
This is the **published version** of the master thesis:

Amorim Maia, Ana Terra; Calcagni, Fulvia , dir. Grasping The Intangible : Using Cultural Ecosystem Services Assessed Through Social Media Data To Understand Green Gentrification In Barcelona, Spain. 2018. (Màster Universitari en Erasmus Mundus en Estudis Ambientals: Ciutats i Sostenibilitat / Erasmus Mundus in Environmental Studies - Cities and Sustainability)

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| Title of the Masters' Thesis | Grasping The Intangible: Using Cultural Ecosystem Services Assessed Through Social Media Data To Understand Green Gentrification In Barcelona, Spain |
| Title of the Masters' Degree | Joint European Masters in Environmental Studies – Cities and Sustainability |
| Journal | Landscape and Urban Planning |
| Author | ANA TERRA AMORIM MAIA ¹ |
| Supervisors | JAMES JOHN TIMOTHY CONNOLLY ^{1,2} JOHANNES LANGEMEYER ^{1,2} |
| Co-supervisor | ENZA LISSANDRELLO ³ |
| Tutor | FULVIA CALCAGNI ¹ |
| Author's and Supervisors' affiliations | ¹ Institute of Environmental Science and Technology (ICTA), Universitat Autònoma de Barcelona (UAB), Edifici Z (ICTA-ICP), Carrer de les Columnes s/n, Campus de la UAB, 08193 Cerdanyola del Vallès, Spain ² Hospital del Mar Medical Research Institute (IMIM), Carrer Doctor Aiguader 88, 08003 Barcelona, Spain ³ Department of Planning, Technical Faculty of IT and Design, Aalborg University (AAU), Rendsburggade 14, Building: 2,351, 9000 Aalborg, Denmark |
| Authors' contact details | aterramaia@gmail.com |
| Supervisors' contact details | jamesjohntimothy.connolly@uab.cat johannes.langemeyer@uab.cat enza@plan.aau.dk fulvia.calcagni@uab.cat |
| Date of submission | September 3, 2018 |

Description of the work performed

The current thesis was developed within the Barcelona Lab for Urban Environmental Justice and Sustainability (BCNUEJ), under the supervision of James John Timothy Connolly and Johannes Langemeyer.

In October 2017 we started to develop the scope of the study, which involved conducting a multidisciplinary research to assess Cultural Ecosystem Services (CES) through social media data, in order to gain insights into the intangible drivers of green gentrification. In the following weeks, I finalized the scope and timeline of my project, which I followed throughout the months, with the invaluable help of my two supervisors and my tutor Fulvia Calcagni.

In November 2017, Fulvia and I started a literature review on articles that used social media data to assess CES. We performed a systematic review of 140 publications, of which 29 were considered highly relevant according to our specific criteria and guidelines. A review article was created based on this work and submitted for publication to the Journal of Sustainability Science, under the special feature “Theoretical traditions in social values for sustainability”.

In the beginning of 2018, I stipulated my research question, hypothesis and specific objectives. I also specified structured methodological steps, where I defined my data sources and created a protocol for photo categorization. Researchers associated with a larger project within the BCNUEJ downloaded the metadata of the photos for the whole Barcelona area from the Flickr API, after which the ones taken within the parks pertaining to my study were extracted. I manually analyzed each photo, following the protocol previously created. I then performed descriptive analyses across the years in search of trends, and cross-tabular analysis relating photo counts with categories of CES. Furthermore, I applied statistical analyses to

gain insight into the relationships between park valuation through CES and processes of social change. Lastly, I evaluated parks greenness, public amenities and artistic and architectural features, to understand the relationship between parks' physical aspects and social outcomes.

In a final stage, I analyzed the results and compared with existing studies, engaging with the related literature and pondering the study's findings and contribution. In my view, the study provided particularly interesting results, which contribute to the present literature and instigate debates on urban planning and public policies.

Suitability of the project within the scope of the research group where it was developed

The Barcelona Lab for Urban Environmental Justice (BCNUEJ <http://www.bcnuej.org/>) develops novel research on environmental justice and sustainability that builds on urban planning, policy, and studies in social inequality and development. My study is situated at the intersection of two of the lab's research projects: GREENLULUS and ENABLE.

GREENLULUS (Green Locally Unwanted Land Uses) examines the conditions under which urban greening projects in distressed neighborhoods reallocate the access and benefits of environmental amenities to historically marginalized groups.

ENABLE (Enabling Green and Blue Infrastructure Potential in Complex Social-Ecological Regions: A System Approach for Assessing Local Solutions) envisions identifying, assessing and facilitating a cost-effective implementation of Green and Blue Infrastructures for optimized distribution of benefits. The project invests heavily in studies on human motivations and perceptions, and the access to benefits they potentially derive from urban ecosystem services. In recent years, the BCNUEJ started working with social media data to assess CES.

My study deepens the assessment of CES through social media data and liaises the findings with green gentrification. I believe my study to be a bridge that connects both projects, by providing an innovative method for assessing perceived CES and relating it to processes of social change. This methodological gap seems to be not only present in the BCNUEJ, but also in the literature and research domains. This way, I humbly believe to have addressed a key methodological gap with this thesis, proposing a novel method to assess the intangible values of CES and contributing to the knowledge of the intricate qualities and features of spaces that trigger green gentrification.

Framing of the thesis within the objectives of the JEMES-CiSu program.

The JEMES CiSu Program aims to enable its graduates to successfully deal with complex urban processes and problems across international, cultural and disciplinary boundaries. The program prepares students to act towards the social and environmental sustainable management of cities, which are cradles of economic growth, centers for political and cultural manifestations, as well as significant consumers and polluters.

Having that in mind, I strongly believe that my thesis fits within the program's framework and contributes to the understanding of the complex urban processes that permeate urban life. By accessing people's perceptions of urban CES, I contribute to the understanding of what attracts people to urban parks and to how that triggers processes of socio-demographic change.

CES are the cultural benefits people derive from ecosystems and in cities they come predominantly from urban parks and gardens. In a densely populated city like Barcelona, urban parks provide oftentimes the sole opportunity for recreation, nature appreciation, social cohesion and place-making. However, many times the implementation or redevelopment of urban green areas redistributes the benefits of the ecosystem services away from the people who used to live in the area, and up towards those who can afford being close to it. This way, studying the processes that drive green gentrification is imperative for making a just, resilient and sustainable city. Urban and environmental planners ought to include these matters when designing public policies, so as to maximize and democratize the benefits of urban green infrastructures.

Information about the journal chosen for submission of the article

The journal chosen for submission of the article is *Landscape and Urban Planning*, which is an international journal aimed at advancing conceptual scientific and applied understandings of landscape in order to promote sustainable solutions for landscape change. The journal is based on the premise that landscape science linked to planning and design can provide mutually supportive outcomes for people and nature.

Landscapes have expressive aesthetic, natural and cultural qualities that are perceived and valued by people in multiple ways. This study has worked with a novel way of assessing the perceived value attributed by people to the landscape, namely, socially shared geographically located photographs. This study fits the impact area of the journal, proposing novel pathways to explore and understand the intangible values associated with the distribution of the benefits of greening. Urban parks are irrevocably fundamental elements of urban landscape and the redevelopment or renaturing of green areas represents a process of landscape change that demands attention from landscape and urban planners and ecologists, in order to ensure the sustainable and equitable distribution of benefits.

Applied research papers submitted to the journal should include at least a small sample of data to demonstrate proof-of-concept. Papers are typically between 4000 and 8000 words, including manuscript text and references, however, some exceptions to the upper length limit may be allowed for reports of large-scale interdisciplinary and transdisciplinary projects. An abstract (250 words), keywords (3-6) and research highlights (3-5) are also required. For more formatting and style guidelines, the “Publication Manual of the American Psychological Association – 6th edition” should be used as guidance.

The student and supervisors have agreed for this draft to extend the number of words to 12,000, as this is a transdisciplinary study that presents a relatively large sample and several analysis processes, but will edit the submission to 8000 words.

Keywords

Green Gentrification, Cultural Ecosystem Services, Social Media, Volunteered Geographic Information, Aesthetics, Recreation

Highlights

- Gentrified parks are associated with Aesthetics and Recreation
- Non-gentrified parks are associated with Cultural Identity and Socialization
- Park greenness does not seem to determine green gentrification
- Visitors seem more attracted to built infrastructure rather than natural features
- Social media is an innovative and efficient pathway to assess CES value

Abstract

Green Gentrification and Cultural Ecosystem Services (CES) literatures are connected in this study to address the intangible aspects and social effects of urban greening. I used geo-located social media data to address the methodological challenges of both fields of research, by assessing the value attributed to CES in 18 urban parks in Barcelona, of which 9 were shown to have experienced green gentrification in previous studies. The metadata for the photos taken between January 2004 and December 2017 in the parks was downloaded from the social media platform Flickr through its API, resulting in 4320 files. After initial selection, 703 photos were analyzed following a protocol of categorization and systematic coding procedures. Descriptive analysis and statistical independence tests were performed to explore the relationship between the attribution of CES categories and green gentrification. Results show that parks that experienced green gentrification were significantly associated with Aesthetics and Recreational Activities, whilst parks that did not experience green gentrification were significantly associated with Cultural Identity and Social Activities. Nearly six times more photos were taken in parks associated with green gentrification; nevertheless, around 80% of all photos depicted built infrastructures rather than ecological features. Analyses of parks' artistic and architectural features confirmed the above-mentioned results. Analysis of social media data supports the hypothesis that the cultural value associated with urban green spaces is a main driver of green gentrification.

1 **1. Introduction**

2 Cities are vast centers of demand for ecosystem services and their rapid expansion
3 prompts increasing challenges for the fair distribution of benefits to people. In densely
4 populated urban areas, urban nature represents fundamental opportunities to increase
5 livability, health and resilience. The benefits of urban nature materialize in tangible (e.g.
6 climate and flood regulation, habitat provision) and intangible (e.g. opportunities for
7 recreation, cultural expression, socialization) ways. These intangible benefits can be difficult
8 to observe, however they play a core role in understanding how urban environments are
9 valued by residents and contribute to social change. One applicable area of study that
10 develops methods for conceptualizing and measuring the intangible benefits derived from
11 nature is Cultural Ecosystem Services (CES); though these methods still find little application
12 in urban environments, hence restricting a systemic understanding of the intangible values.
13 Another perspective on the pathways by which the tangible and intangible benefits of urban
14 nature produce social change is found within the literature on green gentrification, which
15 argues that these benefits can be captured by certain residents as a result of profit-seeking
16 development. With urban CES and green gentrification developing as nascent lines of
17 investigation, the understanding of the ways that the intangible aspects of urban greening
18 shape gentrification and other processes of social change remains a challenge.

