that enable ES values in urban gardens. Dunnett & Quasim (2000) examined the relation of ES values with demographic properties of gardeners and uncovered relations between the perception of values and the age and gender of gardeners as well as with their employment and time they spent in the garden. Breuste & Artmann, (2014) noted ES values to vary with land cover and gardeners' behaviour. Understanding institutional factors in the generation of ES poses a major gap in urban ecosystem service research (Kremer et al., 2016). Institutions, which shape the social-ecological relations in urban gardens, have thus far not received any attention as enabling factors for ES values in urban gardens. Here, we understood institutions to be a grouping of formal and informal rules, and related social practices (Ostrom, 2009:18). As mediators at the interface between the physical garden space, garden users and the wider urban context (*cf.* Bendt et al., 2013; Colding et al., 2013), we presume institutions to be mechanism for enabling ES values and environmental stewardship.

The goal of this study is to understand the production of ES values in urban gardens, since these values may be crucial motivating factors for to engaging in environmental stewardship action in cities. Our paper presents findings from a larger case study on ES from allotment and civic urban gardens in Barcelona, Spain, and builds on the previous valuation of ES and characterization of garden users reported by Camps-Calvet et al. (2016). To carry out our analysis, we first cluster Barcelona's gardens with regard to the specific ES values. We then expand upon previous approaches in order to identify enabling factors for ES values by examining the relation between ES values and (a) user properties, (b) physical garden structures, as well as (c) institutional properties of urban gardens.

Case Study: Urban gardens in Barcelona

The city of Barcelona constitutes one of the most densely populated urban areas in Europe characterized by very low levels of urban green spaces per capita. The average amount per capita is 6.64m² (IDESCAT,

2013), which means Barcelonans have about 1/3 of the green space per capita compared to inhabitants of other European cities (Fuller & Gaston, 2009).

Urban gardens in Barcelona have long suffered from a lack of broader societal and policy appreciation (Domene & Saurí, 2007). We argue that to sustain environmental stewardship in urban areas in the long-run, it is critical to create a broader understanding of the values urban gardens provide. In other (Northern) European cities, such as the city Leipzig in Germany, the “Schreber”-movement enhanced the popularity of urban gardening for educational and leisure purposes as early as the 19th century (Keshavarz, 2015). Today gardens cover about 4.1% (1240 ha) of the total urban surface (own calculation based on Stadt Leipzig, 2015a,b). In Barcelona in turn — as in many parts of the Mediterranean and other urbanizing parts of the world — agricultural production sites and horticulture gardens where gardens have a history of being marginalized and expelled from the city through different waves of urbanization over the course of the 20th century (Roca, 2000; Vendrell & Clanchet, 1992). The Barcelona City Council (2013) estimates that today not more than 0.3% of the city's total surface is used for gardening.

But, on par with larger trends in Europe and around the globe (Caputo et al., 2016), in the last two decades Barcelona is undergoing a dynamic restoration of urban gardens, both through top-down (‘allotment gardens’) and bottom-up (‘civic gardens’) approaches (Camps-Calvet et al. 2015; 2016; Domene & Saurí, 2007) (Figure 1). Top-down approaches include a municipal garden program launched in 1997 for the city-wide creation and allocation of ‘public gardens’ to retired and socially marginalized citizens (Giacchè & Tóth, 2013), as well as the municipal ‘*Pla Buit*’ (*Empty-Spaces Plan*), which since 2013, grants vacant land owned by the municipality to civic initiatives for interim uses (Barcelona City Council, 2015). In parallel, Barcelona is witnessing a considerable emergence of self-governed gardens from the bottom-up. These ‘civic gardens’, or ‘community gardens’ as Camps-Calvet et al. (2016) call

them, are often associated with squatting of vacant public and private land and have gained particular momentum since the beginning of the global financial crisis in 2007-2008 (Camps-Calvet et al., 2015).

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Figure 1: Physical appearance of urban gardens in Barcelona, Spain.



a. Can Mestre founded in 1997 by the municipality.



b. Turull founded in 2004 by the municipality.



c. Can Masdeu founded in 2002 from a civic initiative.



d. Poblenou 2 founded in 2012 from a civic initiative.

Source: Authors' personal photographs.

Data & Methods

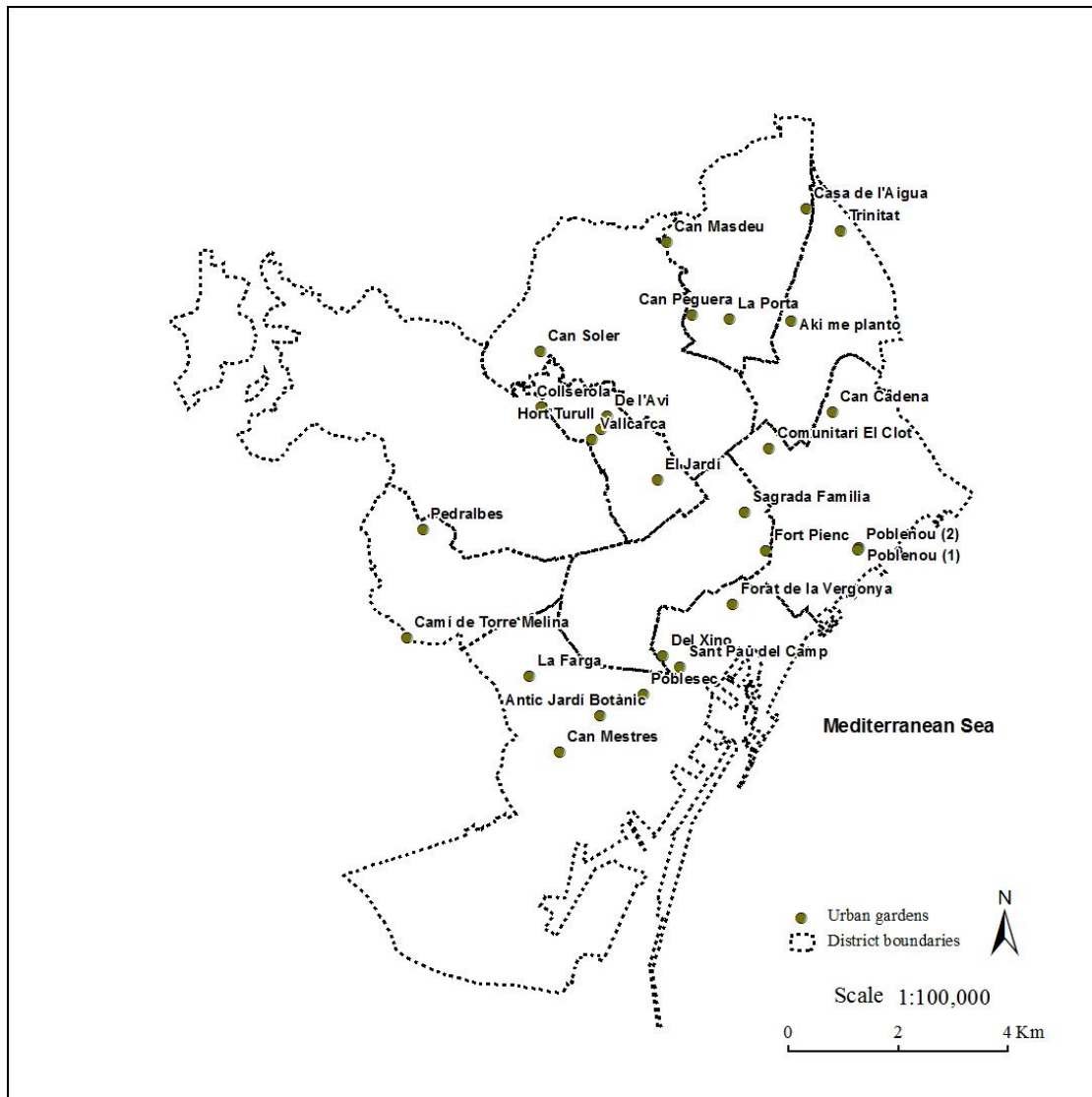
Our research assessed 27 urban gardens within the municipal boundaries of Barcelona (Figure 1) and included 'allotment gardens' created under the municipal garden program. In addition we included 'civic gardens' emerging from bottom-up initiatives, identified by means of web-research and snowball techniques. Due to limited accessibility other types of urban gardens, such as home gardens and school gardens, were excluded from our study. In 2013, at the time we conducted the fieldwork for this study, gardens created under the '*Pla Buits*' (*Empty-Spaces Plan*) were still in an embryonic stage. After initial visits to *Pla Buits* it became apparent that it was too early to fully assess activities, we discarded them from the assessment. We strongly encourage, however, the consideration of gardens emerging from '*Pla*

107 *Buits*’ as well as newly emerging civic gardens, such as the recently restored *Hort de la Font Trobada*, in
108 follow-up research.

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Figure 2: Location of urban gardens in Barcelona, Spain



Own elaboration based on European Urban Atlas, 2005-2007.

Distinguishing garden types based on ES values

110 To broaden our understanding around the heterogeneity of urban gardens, as a first step we rigorously
 111 distinguished garden types by the ES values they provide. For this purpose, we used disaggregated ES
 112 valuation data from Camps-Calvet et al. (2016), derived from a survey among 201 urban gardeners across
 113 the 27 urban gardens in our case study. Of 20 valued ES (listed in Table 1), provisioning services and
 114 cultural services in particular, provide direct benefits to the gardeners and are thus assumed to be more

important in motivating environmental stewardship. The survey used for the valuation of ES by means of a Likert-scale ranking approach is comprehensively described in Camps-Calvet et al. (2016). Based on the survey results, average ES values were generated for each individual garden in our sample. Urban gardens were then categorized by means of a cluster analysis with regard to the ES values they provide. In addition, we applied a non-metrical dimensional scale (NMDS) approach to visualize the 'distances' (the levels of difference) between urban gardens regarding the ES values they provide as well bundles between specific ES values that are produced together.

Table 1: Ecosystem services provided by urban gardens in Barcelona, Spain.

<i>Habitat services</i>	Biodiversity
<i>Provisioning services</i>	Medicinal resources and aromatic plants Food supply (quantity) Food supply (quality)
<i>Regulating services</i>	Air purification Local climate regulation Global climate regulation Maintenance of soil fertility Pollination
<i>Cultural services</i>	Social cohesion & Integration Place-making Political fulfilment Biophilia Aesthetic information Nature & Spiritual experiences Relaxation & Stress reduction Entertainment & Leisure Exercise & Physical recreation Learning & Education Maintenance of cultural heritage

Based on Camps-Calvet et al. (2016) extending the ecosystem service classification introduced by TEEB (2010).

Examination of enabling factors for ES values

In order to examine enabling factors for different ES values, in the second step, we relied on data about garden user characteristics (Camps-Calvet et al., 2016) and assessed biophysical and institutional properties of each of the 27 urban gardens. User properties as well as biophysical and institutional garden properties were examined regarding their statistical significance to sustain ES values. The different garden properties and respective data sources are summarized in Table 2.