19 In this study, I forward the goals of these two perspectives by bringing them together:
20 the CES perspective demonstrates ways of conceptualizing the intangible aspects of urban
21 greening that may fuel processes of gentrification and the green gentrification perspective
22 offers a framework for understanding how CES might drive social change in cities.
23 Therefore, this article addresses key gaps in the literature on CES and green gentrification by
24 situating itself at the intersection of the two bodies of research. Particularly, this study aims at
25 assessing the intangible values of CES through crowdsourced photographs, which reveal

26 people's perception of aesthetic, recreational, social and cultural qualities of green spaces,
27 while also examining to what extent these qualities correlate with processes of social change.

28 My specific objectives are as follows: (1) to identify CES within newly created urban
29 parks from geographically located photo-content and analyze their relation to gentrification;
30 and (2) to contextualize the findings relative to physical park structures including greenness,
31 park amenities, and topological features.

32 **1.1. Green Gentrification**

33 Ruth Glass (1960) offered an early description of the core dynamics of gentrification,
34 by observing a new urban gentry contributing to change in the physical and cultural character
35 of 1950s working-class London quarters. Perez (2004) proposed a straightforward definition
36 of gentrification, describing it as:

37 An economic and social process whereby private capital (real estate firms,
38 developers) and individual homeowners and renters reinvest in fiscally neglected
39 neighborhoods through housing rehabilitation, loft conversions, and the construction
40 of new housing stock. Unlike urban renewal, gentrification is a gradual process,
41 occurring one building or block at a time, slowly reconfiguring the neighborhood
42 landscape of consumption and residence by displacing poor and working-class
43 residents unable to afford to live in 'revitalized' neighborhoods with rising rents,
44 property taxes, and new businesses catering to an upscale clientele. (p. 139)

45

46 Beginning in the 1980s, research on processes of gentrification has examined a
47 number of foundational (e.g. global financial flows) and proximate (e.g. an influx of young
48 artists) drivers of gentrification (Lees, 2000; Smith, 1986; Zukin, 1987). Lately, a new body
49 of research started examining how urban sustainability planning and processes of city re-

50 naturing through public-private redevelopment strategies intensify gentrification (Dale &
51 Newman, 2009; Pearsall, 2010, Solecki & Welch, 1995). This process, where new urban
52 green amenities serve as a catalyst for gentrification is called green, ecological or
53 environmental gentrification and involves the application of an environmental planning
54 agenda associated with public green spaces that generates the displacement or segregation of
55 the most economically vulnerable population from access to the localized benefits of
56 ecosystem services (Dooling, 2009).

57 Neighborhood-scale studies have shown that the greater the amount, size and quality
58 of urban green amenities in transitioning areas, the more attractive and desirable they
59 become, thus causing the displacement of minority groups toward unwanted (and likely less
60 green) areas (Dooling, 2009; Goodling, Green, & McClintock, 2015; Pearsall, 2009).
61 Therefore, green gentrification is a fundamental concern for any urban sustainability model
62 that aims at promoting environmentally and socially responsible urban landscape planning
63 (Anguelovski, Connolly, Masip, & Pearsall, 2018).

64 Although it does establish a convincing empirical base, the available literature on
65 green gentrification does not present an explicit understanding of the intangible benefits of
66 urban green spaces, triggering dynamics of social change. Rather, the focus has been on the
67 ways in which new physical infrastructure relate to socio-demographic alterations in the area.
68 Existing literature fails to systematically address the ways in which new infrastructure
69 associated with urban sustainability programming is differently valued. Thereby, the CES
70 framework can be applied to understand the extent and ways in which people value
71 ecosystem services and how this underlies processes of green gentrification. Accordingly,
72 CES can reveal the elements of attractiveness of urban green spaces that might trigger green
73 gentrification and enlighten the relationship between features of spaces and users'
74 perceptions.

75 1.2. Cultural Ecosystem Services

76 The value of CES can be particularly significant in urbanized landscapes, where the
77 spaces that support recreational activities and social cohesion are of paramount importance
78 for a livable and fair city (Kohn, 2004; Mitchell, 2003). The Millennium Ecosystem
79 Assessment (MA) defines CES as “the non-material benefits people obtain from ecosystems
80 through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic
81 experience, including, e.g., knowledge systems, social relations, and aesthetic values”
82 (Millennium Ecosystem Assessment, 2005, p.40). Chan et al (2011) propose a different
83 concept, where they distinguish services as the production of benefits, which are of value to
84 people; thus CES are “ecosystems' contribution to the nonmaterial benefits (e.g., experiences,
85 capabilities) that people derive from human-ecological relations” (Chan et al., 2011, p.9).

86 CES are produced locally by multifunctional blue and green infrastructures and
87 influence the quality of life in urban environments (Andersson, Tengö, McPhearson, &
88 Kremer, 2015). Therefore, to ensure a fair delivery of urban CES, such green infrastructures
89 ought to be heterogeneous, multifunctional and accessible throughout the city (Gómez-
90 Baggethun et al., 2013). Recent studies show that traditional public parks still play an
91 important role in urban neighborhoods, being for a large share of the population the only
92 provider of adequate urban green and therefore fulfilling the urgent needs of urban dwellers
93 for recreation, nature experience, learning or simply enjoying nature as part of their daily
94 lives (Breuste, Schnellinger, Qureshi, & Faggi, 2013; Tratalos, Fuller, Warren, Davies, &
95 Gaston, 2007).

96 The benefits derived from CES are often directly experienced by the public,
97 influencing their way of living, including environmental stewardship habits, and relating to
98 the urban environment (Daniel et al., 2012), which is a powerful justification for their

99 consistent quantitative assessment, and inclusion in urban planning and landscape design
100 (Alkemade, Burkhard, Crossman, Nedkov, & Petz, 2014; Breuste, Haase, & Elmqvist, 2013;
101 Burkhard, Kandziora, Hou, & Müller, 2014; Crossman et al., 2013). In short, urban CES
102 offer an important window into the ways in which city residents experience the intangible
103 benefits of green infrastructure.

104 However, the physical, mental and emotional benefits obtained from CES are
105 frequently intuitive and depend on human interpretations and perceptions of the landscape,
106 hindering their assessment, due to their intangible and subjective nature (Anthony et al.,
107 2009; Kenter, Hyde, Christie, & Fazey, 2011). Therefore, the values assigned to CES depend
108 on individual and cultural assessments of their contribution to wellbeing and are frequently
109 expressed through indirect manifestations such as increased conviviality and place-making or
110 through sharing photos on social networks (Eicken, Lovecraft, & Druckenmiller, 2009;
111 Scullion, Thomas, Vogt, Pérez-Maqueo, & Logsdon, 2011). As a result, CES suffer from
112 poor quantification and integration in management plans (Rudolf de Groot, van de Berg, &
113 Amelung, 2005).

114 Approaches to operationalize CES include interviews, questionnaires and hedonic
115 pricing models (Burkhard et al., 2014; Milcu, Hanspach, Abson, & Fischer, 2013; MA,
116 2005), but standardized and quantitative assessment approaches, especially in spatially
117 explicit form, remain underdeveloped (Hernández-Morcillo, Plieninger, & Bieling, 2013;
118 Milcu et al., 2013; Satz et al., 2013; Pleasant et al., 2014; Thiagarajah, Wong, Richards, &
119 Friess, 2015).

120 **1.3. Social Media Data As A Tool For Assessing Urban Nature**

121 Social media data offers possibilities for advancing our understanding of green
122 gentrification and CES. Both literatures share the challenge of assessing the intangible

123 benefits of urban greening in a manner that can be operationalized within research and policy.
124 Neither literature, though, has directly explored these possibilities. In response, I use the
125 value attributed to CES through the assessment of social media data to understand the
126 attractiveness of the spaces that might trigger green gentrification in Barcelona, Spain. Thus,
127 in this study social media data functions as a platform for combining the CES and green
128 gentrification perspectives.

129 Crowdsourced and geographically located data, particularly photographs, have proved
130 to be an effective way to better understand CES than has thus far been possible, allowing
131 their quantification and assessment (Langemeyer, Calcagni, & Baró, 2018). Its relevance
132 relies on the capacity of photographs to communicate through visual representations about
133 the perceptual and material dimensions of landscapes and the values that they provide
134 (Stephenson, 2008). The amount of geotagged photos uploaded and shared on social media
135 platforms is increasing exponentially, which leads to the fast increase of crowdsourced
136 geospatial data available (Heipke, 2010). The growing accessibility of large social media
137 databases allows a better understanding of multifaceted socio-ecological relations at an
138 unparalleled spatial-temporal resolution, offering novel insights into how people perceive
139 landscapes and experience CES (Lenormand et al., 2018).

140 Social media geotagged photos have been used to quantify landscape values at a
141 continental scale (van Zanten et al., 2016), explore the relationship between landscape visual
142 character and scenic beauty (Tenerelli, Püffel, & Luque, 2017) and between CES and
143 landscape features (Oteros-Rozas, Martín-López, Fagerholm, Bieling, & Plieninger, 2017).
144 Crowdsourced geographic information has also been used to map the aesthetic value of
145 landscapes (Lieskovský, Rusňák, Klimantová, Izsóff, & Gašparovičová, 2017; Yoshimura, &
146 Hiura, 2017) and of CES (Figueroa-Alfaro, & Tang, 2017), and to measure the spatial
147 covariance between aesthetic value and other ES (Casalegno, Inger, DeSilvey, & Gaston,

148 2013). Social media data have been used to investigate the distribution and identify spatial
149 patterns of the provision of CES across landscapes (Pastur, Peri, Lencinas, García-Llorente,
150 & Martín-López, 2016; Tenerelli, Demšar, & Luque, 2016), as well as to measure spatial
151 behavior, preferences and valuation of CES (Cord, Roebiger, & Schwarz, 2015; Gliozzo,
152 Pettorelli, & Haklay, 2016; Guerrero, Møller, Olafsson, & Snizek, 2016).

153 Some recent studies have begun to use social media data to examine urban green
154 space perception and its contribution to wellbeing (Dunkel, 2015; Kothencz, Kolcsár,
155 Cabrera-Barona, & Szilassi, 2017), demonstrating that the analysis of crowdsourced data may
156 contribute to a more balanced assessment of the perceived landscape, by providing a
157 foundation for better integrating public values into planning processes. Crowdsourced
158 geotagged content has also been used to reveal intangible social and cultural landscape values
159 (Chen, Parkins, & Sherren, 2018), expose cultural differences (Stepchenkova, Kim, &
160 Kirilenko, 2015), assess CES value shifts across time (Thiagarajah et al., 2015) and to
161 estimate spatial and temporal dynamics and the value of nature-based recreation (Sonter,
162 Watson, Wood, & Ricketts, 2016). Further researches have used social media data to study
163 CES generated and used at a fine spatial scale (Richards & Friess, 2015) and in protected
164 areas (Catana, 2016).