Table 2. Properties of urban gardens and characteristics of users examined as enabling factors for ES values

<i>Properties</i>	<i>Criteria</i>	<i>Data Source</i>
Gardeners		
Gender	Masculine; female	Survey (Camps-Calvet et al., 2016)
Age	Average gardeners age	Survey (Camps-Calvet et al., 2016)
Education	Higher education coursed	Survey (Camps-Calvet et al., 2016)
Income	Average household income divided people in the household	Survey (Camps-Calvet et al., 2016)
Origin	Barcelona; Other parts of Catalonia; Other parts of Spain; Other European countries; Non-European countries	Survey (Camps-Calvet et al., 2016)
Migration period	Year of migration (if applicable)	Survey (Camps-Calvet et al., 2016)
Biophysical		
Size	Total garden surface & numbers of workers	Remote sensing & Non-participant observations; Participant observation
Land cover	Sealed surfaces; horticulture land; Other green spaces (e.g. areas with ornamental plants, lawns, trees); Other unsealed surfaces; (e.g. pebble-paths)	Remote sensing; Non-participant observation
Equipment	Compost-boxes; Benches; Shelters	Non-participant observation
Surrounding land-uses	Highways; Parks; Residential areas	Non-participant observation
Institutions		
Foundation	Civic; Public	Review of grey literature; Semi-structured interviews
Property rights	Access; Withdrawal; Management; Exclusion	Review of grey literature; Semi-structured interviews
Decision-making*	Top-down; Participatory	Review of grey literature; Semi-structured interviews

Management	Individual; Collective	Non-participant observations; Participant observation
Practices & Activities	Time spent in the garden; Composting*; Plague treatment*, Educational activities*,	Survey (Camps-Calvet et al., 2016) Participant observation; Semi-structured interviews;

*Not statistically tested as enabling factor for ES values.

a. Gardeners' properties

To examine which garden users' properties were enabling ES values, we used multivariate analysis (least-square multiple regression). In addition to (a) age and (b) gender of gardeners which Dunnett & Quasim (2000) had found to influence ES values, we included (c) education, (d) income, (e) origin and (f) migration period of 201 garden users across 27 urban gardens in Barcelona in the assessment. The main user properties described by Camps-Calvet et al. (2016) can be summarized as follows: About three-quarters of all urban gardeners in Barcelona were found to be male, whereby female gardeners made up about 40% in civic gardens and only about 14% in allotment gardens. Over 80% of the gardeners were above an age of 50 and about 70% were retired. Around 40% of the gardeners had received higher education (beyond secondary school), compared to 20.3% for all of Catalonia (www.idescat.cat, 2011). More than one third of the urban gardeners in Barcelona reported a monthly household (average size of 2.5 persons) income below 1000€, another third of 1000-2000€, and about 15% above 2000€ (the remainder of respondents were not willing to state their income). Gardeners originating from Barcelona were 31%; those from other parts of Catalonia 8%; those from other parts of Spain (mainly from Andalucía) 54%; those from other European member states 4%; and those from Non-European states 2%. Over 80% of the Non-Catalan gardeners migrated to Barcelona during the large rural-urban migration periods before 1980. For our analysis we dropped 30 samples from the original 201 survey samples due to partially incomplete data from survey respondents. Garden user properties aggregated across the remaining 171 samples were related as explanatory variables to ES values as dependent target variables, while internal consistency was assured by means of Chronbach alpha ($\alpha=0.89$). Explanatory variables included age, and income (monthly income in a household divided by the number of people living in the

household) as continuous variables and gender (0= female, 1= masculine), education (0= lower than secondary education, 1= secondary education and higher), origin (0=childhood not spent in Barcelona; 1= childhood spent in Barcelona), and migration period (0= after 1980, 1= before 1980) as binary variables.

The regression analysis was conducted in STATA 12.

b. Biophysical garden properties

To examine biophysical properties as enabling factors of ES values, we first applied a principal component analysis (PCA) to the disaggregated data on ES values (based on Camps-Calvet et al., 2016). Through a superimposition of biophysical garden properties on the PCA results, we then identified those characteristics that showed a significant influence (0.005-level, tested against the unconstrained model through permutation test for PCA under the reduced model) on differences in ES values. The biophysical properties we considered as potentially relevant for influencing ES values included (a) size (surface & number of gardeners), (b) land cover, which Breuste & Artmann (2014) assumed to influence ES values, (c) human artefacts and (d) dominant land-uses in the surroundings of the garden. We assumed the size to potentially influence relational values, such as social cohesion and place making (Chan et al., 2016). The examination of land cover included the surface of cultivated plots, other green spaces (such as areas with ornamental plants, lawns and trees), permeable surfaces (e.g. pebble-paths), and impermeable surfaces (including pavement and shelters). We further examined human artefacts, such as compost-boxes, benches, and shelters. Dominant land-uses in the surroundings, such as continuous urban fabric, parks or transport infrastructure, were viewed as generating specific needs for ES. Biophysical properties were assessed through spatial analysis conducted in *Miramon* and *ArcGIS* based on orthographic photographs from the Catalan Cartographic Institute (resolution 1:5000) and complemented by field notes based on participant (active engagement in gardening activities) and non-participant observations as well as informal conversations with gardeners. The statistical analysis have been carried out in RStudio using the 'vegan'-script developed by Oksanen et al. (2013).

c. *Institutional garden properties*

To examine the relation between institutional properties and ES values, we used the same procedure as described above for biophysical properties, hence, a superimposition of institutional garden properties on the PCA results. The institutional garden properties that have been tested include: (a) garden foundation (civic gardens created by bottom-up citizen's initiatives / allotment gardens implemented by the Barcelona's City Council), (b) property rights, (c) decision-making (public regulation / user assemblies), (d) management (individual / collective plot tending), as well as (e) practices and activities (such as composting, pest treatment, joint gardening, educational activities, group activities), and (f) the time spent in the garden. The 'time spent in the garden', which Dunnett & Quasim (2000) had observed to positively influence ES values, results from the survey are from 201 respondents and has been tested together with the gardener properties as a binary variable (0= less than two hours; 1= more than two hours). All other institutional properties have been assessed by means of semi-structured interviews (N=46), conducted with 44 urban gardeners across all 27 urban gardens (these interviews were also used for the identification of benefits from urban gardens presented in Camps-Calvet et al. 2016) and with two municipal green space managers. Interview partners were chosen for long-term gardening experience or for undertaking some kind of leadership or representation in the respective garden. The two interviews with green space planners specifically addressed the property regime of public and civic gardens in Barcelona. Following Colding et al. (2013), and based on Ostrom & Schlager (1996), property rights were distinguished into the right of (a) access ("the right to enter a defined physical area and enjoy non-subtractive benefits"), (b) withdrawal ("the right to obtain the resource units or 'products' of a resource"), (c) management ("the right to transform the resource by making improvements"), (d) exclusion ("the right to determine who will have an access right, and how that right may be transferred"), and (d) alienation ("the right to sell or lease") (see Table 3; Colding et al., 2013; Ostrom & Schlager, 1996: 133). Information obtained through the interviews was contrasted and complemented by a review of grey

literature, including web-information, newspaper articles and planning documents as well as participant and non-participant observations.

Table 3. Characterization of gardeners regarding their property rights.

	Owner	Proprietor	Claimant	Authorized user	Authorized entrant
Access	X	X	X	X	X
Withdrawal	X	X	X	X	
Management	X	X	X		
Exclusion	X	X			
Alienation	X				

Source: Colding et al. (2013), based on Ostrom & Schlager (1996).

Results

ES values of different types of gardens

With regard to the different ES values, urban gardens in Barcelona can be divided into two main clusters shown in Figure 3. Values that are distinctive for the first cluster ('red cluster' referring to the framings in Figure 3) are 'place-making', 'social cohesion' and 'political fulfilment'. Detailed NMDS results showing bundles of ES values that are produced together are shown in Annex A. The red cluster is exclusively formed by civic gardens. All gardens in this cluster are further characterized by relatively small geographical sizes and respectively low numbers of workers. The vast majority (eight out of nine) of these gardens were founded between 2009 and 2013 (except *Aki me planto* founded in 2003), after the beginning of the economic crisis in Spain, and the gardeners were described as garden proprietors. In addition, all gardens in this cluster were self-governed by participatory decision-making processes, mostly through assemblies; and all (except the twin gardens *Poblenou 1* and *Poblenou 2*) used collectively tended plots. Gardeners in civic gardens widely relied on organic horticultural practices, including the use of manure and composted organic waste for fertilization, and various specific

techniques for the prevention and treatment of pests and plagues, e.g. specific combinations of plant species. Practices were generally orally agreed upon in gardeners' assemblies and enforced through mutual control mechanisms. Common activities, such as the annual distribution of manure, joint meals, educational events and open workshops were observed or reported in most civic gardens.

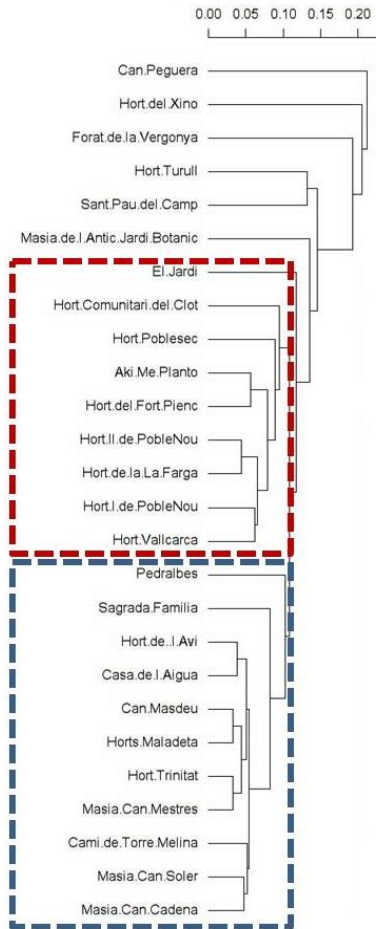
The typical ES values of gardens in the second cluster ('blue cluster' in Figure 3) include 'aesthetic information', 'relaxation & stress reduction', 'entertainment & leisure' and 'biophilia'. In addition, gardens in this cluster are highly valued for the provision of food (quality and quantity). This cluster exclusively includes larger gardens (with twenty or more gardeners) that had been founded before 2009, the beginning of the economic crisis in Spain. The cluster includes nine public gardens and two civic gardens (*Can Masdeu* and *La Porta*). The two civic gardens are an exception in this cluster when it comes to decision-making processes. *Can Masdeu* was the only garden in this cluster with participatory decision-making; all other gardens in the cluster were characterized by top-down decision-making processes. *La Porta* decisions were mainly taken individually. Public gardens provide gardeners with proprietor rights (usually guaranteed for five years) over the plots and authorized user rights over the remaining garden surface. Also, different than the other gardens in this cluster, gardeners in the two civic gardens held proprietor rights over the entire garden surface. Due to the toleration by district authorities at the time of our study, gardeners perceived their proprietor rights at *Can Masdeu* and *La Porta* as relatively stable compared to most other civic gardens, though *La Porta's* existence has been strongly disputed in the time since our study. A common characteristic of all gardens in the blue cluster is the principal tending of the gardens in individual plots (*Can Masdeu* embeds, in addition, a small collectively managed area). The remaining six gardens (*Antic Jardí Botànic*, *Hort Turull*, *Sant Pau del Camp*, *Can Peguera*, *Del Xino*, and *Forat de la Vergonya*) could not clearly be correlated with any larger cluster regarding the ES values perceived. These gardens all show some peculiarities. For example, the particular emergence of *Forat de la Vergonya* out of (violent) contestations (cf. Anguelovski, 2013), claimant rights

237 exclusively held at *Antic Jardí Botànic*, or the particular land-cover at *Del Xino* that barely included any
238 area of food production (this garden was dismantled in 2017). Finally it should be noted that all gardens
239 in our study were almost equally perceived as valuable for the provision of regulating services, such as
240 pollination and improvements of the local climate. Values related to global climate regulations, which
241 were lower in smaller civic gardens, are an exception.