165 Moreover, geotagged photos have been used to identify people's perceptions of
166 "scenicness" (Chesnokova, Nowak, & Purves, 2017; Seresinhe, Moat, & Preis, 2018), to
167 extract scenic routes (Alivand, & Hochmair, 2013) and prioritize areas for scenic
168 conservation (Goldberg, 2015). Finally, social media volunteered geographic information has
169 been useful to monitor visitors and perceived importance of protected areas (Heikinheimo et
170 al., 2017; Levin, Lechner, & Brown, 2017); to assess park visitation and equitable park
171 access (Hamstead et al., 2018); to identify and model forest recreational resources (Upton,
172 Ryan, O'Donoghue, & Dhubhain, 2015); inform restoration priorities (Allan et al., 2015); as

173 well as to quantify nature-based tourism and recreation (Wood, Guerry, Silver, & Lacayo,
174 2013); and assess the potential tourism attractiveness of protected areas (Willemen, Cottam,
175 Drakou, & Burgess, 2015).

176 Based on findings from these studies, I work with the assumption that there is a direct
177 relationship between place attractiveness and uploaded photos. In short, people visit specific
178 parks and upload photos of the most attractive amenities that they are inspired to share with
179 others (Girardin, Fiore, Ratti, & Blat, 2008; Kisilevich, Krstajic, Keim, Andrienko, &
180 Andrienko, 2010; Gliozzo et al., 2016). As a result, a careful disaggregation of crowdsourced
181 and geotagged photos taken within individual parks provides significant evidence for
182 understanding people's engagement with ecosystems and landscape perceptions, as well as
183 meaningful insight into how people value the various amenities portrayed in the photos. In
184 all, social media data add a solid and quantifiable empirical base to efforts to understand how
185 the intangible qualities of urban green spaces affect processes of social change, particularly
186 green gentrification.

187 **1.4. The “Barcelona Study”**

188 The present study builds on the findings of a prior published green gentrification
189 study that examined the social effect of 18 new parks built in several neighborhoods in the
190 city of Barcelona, Spain, over a 15-year period (Anguelovski et al., 2018). Being the first
191 citywide quantitative study of green gentrification associated with parks creation, it examined
192 the distributional outcomes of the city's greening strategy during the 1990s and early 2000s,
193 most of which targeted low-income neighborhoods (Anguelovski et al, 2018). In this study,
194 the researchers tested the occurrence of green gentrification in areas that received new green
195 spaces by means of examining how proximity to the new parks affected changes in five
196 socio-demographic indicators: house sales prices, income, educational attainment, country of

197 origin, and age of the local population. Particularly, the study examined the extent to which
 198 these variables changed in the direction expected for gentrification directly around the new
 199 parks to a greater extent than in the city district (there are nine districts in Barcelona)
 200 containing the park. In short, if gentrification was more intense near a park than in the
 201 district, then green gentrification was considered to have occurred. Figure 1 shows the 18
 202 parks pertaining to the study, their location in the map of Barcelona, the year of construction,
 203 and size in Acres.

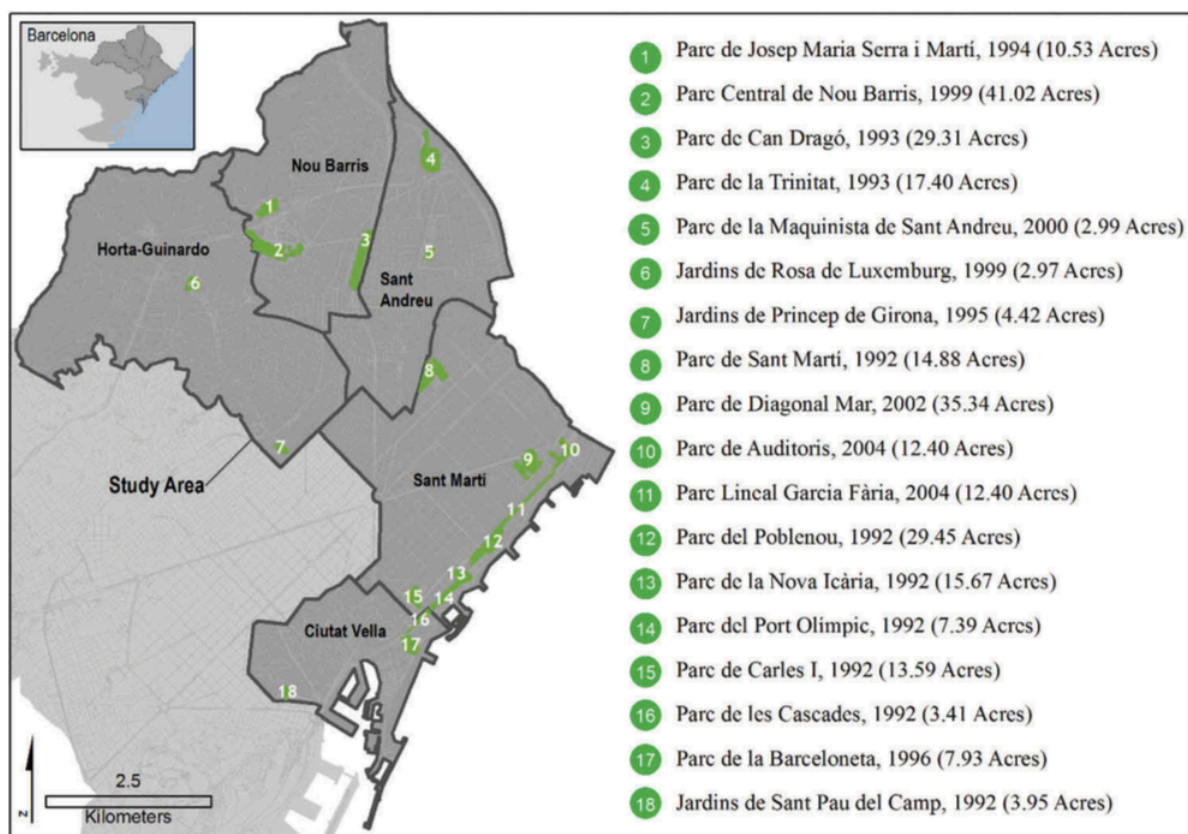


Figure 1. Parks built between the period of 1992 and 2004. Reprinted from *Assessing green gentrification in historically disenfranchised neighborhoods: a longitudinal and spatial analysis of Barcelona*, by Anguelovski, I., Connolly, J. J., Masip, L., & Pearsall, H. (2018), *Urban Geography*, 39(3), 458-491. Reprinted with authors' permission.

204 The study's goals were to quantitatively test whether the implementation of a
 205 citywide greening agenda improved the equitable distribution of new environmental
 206 amenities or created new inequities. Its results indicated clear green gentrification trends in
 207 several historically underserved areas of Barcelona but not all, revealing that the impacts of
 208 creating parks in socially vulnerable neighborhoods are not monolithic. Rather, they were
 209 assumed to depend on the context of creation, setting, and overall built environment. Nine
 210 parks were found to be associated with green gentrification and nine were not. Table 1 shows
 211 the list of parks and their association to green gentrification.

Table 1

Parks associated with green gentrification and parks not associated with green gentrification. Source: Anguelovski et al., 2018

| Parks associated with green gentrification | Parks not associated with green gentrification |
|---|---|
| Jardins de Princep de Girona | Jardins de Rosa de Luxemburg |
| Parc de Auditoris | Parc Central de Nou Barris |
| Parc de Carles I | Parc de Josep Maria Serra Martí |
| Parc de Diagonal Mar | Parc de Can Dragó |
| Parc de la Nova Icària | Parc de la Barceloneta |
| Parc de les Cascades | Parc de la Maquinista de Sant Andreu |
| Parc del Poblenou | Parc de la Trinitat |
| Parc del Port Olímpic | Parc de Sant Martí |
| Parc Lineal Garcia Faria | Parc de Sant Pau del Camp |

212 The present study builds on the prior work of Anguelovski et al. (2018) to test the
 213 hypothesis that the cultural value associated with urban green spaces is a main driver of green
 214 gentrification. The study by Anguelovski et al. (2018) demonstrates that there are likely
 215 generalized city-based as well as localized drivers implied in the qualities of the green spaces
 216 that produce green gentrification; nevertheless, it lacks a comprehensive understanding of the
 217 reasons underlying these drivers where green gentrification was observed. In order to

218 examine the underlying drivers of green gentrification in Barcelona, this study asks if the
219 nine parks associated with green gentrification produced higher CES values than the nine that
220 were not.

221 **2. Methodology**

222 In this study our primary data source was 4,320 crowd-sourced images uploaded on
223 the online photo-sharing platform Flickr between January 2004 and December 2017 that were
224 geographically tagged within the boundaries of the 18 urban parks and gardens analyzed in
225 the abovementioned “Barcelona Study”. By linking the Flickr data geographically with the
226 parks already studied, I coded each photo as having been taken at one of the 9 parks that were
227 associated with green gentrification (594 photos in total) or not (109 photos in total). I
228 assessed and classified the photos into 4 main categories of CES, and a further 20
229 subcategories to reveal how CES values, people’s perceptions of the environment, and their
230 relationship to landscape features varied between the two types of parks.

231 **2.1. Data: Flickr Photos**

232 The social media data used for this study includes a subset of photos extracted as a
233 part of a larger ongoing study that examines CES throughout the Barcelona region. In order
234 to build this dataset, researchers associated with the larger project downloaded the metadata
235 of the photos for the entire Barcelona area from the Flickr API and then I extracted those
236 photos taken within the park boundaries. The script used by the researchers was written in
237 ECMAScript 6 or ES6 on Github and the queries were run in April 2018.

238 The query outcomes were grouped in .csv format files, which were divided per month
239 and included all the pictures taken during that period across the area of interest. Table A-1 in

240 Appendix A shows the information that was gathered from each photo. The files were then
241 imported into ArcMap© v10.5 using a coordinate system suitable to the study
242 area (ETRS89_UTM_zone_31N).

243 **2.2. CES & Gentrification Analysis**

244 *Checking picture validity*

245 I confirmed through manual checks the location of all photos and removed from the
246 dataset the ones that appeared invalid. Photos considered “invalid” include duplicates; photos
247 with unidentifiable subjects; and photos that were erroneously located in the park, such as
248 those taken inside of apartments or restaurants situated on the periphery of the park.
249 Furthermore, photos portraying indoor environments, such as apartments and conference
250 halls, or outdoor environments but focusing on objects unrelated to the environment (i.e. cars,
251 trains) were tagged as “invalid content” and excluded from the analysis. As a general rule for
252 a picture to be considered valid, the elements depicted as the main subject in the photos
253 needed to have an explicit connection to a CES provided by urban parks. However, this did
254 not mean that photos were limited to natural elements or the ecological environment. For
255 example, photos depicting manmade elements such as buildings, infrastructure, other
256 constructions and art objects were considered valid and tagged as “not green” for the
257 purposes of analysis, while photos depicting natural elements as the main subject were tagged
258 as “green”. In addition, photos taken from inside the parks, which pictured subjects located
259 outside (i.e. surrounding buildings) were considered valid but were tagged as “outside” for
260 the purposes of analysis.