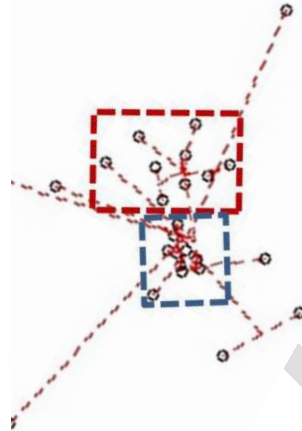
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Figure 3: Common characteristics of urban gardens regarding their ecosystem service values.

Cluster dendrogram



NMDS



Garden characteristics

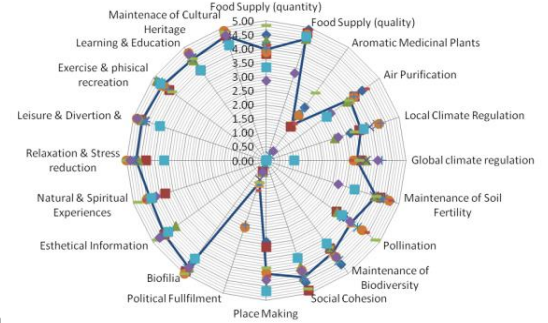
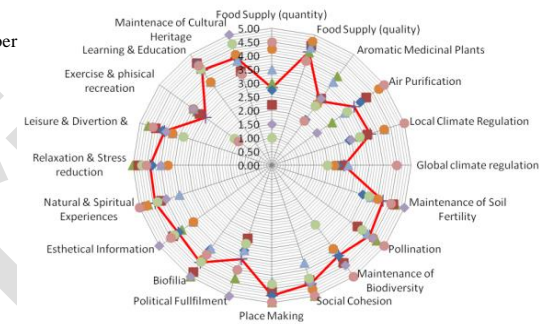
Red cluster

- Small geographical size / number of workers
- Emergence 2009-2013
- Participatory decision-making
- Proprietors
- Collective management
- 60% masculine gardeners
- High level of education
- Migration after 1990 (if applicable)

Blue cluster

- Large geographical size / >20 workers per garden
- Emergence 2002-2009
- Top-down decision-making
- Auth. users of gardens / proprietors of plots
- Individual management
- >85% masculine gardeners
- Extreme low level of education
- Migration before 1970 (if applicable)

Ecosystem service values



Left: Cluster dendrogram showing two main clusters (red and blue frame).

Centre left: 'Top view' of the two main clusters (based on NMDS).

Centre right: Generalization of garden characteristics in the two main clusters (exceptions are given).

Right: Ecosystem service values in the two main garden clusters.

Factors enabling ES values

When observing different ES values in the distinctive gardens, as a second step, we systematically examined the specific enabling factors for ES values. An overview of the main characteristics of urban gardens in Barcelona underlying the examination is given in Annex A. Significant factors have been found across all three domains, (a) gardeners' properties, (b) biophysical garden structures and (c) the institutional garden settings. Results from the correlation analysis between gardeners' properties and ES values are shown in Table 4; overall gardeners' properties only explained 24.0% of the variance, indicating that there were other important factors, such as biophysical and institutional garden properties, enabling ES values. An overview of biophysical and institutional characteristics that significantly ($P \leq 0.005$) influenced ES values is given in Figure 4. These results derived from a PCA explained another 46.3% of the variance. This means that overall, more than 70 % of the variance of ES values can be explained by the enabling factors systematically addressed in this study.

a. Gardeners' properties

Among the specific characteristics of garden users (assessed by Camps-Calvet et al., 2016), gender ($P \leq 0.001$), education ($P \leq 0.05$) and migration period ($P \leq 0.05$), were found to determine the values of urban gardens significantly. For dichotomous variables, such as gender, the negative correlation observed means that women (variable: 0) value ES higher than men (variable: 1) (Figure 4). Respectively gardeners with lower education levels (0) attach higher values than those with higher education levels (1), and people who migrated to Barcelona before 1980 (0) perceive in average a higher importance of ES from urban gardens than their peers who arrived later (1). In addition, gardeners' income ($P \leq 0.1$) and origin

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262 (P≤0.1) may have an influence on the perception of values, whereby individuals with lower income and
263 gardeners from Barcelona valued gardens to a greater extent than their peers.

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Table 4. Correlations between properties of urban gardeners and ES values

Explanatory Variable	Definition	Coefficient (standard error)	P> T
Gender	<i>Dichotomous variable:</i> Woman (0) Man (1)	-0.3376 (0.0893)	0.000***
Age	<i>Continuous variable:</i> Respondent's age (in years)	0.0013 (0.0032)	0.694
Education	<i>Dichotomous variable:</i> Lower than secondary school (0) Secondary school and higher (1)	-0.2034 (0.1063)	0.057*
Income	<i>Continuous variable:</i> Monthly household income divided by total persons living in the household	-0.0002 (0.0000)	0.100*
Origin	<i>Dichotomous variable:</i> Not born in Barcelona (0) Born in Barcelona (1)	0.2109 (0.1178)	0.075*
Migration period	<i>Dichotomous variable:</i> Migrated to Barcelona after 1980 (0) Migrated to Barcelona before 1980 (1)	0.2844 (0.1391)	0.042**

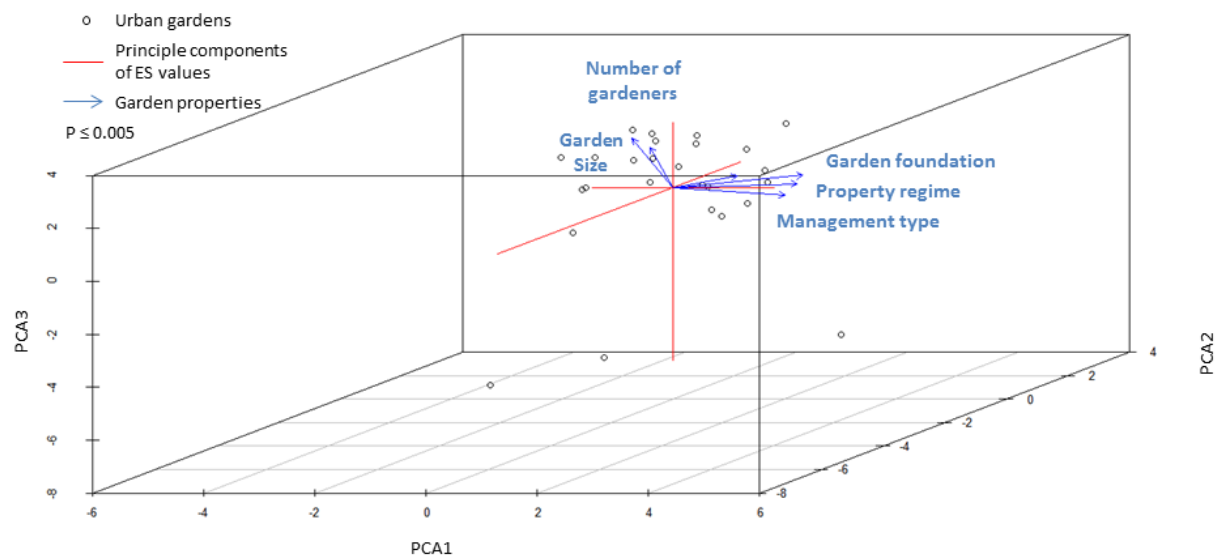
Significance levels ($P>|T|$): ***0.01, **0.05, *0.1. For dichotomous variables: A positive correlation means the variable 1 values ES higher than the variable 0, and vice-versa. For continuous variables: A positive correlation means that the higher the value of the variable the higher the value for ES, and vice-versa.

b. Biophysical garden properties enabling ES values

Among the biophysical garden properties, the size of gardens was the only characteristic with significant ($P\leq 0.005$) influence on the perception of ES values both in terms of surface and number of gardeners (Figure 4). The size of gardens in our sample ranged between 274m² and 9125m², correspondingly, the number of active gardeners ranged from 5-10 in smaller gardens, like *Forat de la Vergonya*, *Poble-sec* or

Del Xino, to over 50 gardeners in *Can Masdeu* and the twin-gardens *Poblenou 1* and *Poblenou 2*. A surprising finding from our study is that the land cover did not significantly explain ES values despite the fact that it varied considerably between gardens. For example, at *Hort del Xino* the space for horticultural cultivation was limited to about 5%, while in other gardens, 80% or more of the gardens' surface was used for the cultivation of food plants. Yet, our methodology shows some limitations with regard to the examination of land uses since exceptional observations such as the use of high-beds (due to known or suspected soil pollution), or the specific use of land for the reproduction of seeds for the maintenance of landraces, as observed at *Antic Jardí Botànic*, could not be considered in the statistical testing. The same is true for the cultivation of specific landraces by migrant gardeners, i.e. local, traditional, horticulture varieties, including *Solanum tuberosum*, *Vicia faba* and *Lactuca sativa*, while differences in cultivated plant varieties were generally small (most commonly including *Allium cepa*, varieties of *Brassica oleracea*, *Beta vulgaris*, *Capsicum annuum*, *Daucus carota*, *Fragaria × ananassa*, *Lactuca sativa*, *Solanum lycopersicum*, *Solanum melongena*, *Solanum tuberosum*, *Spinacia oleracea*, and *Vicia faba*). Garden equipment and surroundings also did not show significance as factors that enable ES values.

Figure 4: Significant biophysical and institutional garden properties enabling ES values



c. Institutional garden properties enabling ES values

Institutional garden properties assessed in our study included common rules and practices. Of different gardening practices, only the time spent in the garden showed significant influence ($P \leq 0.04$; Coefficient 0.20; Standard error 0.10) on ES values. In addition, we found the year of the gardens' foundation statistically significant in its influence on ES values ($P \leq 0.005$). Other significant enabling factors determining ES values were the management type ($P \leq 0.005$), i.e. tending of gardens either collectively or individually, and gardeners' property rights ($P \leq 0.005$). In civic gardens, gardeners effectively act as proprietors, conducting rights of access, withdrawal, management, and exclusion. However, only a minority of civic gardens aspired for and reached legal agreements with the formal land owners, and the proprietor right was often disputed. Formal toleration from the district governments exists for *Forat de la Vergonya* (cf. Angelovski 2013). Gardeners in public gardens can be described as hybrids between authorized users and proprietors (see Table 1). For their individual plots they hold proprietors rights for a non-renewable five-year term, which includes rights of access, withdrawal, management, and the right of

exclusion. Yet, individual plots in public gardens covered on average only 51% (range: 30-75%) of the gardens' total surfaces. For the remaining garden surface gardeners only hold the rights of *access*, and withdrawal, which defines the gardeners as authorized users of these areas (an exception is the garden *De l'Avi*, where gardeners also hold the right to manage areas not included in their plots). A singular case regarding the gardeners' property rights is again *Hort de la Masia de l'Antic Jardí Botànic*. This garden was run by volunteers organized in a formal association under professional guidance; which defines the 20 gardeners as claimants, assigned with access, withdrawal, and limited management rights.