261 *Protocol for photo selection and categorization*

262 The coding categories for the visual content analysis were established, following a
263 protocol for selection and categorization of photos. Five groupings of CES were defined,
264 based on those stipulated in a commonly used reference point, the Millennium Ecosystem
265 Assessment (2005). The CES categories were further divided into 20 subcategories, each of
266 which had a range of specific activity- or object-related tags that helped describe the photo
267 content. A total of 55 tags were created and used to describe specific objects or activities
268 illustrated. Table 2 shows the main and subcategories of CES used in the visual content
269 analysis. For the sake of simplicity, the 55 activity-related tags have been omitted from this
270 table (but can be found in Table B-1, Appendix B).

Table 2

Cultural Ecosystem Services and related categories for visual content analysis.

| CES Category | Description | CES subcategory |
|--|---|------------------------|
| Recreation and Mental and Physical Health | Nature-based leisure-oriented activities, physical and intellectual activities, as well as activities performed for enjoyment or entertainment. | Athletics |
| | | Pets |
| | | Play |
| | | Kids |
| | | Esoteric |
| | | On Wheels |
| | | Picnic |
| | | Relaxation |
| | | Intellectual |
| Aesthetic Value | People's perceptions and judgments of natural beauty and appreciation and interaction with the environment. | Entertainment |
| | | Species (plant) |
| | | Species (animal) |
| | | Landscape |
| | | Construction |
| | | Art Object |
| Socialization | Social or political activities, aimed to strengthen social bonds or fulfill political motivations. | People |
| | | Social cohesion |
| | | Political Fulfillment |
| Spiritual Experience and Sense of Place | Religion, natural heritage, spiritual sense of belonging, traditional knowledge and associated customs | Religious |
| | | Symbols |
| | | Mindfulness |
| | | Sense of place |
| Cultural Identity, Knowledge and Heritage | Legacy of physical science artifacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations | Knowledge |
| | | Cultural heritage |

Note: CES categories and subcategories inspired by the ones listed by the Millennium Ecosystem Assessment, 2005; and the Food and Agriculture Organization of the United Nations, 2018.

271 Four additional subcategories were included in the original coding design, but were
272 not found in any of the analyzed photos. These included: (1 and 2) Recreational Activities:
273 “Esoteric”, and “Intellectual”; (3) Aesthetic Value: “Inorganic”; and (4) Cultural Identity,
274 Knowledge and Heritage: “Knowledge”. As well, there was no photo coded for the main CES
275 category Spiritual Experience and Sense of Place, though these were also included in the
276 original coding scheme.

277 *Photo categorization*

278 I categorized the photos from the most recent (December, 2017) to the oldest
279 (January, 2004). Each valid photo received at least one major and one subcategory of CES,
280 followed by the specific tags to describe the content or the activity pictured. A further
281 category was created to register whether the main subject portrayed was green (natural
282 environment) or not green (non-natural / built environment). It is worth noting that a photo
283 could be tagged with more than one category of CES (i.e. one photo could be tagged with
284 both “Aesthetics” and “Recreation”), however, it could only be tagged as either “Green” or
285 “Not green”.

286 *Gentrification analysis*

287 In order to analyze how green gentrification relates to the values portrayed on social
288 media, pictures were divided by year and by park and cross tabulation analyses were
289 conducted separately for the parks that experienced green gentrification processes and the
290 ones that did not. Descriptive analyses were performed to measure the percentage of photos
291 that depicted each CES, the ratio of photos depicting green and non-green settings, and the
292 proportion of photos taken from outside the parks. Finally, a master cross tabulation analysis

293 was conducted with the aggregated categorization of all years divided for the parks that
 294 experienced green gentrification and the ones that did not.

295 *Chi-Square Independence Test*

296 A Chi-Square Independence Test was performed using IBM SPSS Statistics 24 to
 297 verify the relationship between the attribution of the CES categories and whether or not a
 298 park has experienced green gentrification. The Chi-Square test determines if and to what
 299 extent there is a difference between the expected frequencies and the observed ones for the
 300 main categories of CES and the two groups of parks. The formula for the Chi-Square statistic
 301 test used is shown below:

$$X_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

302 Where:

303 X^2 = Chi-Square

304 c = Degrees of freedom;

305 O = Observed value;

306 E = Expected value

307 All tests were run with a degree of freedom $df = 1$.

308 **2.2. Greenness, Park Amenities And Features Analysis**

309 In order to control for underlying physical conditions that might generate more social
 310 media photos, the size, greenness, and amenities of each park were identified. The size and
 311 extent of greenness for parks within each category was analyzed because we might expect
 312 more photos in larger or greener parks. The total area of parks was calculated using ArcMap
 313 10.5 software. With regard to the measure of “greenness”, I calculated the average

314 Normalized Difference Vegetation Index (NDVI) for all parks using points derived from high
315 resolution imagery taken in 2010 (a midpoint year within our dataset). NDVI is a commonly
316 used indicator of the density of green, with values varying from -1.0 to 1.0.

317 In order to test whether more photos were taken in parks with certain physical
318 attributes, the municipal database of parks and gardens ([http://www.barcelona.cat/en/what-to-](http://www.barcelona.cat/en/what-to-do-in-bcn/parks-and-gardens)
319 [do-in-bcn/parks-and-gardens](http://www.barcelona.cat/en/what-to-do-in-bcn/parks-and-gardens)) was accessed to obtain a detailed list of amenities present in
320 the parks. The amenities listed for the 18 parks in this study include: recreational areas for
321 dogs, children’s playground areas, Ping-Pong tables, skateboard tracks, football fields,
322 Petanque fields, tennis courts, and model racing circuits. The database also includes a section
323 with the “Art and Architecture” featured in each park. These include significant historical
324 constructions, emblematic architectural structures, monuments, sculptures, water structures
325 (lakes and fountains), landscaping (hills, dunes, trees), auditoriums, and sports facilities. A
326 cross-tabulation was conducted relating the percentage of photos per park tagged with
327 specific sub categories of CES to the list of amenities and “Art and Architecture” features in
328 that park.

329 **3. Results**

330 **3.1 CES & Green Gentrification**

331 From the 4320 photos retrieved from Flickr, 703 were designated as applicable to this
332 study after applying the initial guiding filters. Figure 2 shows the amount of photos used per
333 park. Blue columns represent parks that experienced green gentrification and red columns
334 represent parks where no green gentrification was observed. 594 (85%) were taken in parks
335 that experienced green gentrification and 109 (15%) in parks that did not.

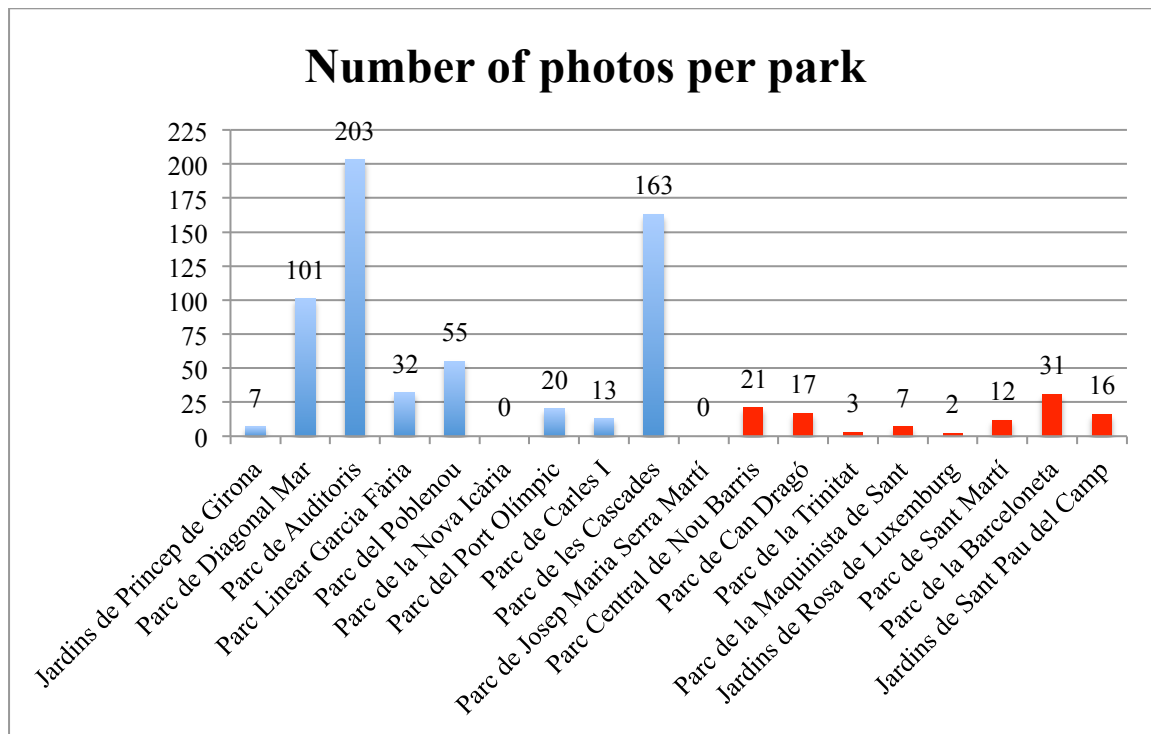


Figure 2. Number of photos per park. Blue columns represent parks associated with green gentrification and red columns represent parks not associated with green gentrification.

336 As per this graph, there are four parks primarily driving the large difference in the
 337 number of photos taken in parks that experienced green gentrification. These four parks are:
 338 Parc de Diagonal Mar, Parc dels Auditoris, Parc del Poblenou and Parc de les Cascades. Built
 339 in 1999, Parc de Diagonal Mar is Barcelona's second largest park (340,000 m²). It features a
 340 large lake and hills covered in grass, a landscaping project designed by architect Enric
 341 Miralles, as well as artistic interventions such as large metallic structures, big flower pots and
 342 round concrete benches. Parc dels Auditoris is a large multipurpose space, with auditoriums
 343 that regularly host a large variety of events, artificial dunes and a bathing area. It was built as
 344 part of the redevelopment carried out on the River Sant Adrià de Bèsos seafront for the 2004
 345 Barcelona Universal Forum of Cultures. Parc del Poblenou offers direct access to the beach
 346 and features pine groves, dunes, a lake and a large esplanade. Parc de les Cascades was built

347 on coastal land that the city reclaimed for the 1992 Olympic Games and served as a gateway
 348 to what was then the Olympic Village, as well as a path to the beach. It features an artificial
 349 waterfall and a series of iconic sculptures. The latter two parks are two of five large green
 350 spaces (together with Parc del Port Olímpic, Parc de la Nova Icària, and Parc de Carles I) that
 351 were built on the former industrial area of Poblenou at the start of the 1990's.