Discussion

Our study explores the generation of ES values in 27 urban gardens of Barcelona. While biophysical properties, except garden size in terms of surface and number of gardeners, seem to have only a limited influence on the different values of urban gardens, a major finding of this work is that ES values - which we presume to incentivize stewardship practices - are more strongly correlated with institutions and the characteristics of garden users. In terms of theoretical context, we suggest that our exploration herein provides new insights on the role of 'urban green commons' (Colding et al., 2013), as a noteworthy link to and foundation for future research on bottom-up nature-based solutions in the field of transitions thinking towards more sustainable cities (e.g. Geels & Raven, 2006; Grin et al., 2010). Such transitions and the required 'niche innovations' (Schot & Geels, 2008) have been receiving much attention of late (Kabisch et al., 2016). However, technological innovations within, for instance, energy technologies and infrastructure (e.g. Boyd & Juhola, 2014) seem to have gained more interest than socially innovative nature-based approaches. Based on this shortcoming, Seyfang & Haxeltine (2012) suggest that social aspects, such as identity building and sense of community within wider societal shifts, need more theoretical consideration and development. Knowledge on the foundation of human values related to ES may thereby provide valid

information for urban green space governance (Primmer & Furman, 2012) that enhances environmental stewardship and thereby the adaptive capacity to maintain and increase ES values for human wellbeing in cities (Dietz et al., 2003; Folke et al., 2005).

Value(s) of gardens for inclusive urban regeneration

It has been argued that the specific situation of economic crisis, present in Barcelona since 2009, enhanced a politically motivated civic gardening and environmental stewardship movement as a resistance to predominant models of urban development (Camps-Calvet et al, 2015). In this context, it is worth highlighting that in post-crisis gardens (red cluster) the political ideal of food sovereignty and the knowledge of food production were far more important than the actual quantity of produced food. The emergence of urban gardens in Barcelona during the economic crisis can thus not (mainly) be explained with the need for enhanced food supply — the small surface of gardens in the red cluster and a lower proportion of land used for the cultivation of food plants reflect this — but rather as the cultivation of mind and utopias, i.e. ‘food for thought’, and experimental engagement with the urban environment.

The smaller surface and a limited number of gardeners seem to enhance the perception of *collective values* in urban gardens. That means relational values associated with cultural ES experienced in groups (cf. Chan et al. 2016), such as ‘political fulfilment’, ‘social cohesion’ and ‘place-making’, i.e. the community-based creation of meaning in relation to the garden’s physical and social design (Noori, & Benson, 2016).

Results indicate a considerable shift towards these *collective values*, expressing both contestations to the predominant institutional model as well as a request for stronger community resilience in cities (Camps-Calvet et al., 2015), since the beginning of the economic crisis in 2009.

Tidball (2012) explains the “community-based ecological restoration” in moments of crisis are manifestations of an urge to express human’s affinity with nature through the creation of restorative environments; this may allow citizens to reconnect to their “ecological self and sense of ecological place” (Tidball & Stedman, 2013). Civic gardens in Barcelona may thus be interpreted as places where adaptive capacity in the face of the economic crisis is built. In this line of thinking, gardens can be seen as seeds for adaptation and transition, and claims for a just and sustainable city (Dempsey et al., 2011; Fainstein, 2010). Put in other words, urban gardens serve as protective membranes for niche innovations (Schot & Geels, 2008) and places for experiments with new and diverse forms of value articulation, decision-making, social practices in a potential transition towards an socially inclusive and ecosystem based urban regeneration (*cf.* Bendt et al., 2013).

Value(s) of urban gardens for environmental stewardship

Results show values of urban gardens to be at least partly related to the socio-demographic characteristics of garden users’. Thereby, confirming previous findings by Dunnett & Quasim (2000). It has been argued that citizens lacking economic purchasing power, (especially retired and unemployed people) have stronger incentives for engaging in urban gardening (Camps-Calvet et al., 2016). We believe in addition, that childhood socialization might be a strong incentive for environmental stewardship through urban gardening. This belief is fortified by the fact that a large majority of citizens who engage in urban gardening migrated to Barcelona from rural areas where increased exposure to agriculture is likely. Despite there being fewer female urban gardeners in Barcelona, there seemed to be a stronger appreciation of ES by female garden users. Martín-López et al. (2012) related stronger female environmental stewardship to the specific role of women in agro-ecological labour, expertise and knowledge. The low number of female gardeners in Barcelona, which stands in sharp contrast to figures with regard to the

gender of gardeners from Northern Europe (Barthel et al., 2010), might indicate institutional or cultural barriers impeding females from engaging in urban gardening. Yet, civic gardens have shown to be more inclusive with regard to gender. Results also indicate that lower educational levels stipulate the appreciation of urban gardens for the provision of ES, indicating that formal education does not necessarily increase awareness for the importance of multi-functional green spaces in cities. If these observations hold true, the inherent social-ecological understanding gained during childhood might be a stronger incentive for civic engagement in local stewardship action than formal cognitive appreciation of ES values (*cf.* Giusti et al., 2014). Future research on environmental stewardship is encouraged to address the role of migrant gardeners, female gardeners and childhood experiences more thoroughly.

Opposite from our expectations, differences in the land-uses of urban gardens did not appear to play a critical role for different ES values of urban gardens. On the one hand, this may be due to the fact that gardens are quite homogeneously perceived as valuable for the provision of regulating services and habitat services, which we expected to be the closest ES values related to land-use for their stronger biophysical character. On the other hand, various specificities of land uses could not be tested for their statistical significance and thus escaped our systematic analysis. We assume these factors to be embedded in the 30% of variance in ES values that our methodological approach was not able to explain.

Results showed a stronger perception of *individual values* such as 'aesthetic information', 'relaxation & stress reduction', and 'biophilia', related to gardens founded before 2009. *Individual values* are often rooted in long-term care and stewardship relations (*cf.* Chan et al. 2016). Gardeners in older gardens were also more inclined to develop place specific knowledge and values with a bearing on food production, both in terms of quality and quantity, and the exchange of such knowledge through learning and

education. Results akin to this observation have been found for urban gardens in Berlin. Bendt et al. (2013) highlighted that social practices and social learning as well as political engagement had stronger importance in younger gardens and described a focus on individual values in older gardens. This finding might point towards a more general pattern between the values of younger and older gardens. It may also potentially imply a trade-off for urban planning that aims to boost the stewardship of ES between collective values, such as place-making and social cohesion, and individual values, such as recreation (cf. Bendt et al., 2013).

Our results further demonstrate links between property rights and ES values generated by urban gardens. The strong value for place-making, often the base for sense of place and community (cf. Raymond et al., 2010; Noori, & Benson, 2016) in civic gardens indicates a beneficial relationship between extended property rights to inclusive urban green spaces and the creation of *collective values*. Since cities are usually loci of social diversity (Zanoni & Janssens, 2009), we argue here that green spaces with property rights that are inclusive to a rich variety of lifestyles, gender, ethnicities and different age-groups, are rendered especially relevant for environmental stewardship among heterogeneous urban populations (Colding & Barthel, 2013). Gardeners who hold proprietor rights have the possibility to learn how to adapt the garden's physical and institutional design with regard to the ES they appreciate most, which makes their engagement more beneficial. From the perspective of adaptive ecosystem governance (Boyd & Folke, 2011), creating a feedback-loop that allows for an alteration of the social-ecological properties of urban gardens to changing human demands, depends on the capacity of institutional actors to consider citizens' values (Dietz et al., 2003). In gardens, where gardeners have reduced ability to decide on and design the social-ecological garden structure, this feedback is not given. In this context, the recent shift in urban garden policies by Barcelona's municipal green space planners towards the '*Pla Buits*' (*Empty-*

Spaces Plan) seems worth mentioning, amplifying both property rights and physical space for the civic management of urban green spaces might foster adaptive management given '*Pla Buits*' gardens will remain over time. Our study further indicates that public gardens embedded in the municipal garden program constitute a concrete potential to introduce experimental co-creation structures by extending gardeners' management rights beyond the individual garden plots and involving them in decision-making.

Conclusion

From the perspective of civic ecology (Krasny & Tidball, 2009^b) "the sustainable city does not only weave nature into its physical landscape, but also into the everyday practices and experiences of its citizens" (Bendt et al., 2013:29). Thinking of cities as coupled social-ecological systems is still not yet widely adapted in urban planning. However we found here that *values* related to garden ES in urban Barcelona tend to emerge from complex social-ecological relations, including institutions mediating interrelations between the social and biophysical space in cities. Properties of relevance are the size of gardens (including surface and number of gardeners), the management regimes, the property rights and the gender, education and migratory background of the gardeners. Our study thereby shows that a more holistic understanding and consideration of the underlying properties that give value(s) to urban gardens is required to improve urban planning and to design nature-based solutions as integrated parts of urban green infrastructure strategies.

Cities are rapidly developing from socio-demographic and biophysical perspectives, and the stewardship of ES for urban inhabitants is among the great challenges in an urbanizing world. Involving civic stewardship groups have been highlighted as a promising way to build creative capacity and resilience in cities (Colding & Barthel, 2013; Andersson et al., 2014). Our study creates new understanding about

motivations for people to engage in civic stewardship, by highlighting underlying properties that give value(s) to ES generated by gardens in Barcelona.

However, incentivizing civic engagement in local stewardship activities does not seem as linear as creating awareness for the values related to ES from urban green spaces. For instance, our study suggests that civic institutions and childhood socialization, including gender roles and the understanding of social-ecological relations (usually gained in rural environments), may be an important explanation for valuing urban gardens and engaging in stewardship action. The confirmation of these findings in future research will increase the challenge to create environmental stewardship in a world of an increasingly individualized life-style, where more and more people living in cities do not experience direct dependencies on healthy ecosystems in their day-to-day life. Even small patches of green spaces, such as urban gardens in Barcelona, may thus become important pieces for an inclusive urban regeneration that allows civic engagement in stewardship relationships with nature.

From our study we assume that judiciously designed green infrastructure strategies might enhance or modify people's stewardship motivations. Hence, green infrastructure strategies must take into account and draw on the fact that cities are often hotspots of tensions between cosmopolitan mindscapes and local pockets of resistance, rich in terms of diversity related to world-views and life-styles. Therefore opportunity structures for stewardship should be tailored to fit micro-scale specific urban circumstances. Future studies may engage in a comparative agenda with focus on motivations related to urban civic stewardship across cities of varying histories and geographies. Also, action-based research approaches might create further understanding on barriers to the stronger inclusion of specific social groups, including female and migrants, in urban gardening.

451
452 This paper ends with a policy suggestion to green planning authorities in Barcelona and elsewhere;
453 flexibility and tolerance to pluralistic ways in how urban gardens may be managed, gained through civic
454 engagement and participatory decision-making, may broaden the relevance of urban gardens as innovative
455 stewardship arenas for ES generation. Such a strategy promises to attract broader citizen groups that seek
456 to intertwine gardening practices with wider sets of issues: cultural, political, community, and spiritual.
457 This may further increase the importance of urban gardens as restorative urban pockets and places for
458 social-ecological experiments, as well as to motivate people to engage in transiting towards a more
459 socially inclusive, sustainable, and resilient cities.

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