352 I also analyzed this data throughout time to look for significant trends. Regarding the
 353 number of photos taken across years, there seems to be a slight increase in the amount of
 354 photos taken in the parks that did not experience green gentrification, as can be seen on
 355 Figure 3, which shows only the period between 2007 and 2016 (the years for which there are
 356 a substantial number of data points).

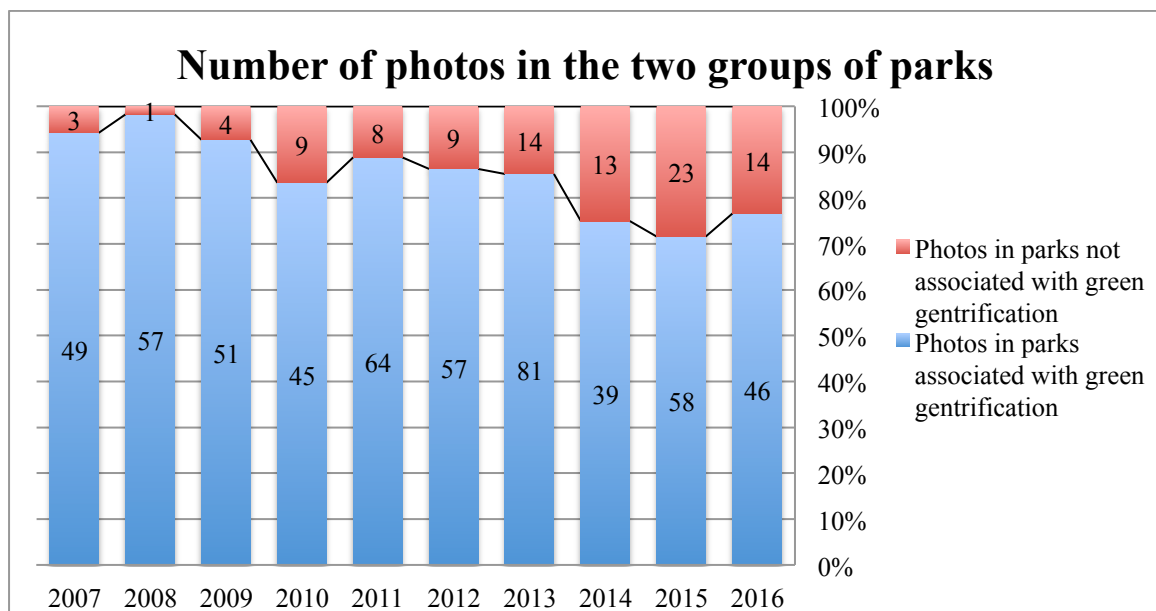


Figure 3. Amount of photos used in parks that experienced green gentrification (blue) and parks that did not (red).

357 *Proportion of photos and respective CES*

358 Parks that experienced green gentrification show a clear higher proportion of the
 359 photos that reflect Aesthetic and Recreational services, while the difference is very small for
 360 photos showing Cultural Identity and Socialization services. Cultural identity is in fact lower
 361 in parks that experienced green gentrification, though the small number of photos makes it
 362 difficult to interpret the significance of this exception. Figure 4 shows the distribution of
 363 categories of CES for all photos taken.

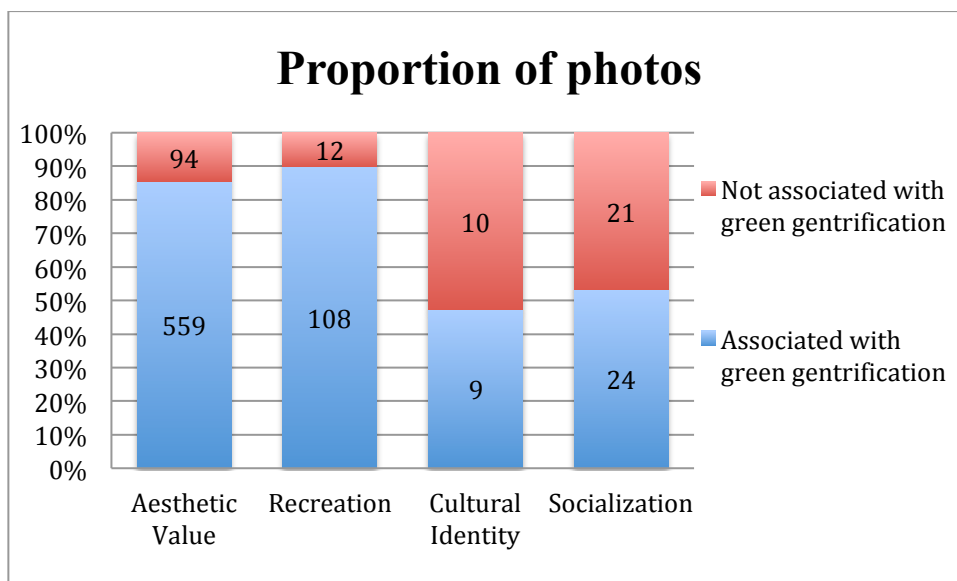


Figure 4. Proportion of CES identified in parks that experienced green gentrification (blue) and parks that did not (red).

364 From a CES perspective, Aesthetic Value was the most common CES illustrated in all
 365 photos, regardless of whether the park was associated with green gentrification or not: 88%
 366 (or 522) of the photos taken in parks that experienced green gentrification were tagged as
 367 “Aesthetic Value”, as were 79% (or 86) of the photos taken in parks not associated with
 368 green gentrification. Similarly, 17% (or 100) of all photos taken in gentrified parks were
 369 tagged as “Recreation” as were 11% (or 12) of the ones taken in non-gentrified parks. Eight

370 photos (1%) in parks that experienced green gentrification were tagged as “Cultural Identity”,
 371 while 11 photos (10%) received this tag on parks not associated with green gentrification.
 372 Finally, 23 photos (4%) taken in gentrified parks and 16 photos (15%) taken in non-gentrified
 373 parks were tagged as “Socialization”. This distribution is showed on Figure 5.

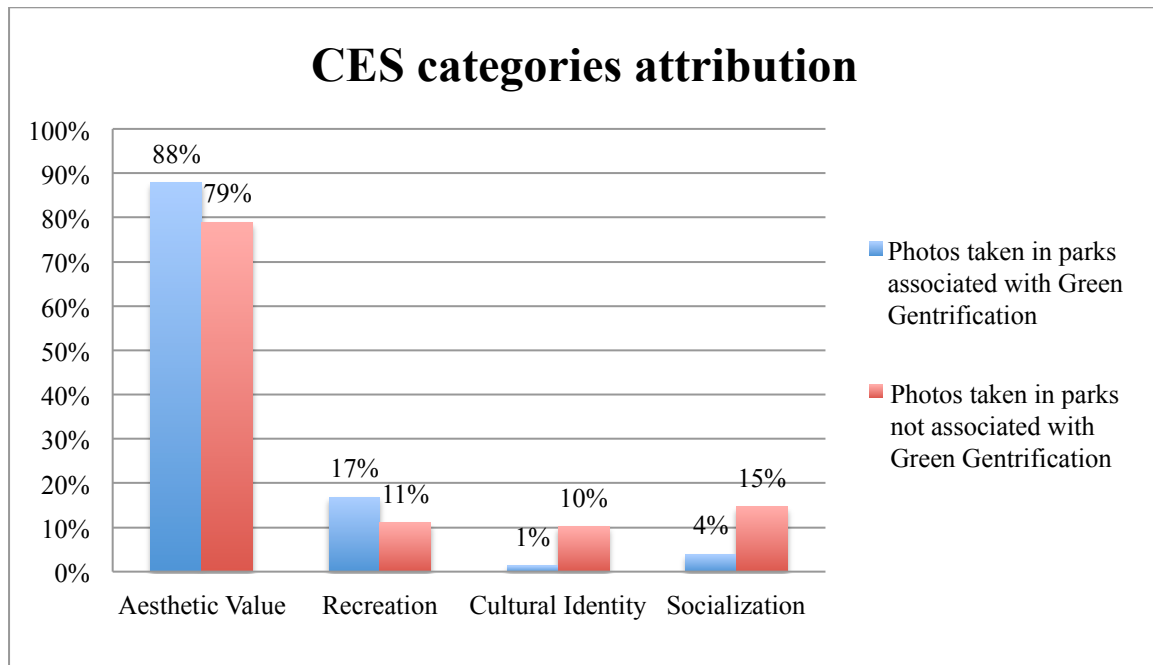


Figure 5. Photos tagged as Aesthetic Value, Recreation, Cultural Identity and Socialization in parks that experienced green gentrification (blue) and parks that did not (red).

374 The present study is based on the hypothesis that the cultural value associated with
 375 urban green spaces might be a main driver of green gentrification. A Chi Square Test of
 376 Independence and Phi Analysis were performed to examine the relationship between
 377 observed green gentrification and the four categories of CES. The results obtained through
 378 the chi square test support our hypothesis, inasmuch as there is a weak but mostly significant
 379 association between the categories of CES and the groups of parks. Table 3 shows the test
 380 results of Pearson’s Chi-Square value, p-value and Phi value for the four categories of CES.

Table 3

Chi-Square Test of Independence Results: Pearson Chi Square Value, p-Value and Phi for Aesthetics, Recreation, Cultural Identity and Socialization

| | Aesthetics | Recreation | Cultural | Socialization |
|--------------------|------------|------------|----------|---------------|
| Pearson Chi-Square | 4,063 | 3,554 | 27,168 | 22,812 |
| p-value | 0,044 | 0,059 | 0,000 | 0,000 |
| Phi | 0,076 | 0,071 | -0,197 | -0,18 |

381 Green gentrification parks differ significantly from non-green gentrification parks
 382 with regard to the number of photos tagged as “Aesthetics” and “Recreation”, but do not
 383 differ with regard to the number of photos tagged as “Cultural Identity” or “Socialization.” A
 384 chi square test of independence was calculated comparing the frequency of photos tagged as
 385 “Aesthetics.” A significant interaction was found: $X^2(1, N = 703) = 4.06, p = 0.04, \phi =$
 386 0.08 . Green gentrified parks were more likely to have “Aesthetics” photos (88%) than non-
 387 green gentrified parks (79%). In the chi square test of independence for photos tagged as
 388 “Recreation”, there was a nearly significant interaction: $X^2(1, N = 703) = 3.55, p =$
 389 $0.06, \phi = 0.07$). Again, green gentrified parks were more likely to have “Recreation” photos
 390 (17%) than non-green gentrified parks (11%). Meanwhile, the opposite result was found in
 391 the chi square test of independence for photos tagged as “Cultural Identity” and
 392 “Socialization.” There was still a significant interaction: $X^2(1, N = 703) = 27.17, p =$
 393 $0.00, \phi = -0.20$ and $X^2(1, N = 703) = 22.81, p = 0.00, \phi = 0.18$ respectively. Here,
 394 non-green gentrified parks were more likely to have higher counts of “Cultural Identity”
 395 (10%) and “Socialization” (15%) than green gentrified parks (1% and 4% respectively).

396 *Subcategory photo counts*

397 A further analysis was conducted relating the photo counts for the two types of parks
 398 with the categories of CES. Table 4 shows the proportions of photos taken by park type and
 399 subcategory. The percentage relates to the total amount of photos tagged within that category
 400 of CES (i.e. 42% of the photos taken in parks associated with green gentrification and tagged
 401 as “Aesthetics” depicted some sort of “Construction” as the main subject).

Table 4

Proportions of photos taken by park type and sub-categories

| CES category | CES sub-category | Gentrified | | Non-Gentrified | |
|----------------------|-------------------|------------|-----------------------------|----------------|-----------------------------|
| | | Count | % of all photos in category | Count | % of all photos in category |
| Aesthetics | Animal | 21 | 3% | 1 | 0% |
| | Plant | 14 | 2% | 2 | 0% |
| | Landscape | 144 | 24% | 21 | 3% |
| | Construction | 258 | 42% | 41 | 7% |
| | Art Object | 179 | 29% | 22 | 4% |
| | People | 54 | 9% | 6 | 1% |
| Recreation | Athletics | 14 | 13% | 2 | 2% |
| | Pet | 5 | 4% | 2 | 2% |
| | Play | 5 | 4% | 2 | 2% |
| | Kids | 7 | 6% | 0 | 0% |
| | Wheels | 27 | 24% | 5 | 4% |
| | Relaxation | 9 | 8% | 0 | 0% |
| | Entertainment | 31 | 28% | 3 | 3% |
| Culture | Cultural Heritage | 2 | 11% | 9 | 47% |
| Socialization | Social Cohesion | 18 | 46% | 13 | 33% |
| | Political | 1 | 3% | 3 | 8% |
| | Fulfillment | | | | |

402 These results provide insights into what aspects within the major CES categories
 403 particularly drive the differences in photo counts across park types. Construction and Art
 404 Object were the most photographed subcategories within Aesthetics and present the strongest

405 divide between green gentrified and non-gentrified parks in that category. In Recreation,
406 Entertainment is a driving force of photos associated with green gentrification. Cultural
407 Heritage and Social Cohesion were the most photographed subcategories in parks not
408 associated with green gentrification. Interestingly, Social Cohesion presented high counts for
409 both gentrified and non-gentrified parks, thus, a chi square test was run for this subcategory.
410 The results show a weak though significant negative association between a photo being
411 tagged for social cohesion and green gentrification: $X^2(1, N 703) = 18.31, p = 0.00, \phi =$
412 0.16.

413 **3.2. Analysis Of Parks Greenness, Amenities And Features**

414 *Green vs. Non-Green Subjects*

415 In order to assess whether to expect a difference in the number of green photos in
416 parks associated with green gentrification versus parks not associated, I analyzed the size and
417 extent of “greenness” for parks within each category. With regard to the total area of parks
418 that experienced green gentrification compared to the total area of the parks that did not
419 experience green gentrification, the results are similar: the first group presented a total area of
420 542,562 m², and the latter an area of 530,057 m². The average NDVI value of the 406 points
421 measured in the gentrified parks was 0.12 and the average NDVI value of 562 points
422 measured in non-gentrified parks was 0.17. Thus, non-gentrified parks are slightly greener
423 than gentrified parks, but both groups of parks have similar levels of low to moderate
424 greenness (relative to a non-developed preserved natural area). Despite the different number
425 of photos, both groups of parks presented similar proportions of green and non-green subjects
426 and the overall area of the parks does not differ greatly. Thus, we do not expect much
427 variation in the number of photos tagged as green across the two park types as a result of
428 underlying physical conditions.

429 The results indicate that the focus of photos taken within the parks was on non-green
430 aspects of park infrastructure rather than on ecological features: 81% of the photos taken in
431 parks associated with green gentrification were tagged as “non-green”, as were 82% of the
432 photos taken in parks that did not experience green gentrification. Figures 6 and 7 show this
433 trend.

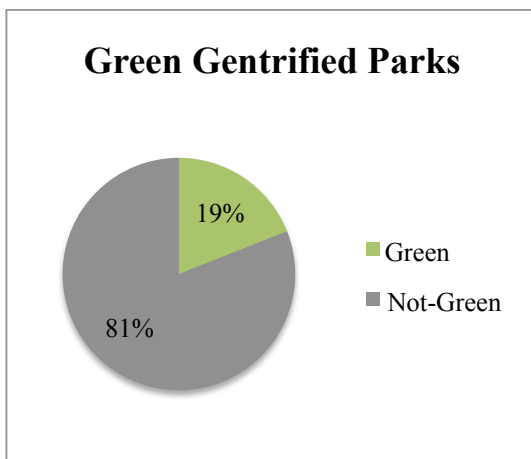


Figure 6. Green and Not-Green subjects in parks associated with green gentrification

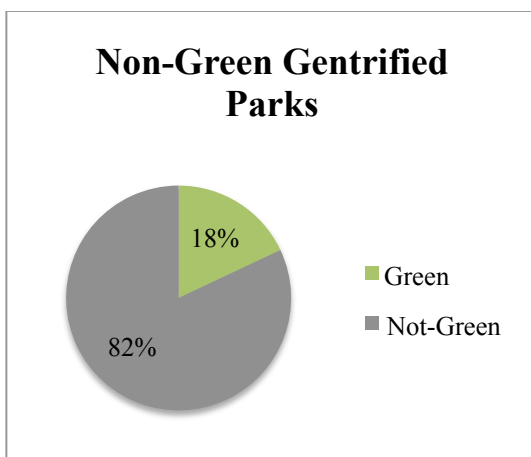


Figure 7. Green and Not-Green subjects in parks not associated with green gentrification

434 A chi square test of independence was performed to examine the relationship between
435 observed green gentrification and whether the main subject portrayed in the photo is green or
436 not green. The relation between green gentrification and green subjects was not significant,
437 $X^2(1, N = 703) = 0.01, p = 0.91, \varphi < 0.01$. Neither was the relationship observed between
438 green gentrification and not-green subjects: $X^2(2, N = 703) = 0.01, p = 0.91, \varphi < -0.01$.
439 In sum, neither the biophysical conditions of the parks (size, NDVI greenness) nor the
440 representation of green in social media photos seem to differ significantly between green
441 gentrification and non-green gentrification parks.

442 *Park amenities and features analysis*

443 The analysis of park public amenities showed that the basic facilities offered in the
444 parks did not particularly instigate people to take certain types of photos. There are two ways
445 of thinking about the physical aspects of the parks: the first is the formal list of public
446 amenities provided by the city; the second is the additional features that exist in the parks.
447 The formal public amenities have little impact on photos, but the additional features seem to
448 matter substantially.

449 Non-art amenities rarely appeared in photos, except for a few photos portraying the
450 skateboard track in Parc del Poblenou (5 out of 55 photos taken in the park); 1 out of 7 photos
451 depicting pets in Jardins de Príncep de Girona, a park with recreational area for dogs; and 2
452 photos showing kids in Parc del Port Olímpic, which has a children's play area.

453 Contrariwise, the "Art and Architecture" features present in the parks seem to have
454 drawn people to take photos. The results of the statistical "Art and Architecture" feature
455 analysis show that there is a remarkable relationship between park features and photo
456 subjects, identified by the tags attributed to the photos taken in the park. For parks that
457 experienced green gentrification, there is a significant relationship between the tags attributed

458 to the main subjects portrayed and the features listed. For instance, in the Parc de les
459 Cascades, 2 sculptures are reported as “Art and Architecture” features, namely “El Poder de
460 la Palaura” and “David I Goliat”. Accordingly, 69% of the photos taken in that park were
461 tagged as “Art Object”, and specifically tagged as “sculpture”. Park del Poblenou features a
462 lake and large esplanade, apart from several surrounding buildings with architectural interest,
463 which resulted in 62% of the photos tagged as “Landscape” or “Construction”. In Parc de
464 Diagonal Mar, 41% of the pictures taken depicted “Construction” subjects, and included
465 photos of surrounding buildings and of the large lake and wooden bridge. Another
466 remarkable instance is Park dels Auditoris, which has open-air and indoor auditoriums. This
467 park showed the highest count for photos tagged as “Entertainment” (14% of all pictures
468 taken in this park and 85% of the total amount of photos tagged as “Entertainment”).
469 Moreover, 65% of the photos taken in this park were tagged as “Construction” and this was
470 mainly due to the peculiar architecture of the triangular Auditori Fòrum and Museu Blau, as
471 well as the neighboring Torre Telefonica Diagonal 00.

472 Remarkably, for the parks that did not experience green gentrification, a higher
473 percentage of photos depicting “Social Cohesion”, “Cultural Heritage” and “Political
474 Fulfillment” was verified and this could also be related to the features present in these parks.
475 In Parc de San Martí there is one of Barcelona’s greatest urban allotments, Can Cadena.
476 Boasting 16 plots cultivated by the district’s senior citizens and occupying a total of 800 m²,
477 it features areas for farm animals, composting and a classroom for training in organic
478 agriculture. This park has recorded 42% of photos tagged as “Cultural Heritage” and 25% as
479 “Social Cohesion”, achieving some of the highest counts among all parks for these
480 subcategories. This park also features the San Martí de Provençals Parish, which dates back
481 to the XI century and was depicted in 42% of the pictures taken in this park. Another
482 remarkable park not associated with green gentrification is Parc Can Dragó, which features

483 sports facilities and the biggest open-air swimming pool in Barcelona, apart from squares,
484 resting areas, landscaping and the sculpture “Aurigues Olímpics”. This combination of
485 features has resulted in 30% of the photos depicting athletic activities, either on wheels or
486 not, and 24% of the photos depicting “Socialization”, be it “Social Cohesion” or “Political
487 Fulfillment”. Finally, Parc Central de Nou Barris is known to have many uses as a leisure,
488 walking and rest area, as well as being a thoroughfare and neighborhood connection point for
489 pedestrians. Correspondingly, in this park, 14% of the photos portrayed some aspect of
490 “Cultural Heritage” and 24% some form of “Social Cohesion”. The park features big lakes
491 and fountains, as well as an aqueduct that was turned into a bridge, which justifies 29% of the
492 photos being tagged as “Construction”. The park also features a sculptural ensemble (“Palma
493 i Diapasó”), which is portrayed in 29% of the photos taken.

494 **4. Discussion**

495 **4.1. Green Gentrification & Photo Counts**

496 The number of photos taken in parks associated with green gentrification (594)
497 presents a nearly six-fold increase over the number of photos in parks where no green
498 gentrification occurred (109). This occurs despite roughly equivalent area and levels of
499 greenness, which provides an initial indicator of the higher attractiveness of these parks.
500 Particularly, four parks that were associated with green gentrification in the “Barcelona
501 Study” presented the highest amounts of photos: Parc de Diagonal Mar (101), Parc dels
502 Auditoris (203), Parc del Poblenou (55) and Parc de Carles I (163). These parks were part of
503 the redevelopment projects, which took place in the coastal region in the 1990s, in
504 preparation for major events hosted by the city of Barcelona. In addition to similar socio-
505 political contexts of creation, they all have particular landscape and architectural features,

506 including lakes, sculptures, and landscaping design that were well-represented in the aesthetic
507 and recreational CES photos.

508 **4.2. Green Gentrification & CES Attribution**

509 Aesthetic-oriented photos were the most common in the sample, representing 88% of
510 the photos taken in parks associated with green gentrification and 79% of the photos taken in
511 parks not associated. Recreation seems to follow the same trend, with 17% and 11% of the
512 photos respectively. Cultural Identity and Socialization present an inverse trend, featuring
513 more photos in parks not associated with green gentrification than otherwise.

514 There is a significant ($p = 0.04$) difference between the amount of photos tagged as
515 “Aesthetic” in gentrified versus non-gentrified parks, with more of such photos in parks that
516 experienced green gentrification. Likewise, a weak but nearly significant association shows
517 that photos tagged as “Recreation” are also associated with gentrified Parks. Conversely
518 photos tagged as “Socialization” and “Cultural Identity” were significantly associated with
519 non-gentrified parks.

520 Generally, community-focused features were registered in parks not associated with
521 green gentrification, whilst aesthetics, artistic, event or tourist-focused features were
522 associated with parks that experienced green gentrification. The choice of installing aesthetic-
523 oriented features in urban parks resonates with Matthews’ (2010) proposition, according to
524 which the installation of artistic features is carried out purposely by city planners and private
525 investors, for their ability to catalyze and naturalize reinvestment in declining or
526 underdeveloped areas, therefore accelerating regional growth and development.

527 The protocol for photo analysis was based on the categories of CES from the
528 Millennium Ecosystem Assessment and included more categories than what was found in the
529 sample of photos. For instance, there were no cases of religious or spiritual practices or

530 symbols, which could be due to the fact that, despite being an important part of CES, such
531 manifestations are not a common practice in urban green spaces, at least in Barcelona. That
532 these codes were not observed likely reflects the dense urban aspect of the parks examined,
533 which were not amenable as sites of spiritual or religious activity. This confirms findings by
534 Langemeyer, Baró, Roebeling, & Gómez-Baggethun, (2015), in the way that intensively
535 managed green spaces might hinder public engagement, producing lower opportunities for
536 spiritual experience and sense of place.

537 An important factor that seems to attract people to the parks that experienced green
538 gentrification is the surrounding buildings, which is not so much a feature of the park itself,
539 but rather of the area where it is located. Many photos were taken from inside the parks,
540 depicting buildings located outside (i.e. the Telefonica Building in Parc de Auditoris, the
541 Mapfre Tower and Hotel Arts in front of Parc Olímpic, and the buildings pertaining to the
542 22@Barcelona project in the formerly industrial area of Poblenou, in the district of San
543 Martí). This might indicate that what attracts people to these parks is the surrounding built
544 environment, showing that there is a relationship between the location of the park and the
545 attractiveness attributed to it. These outcomes are in line with those from previous studies,
546 which revealed that visitors' impressions of the parks are influenced by the scene surrounding
547 the park, in the way that building density, architecture and aesthetics around urban parks are
548 crucial determinants in human perception of urban green spaces (Kothencz & Blaschke,
549 2017, Nordh, & Østby, 2013).

550 **4.3. Green Gentrification & Parks Greenness**

551 Taking into consideration the high photo differentials for both types of parks, it can be
552 said that despite having equivalent area and NDVI values, people have valued these places
553 very differently, insofar as social media is concerned. Photographs functioned as a proxy for

554 the perceived CES, therefore when it comes to choosing the main subjects portrayed in a
555 picture, it seems that the built environment or the recreational and social activities developed
556 in the park are more significant than the ecological elements, regardless of whether the park
557 was associated with gentrification or not. The chi square test confirms this premise, by
558 displaying little evidence that the extent of greenness matters differently in gentrified and
559 non-gentrified parks. This echoes previous studies, which showed that there is no clear
560 relationship between parks' greenness (area weighed NDVI for the parks and area of
561 vegetated surfaces) and their appeal to visitors, although the percentage of vegetated surfaces
562 seems to make a difference in visitors appeal (Kothencz & Blaschke, 2017).

563 These results suggest that even though the creation of urban green areas might well
564 trigger green gentrification, park greenness seems to be a less relevant factor. Other factors
565 both inside the parks (i.e. sports facilities, artistic features, opportunities for social cohesion)
566 and outside of the parks (i.e. location, socioeconomic context) seem to be more determinant
567 drivers of green gentrification. This conforms with findings by Hamstead et al., (2018), who
568 have reported that social media activity in urban parks is positively associated with water
569 bodies, athletic facilities and impervious surfaces, but negatively correlated with green
570 spaces, inferring that while people derive benefits from nature, they might not be motivated
571 to visit a park for the kind of green space that it offers. My findings also echo Ngom et al
572 (2016), according to whom a park's shape, geographic location, accessibility and
573 attractiveness are decisive elements to identify socio-demographic inequity and
574 environmental injustices. The CES framework supported reaching these conclusions, offering
575 unique insights into the intangible values that trigger green gentrification.

576 **4.4. Green Gentrification & Parks' Amenities And Features**

577 Remarkably, community-focused amenities have triggered photos portraying social
578 and cultural activities, whereas tourist or event-focused amenities have triggered photos with
579 a more aesthetic nature. As an illustration, the large urban allotments and gardens in Park de
580 San Martí motivated photos portraying Cultural Heritage and Social Cohesion; and the open-
581 air swimming pool in Parc de Can Dragó inspired photos portraying recreational and social
582 activities, reinforcing that community-driven features such as sports facilities, resting areas
583 and urban gardens stimulate socialization and cultural identity and might be instruments to
584 prevent green gentrification. Conversely, parks associated with green gentrification presented
585 predominantly photos of constructions and art objects. Thus the artistic and architectural
586 features in the parks (and especially to whom they are directed) may determine the kind of
587 attractiveness this park will exert over the surrounding community and can help to explain
588 the social changes experienced.

589 **4.5. Strengths And Limitations In Using Geo-Located User Content**

590 The system for photo categorization was subjected to biased assessments, since it
591 depends on the evaluator's subjective perception of the picture's subject and motivation.
592 Furthermore, the results reflect the preferences of specific city dwellers and might be biased
593 demographically, geographically, as well as by Flickr penetration rate in Barcelona. Social
594 media user statistics show that Flickr users tend to be between 35 and 39 years old and that
595 Flickr is most popular amongst men and earners in the US\$40-50 and US\$75-100K income
596 brackets (Verto Analytics, 2018). However, despite not being the most popular photo-sharing
597 platform, Flickr is suitable for assessing CES mainly due to its API openness and
598 accessibility. Nevertheless, the lower number of Flickr users might have resulted in biased
599 assessments, generating a sample size that might not be consistently representative of the
600 population's preferences. Although green space attractiveness is defined and measured by

601 multiple functions (Ngom, Gosselin, & Blais, 2016), social media has proven to be an
602 innovative metric for measuring CES, providing a deeper understanding of the intangible
603 values that permeate both CES and green gentrification literatures. To further enrich this
604 debate, studies with reviews (i.e Google Reviews) are recommended, providing specific user
605 experiences of green spaces through ratings and testimonials. Semi-structured interviews and
606 participatory action research might also contribute to further research.

607 The parks Lineal García Faria, Parc del Poblenou, Parc de la Nova Icària, Parc del
608 Port Olímpic, Parc de Carles I, and Parc de les Cascades constitute a continuum of linear
609 parks, which starts to the east at the Forum and extends until Parc de la Barceloneta.
610 Oftentimes they do not present clear boundaries in mapping systems, which may have caused
611 incorrect geographic tags and consequently marginally erroneous attribution of photo counts
612 and categories. Park names and boundaries on Google Maps, for example, often differ from
613 the names in the municipal database and this may be due to the lack of clear thresholds
614 separating the sections of linear parks.

615 The chi square test provided valuable insights into the associations between CES
616 values and green gentrification. Studies with a bigger sample might provide more
617 comprehensive results and potentially stronger associations.

618 **5. Conclusions**

619 The analyses of CES perception through social media have shown that parks that
620 experienced green gentrification in Barcelona are significantly associated with aesthetics and
621 recreational activities, whilst parks that did not experience green gentrification are
622 significantly associated with cultural identity and social activities. This was confirmed by
623 both the analysis of photo counts and the chi square test of independence. These findings

624 reiterate our hypothesis, demonstrating that parks that produced higher aesthetic and
625 recreational values were linked to triggering green gentrification processes, whilst parks with
626 higher cultural and social values were not.

627 Moreover, the results of this study have shown that rather than the ecological aspects
628 and natural elements, it is the built infrastructures present in the parks that attract people and
629 motivate picture taking. Within built infrastructures, it is not particularly the amenities
630 installed in the park for public usage, such as children’s play areas, or recreational areas for
631 dogs, but rather the architectural and artistic features present in the park which seem to
632 inspire taking pictures. In parks that experienced green gentrification, the mostly
633 photographed subjects were features related to scenicness, in other words, “picturesque”
634 features, mainly art objects, constructions of architectural interest and general landscape.
635 Photos taken from attractive surrounding buildings proved that there is a relationship between
636 the location of the park and the attractiveness attributed to it: parks located in former
637 industrial, currently redeveloping neighborhoods have shown particularly high rates of photos
638 taken of surrounding built landscape.

639 Hence, this study also demonstrates how green gentrification goes beyond the “green”
640 contained in the park, and brings the discussion to the interconnection between the built and
641 green. Therefore, the CES concept in its original idea becomes too narrow to explain the
642 implications for green gentrification; however, it still helps to understand some of the
643 intangible aspects of green gentrification. I find that the green element cannot be considered
644 the sole main factor for driving social changes resulting from the installation of green
645 infrastructures: unless we consider the built infrastructure contained inside the parks and in
646 its surroundings, we will not fully understand the drivers and implications of green
647 gentrification.

648 Social media data analysis of CES has proved to be a valuable resource to address the
649 methodological challenges of both CES and green gentrification studies. The usage of social
650 media data has helped to confirm that the cultural value associated with urban green spaces is
651 a main driver of green gentrification, and that green gentrification is particularly associated
652 with the Aesthetics and Recreation offered and perceived in the parks. Social media also
653 contributed to the understanding that the ecological elements cannot be considered as the sole
654 main driver of green gentrification. Due to the wide accessibility of social media, these
655 methods can potentially be applied in any other city where there is interest in exploring the
656 values assigned to CES and their relationship to socioeconomic changes, making this an
657 important tool for landscape planning, management and policy.

658 **5.1. Policy And Planning Implications**

659 Previous studies have shown that the social and historical conditions in which urban
660 parks are built are determining factors for generating green gentrification. However, this
661 study has shown that the features present in the parks also play a significant role in
662 determining whether the parks will trigger green gentrification processes or not. Parks built in
663 socially disadvantaged neighborhoods, which offered opportunities for socialization and
664 recreation (i.e. sports facilities and urban gardens) seem to have presented a smaller
665 likelihood of triggering green gentrification processes. Conversely, parks built in redeveloped
666 industrial areas with an offer of landscaping, artistic and architectural features seem to have a
667 greater likelihood of driving green gentrification.

668 For the distribution of the benefits of new and redeveloped green areas to be
669 equitable, it is necessary to look beyond park “greenness”, into the built infrastructures
670 offered in the park, as it seems to be the combination of green infrastructures with other
671 aspects that triggers (i.e. tourist-driven monumental inventory) or prevents (i.e. community-

672 driven features) green gentrification. In order to minimize the effects of green gentrification
673 and maximize the benefits of greening, urban green infrastructures should include places that,
674 apart from being aesthetically pleasing, offer opportunities for social cohesion, place-making
675 and socialization, such as sports facilities, resting areas and urban gardens.

676 The active involvement of urban and environmental planners and designers is vital to
677 create strategies for urban green spaces that improve livability, public health and resilience in
678 the cities, without detriment of environmental equity and social justice in urban communities.
679 Without clearly focused public policy intervention, environmental improvements will
680 continue to unfairly distribute the benefits of the environmental goods away from those who
681 originally lived near it, toward those who can afford its higher price.

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Individual Tables

Table 1

Parks associated with green gentrification and parks not associated with green gentrification. Source: Anguelovski et al., 2018

| Parks associated with green gentrification | Parks not associated with green gentrification |
|---|---|
| Jardins de Príncep de Girona | Jardins de Rosa de Luxemburg |
| Parc de Auditoris | Parc Central de Nou Barris |
| Parc de Carles I | Parc de Josep Maria Serra Martí |
| Parc de Diagonal Mar | Parc de Can Dragó |
| Parc de la Nova Icària | Parc de la Barceloneta |
| Parc de les Cascades | Parc de la Maquinista de Sant Andreu |
| Parc del Poblenou | Parc de la Trinitat |
| Parc del Port Olímpic | Parc de Sant Martí |
| Parc Lineal Garcia Faria | Parc de Sant Pau del Camp |

Table 2

Cultural Ecosystem Services and related categories for visual content analysis.

| CES Category | Description | CES subcategory |
|--|---|------------------------|
| Recreation and Mental and Physical Health | Nature-based leisure-oriented activities, physical and intellectual activities, as well as activities performed for enjoyment or entertainment. | Athletics |
| | | Pets |
| | | Play |
| | | Kids |
| | | Esoteric |
| | | On Wheels |
| | | Picnic |
| | | Relaxation |
| | | Intellectual |
| | | Entertainment |
| Aesthetic Value | People's perceptions and judgments of natural beauty and appreciation and interaction with the environment. | Species (plant) |
| | | Species (animal) |
| | | Landscape |
| | | Construction |
| | | Art Object |
| Socialization | Social or political activities, aimed to strengthen social bonds or fulfill political motivations. | People |
| | | Social cohesion |
| Spiritual Experience and Sense of Place | Religion, natural heritage, spiritual sense of belonging, traditional knowledge and associated customs | Political Fulfillment |
| | | Religious |
| | | Symbols |
| Cultural Identity, Knowledge and Heritage | Legacy of physical science artifacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations | Mindfulness |
| | | Sense of place |
| | | Knowledge |
| | | Cultural heritage |

Note: CES categories and subcategories inspired by the ones listed by the Millennium Ecosystem Assessment, 2005; and the Food and Agriculture Organization of the United Nations, 2018.

Table 3

Chi-Square Test of Independence Results: Pearson Chi Square Value, p-Value and Phi for Aesthetics, Recreation, Cultural Identity and Socialization

| | Aesthetics | Recreation | Cultural | Socialization |
|--------------------|------------|------------|----------|---------------|
| Pearson Chi-Square | 4,063 | 3,554 | 27,168 | 22,812 |
| p-value | 0,044 | 0,059 | 0,000 | 0,000 |
| Phi | 0,076 | 0,071 | -0,197 | -0,18 |

Table 4

Proportions of photos taken by park type and sub-categories

| CES category | CES sub-category | Gentrified | | Non-Gentrified | |
|----------------------|-------------------|------------|-----------------------------|----------------|-----------------------------|
| | | Count | % of all photos in category | Count | % of all photos in category |
| Aesthetics | Animal | 21 | 3% | 1 | 0% |
| | Plant | 14 | 2% | 2 | 0% |
| | Landscape | 144 | 24% | 21 | 3% |
| | Construction | 258 | 42% | 41 | 7% |
| | Art Object | 179 | 29% | 22 | 4% |
| | People | 54 | 9% | 6 | 1% |
| Recreation | Athletics | 14 | 13% | 2 | 2% |
| | Pet | 5 | 4% | 2 | 2% |
| | Play | 5 | 4% | 2 | 2% |
| | Kids | 7 | 6% | 0 | 0% |
| | Wheels | 27 | 24% | 5 | 4% |
| | Relaxation | 9 | 8% | 0 | 0% |
| | Entertainment | 31 | 28% | 3 | 3% |
| Culture | Cultural Heritage | 2 | 11% | 9 | 47% |
| Socialization | Social Cohesion | 18 | 46% | 13 | 33% |
| | Political | 1 | 3% | 3 | 8% |
| | Fulfillment | | | | |

Table A-1

Information downloaded from each photo

| URL | Tags | Description |
|-----------|--------------------------|---------------|
| Latitude | Owner name | Date uploaded |
| Longitude | Owner ID | Date taken |
| ID | Name of the Neighborhood | |
| Title | Name of the Park | |

Table B-1

Activity-related tags to categorize photos

| Aesthetic Value | Recreation and Mental and Physical Health | CES Category | | |
|----------------------|---|--|-------------------------|---|
| | | Cultural Identity, Knowledge and Heritage | Socialization | Spiritual Experience and Sense of Place |
| Dog | Walking | Monument | Integration | Religious practice |
| Bird | Running | Cultural Event | Meeting | Religious symbol |
| Insect | Hiking | | Social Relations | Mindfulness |
| Tree | Dog-walking | | Urban Gardening | Sense of place |
| Bush | Team Sports | | Political Activity | |
| Grassland | Playground | | Demonstration | |
| Flower | Rollerblading | | Intellectual | |
| Leaf | Biking | | Educational Activity | |
| Panoramic View | Skating | | | |
| Landscape general | Eating | | | |
| Sunset | Drinking | | | |
| Building | Lying Down | | | |
| Architecture | Sunbathing | | | |
| Water fountain | Music Concert | | | |
| Water surface | Cultural Event | | | |
| Railway | | | | |
| Road | | | | |
| Fence | | | | |
| Light Pole | | | | |
| Staircase | | | | |
| Tower | | | | |
| Sculpture | | | | |
| Statue | | | | |
| Graffiti | | | | |
| Selfie | | | | |
| People general | | | | |

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Appendix A – Information Retrieved From Flickr Metadata

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Appendix A – Information Retrieved From Flickr Metadata

Table A-1

Information retrieved from the metadata for each photo downloaded from the Flickr API

| | | |
|-----------|--------------------------|---------------|
| URL | Tags | Description |
| Latitude | Owner name | Date uploaded |
| Longitude | Owner ID | Date taken |
| ID | Name of the Neighborhood | |
| Title | Name of the Park | |

Appendix B – Tags Associated To CES Subcategories

Table B-1

Activity-related tags to categorize photos

| Aesthetic Value | Recreation and Mental and Physical Health | CES Category | | |
|----------------------|---|--|-------------------------|---|
| | | Cultural Identity, Knowledge and Heritage | Socialization | Spiritual Experience and Sense of Place |
| Dog | Walking | Monument | Integration | Religious practice |
| Bird | Running | Cultural Event | Meeting | Religious symbol |
| Insect | Hiking | | Social Relations | Mindfulness |
| Tree | Dog-walking | | Urban Gardening | Sense of place |
| Bush | Team Sports | | Political Activity | |
| Grassland | Playground | | Demonstration | |
| Flower | Rollerblading | | Intellectual | |
| Leaf | Biking | | Educational Activity | |
| Panoramic View | Skating | | | |
| Landscape general | Eating | | | |
| Sunset | Drinking | | | |
| Building | Lying Down | | | |
| Architecture | Sunbathing | | | |
| Water fountain | Music Concert | | | |
| Water surface | Cultural Event | | | |
| Railway | | | | |
| Road | | | | |
| Fence | | | | |
| Light Pole | | | | |
| Staircase | | | | |
| Tower | | | | |
| Sculpture | | | | |
| Statue | | | | |
| Graffiti | | | | |
| Selfie | | | | |
| People general | | | | |

Acknowledgements

I'd like to thank my supervisors James John Timothy Connolly and Johannes Langemeyer, for their invaluable support, contribution, motivation and patience: thank you and dankeschön!

I'd like to acknowledge the help from my tutor and PhD candidate Fulvia Calcagni, who has dealt with my many doubts and helped me throughout the whole process: grazie mille!

I'd like to thank the Barcelona Lab for Urban Environmental Justice (BCNUEJ) for letting me conduct my research within the scope of their projects and the Institute of Environmental Science and Technology of the Autonomous University of Barcelona (ICTA – UAB), for providing the infrastructure and being foundational for the accomplishment of this thesis: merci!

This research has been possible thanks to the JEMES CiSu Consortium Scholarship awarded to Ana Terra Amorim Maia by the Autonomous University of Barcelona (UAB) contract number JEMES CiSu UAB 2016/No1.

I'd like to thank my master colleagues, who made this learning journey more enjoyable. I now know that I will have friends and fellow scientists all over the world.

Finally, I'd like to express my infinite gratitude to my parents, without whom none of this would have been possible. For your unconditional support and faith in me: muito obrigada!