



Linking biological and cultural diversity: a novel approach for urban greenspaces planning and management

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Doutoramento em Biodiversidade, Genética e Evolução

Paula Isabel de Sousa Gonçalves

Tese orientada por:

Professora Doutora Margarida Santos Reis

UNIVERSIDADE DE LISBOA

FACULDADE DE CIÊNCIAS



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Nota Prévia

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Beat the beast. Hurrah for the BCD girls

It always seems impossible until it's done – *Nelson Mandela*

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ABSTRACT

Planning and managing ecologically sound and inclusive Urban Green Spaces (UGS) providing meaningful experiences that contribute for visitors well-being is of paramount relevance and requires a deep integration of natural and social sciences knowledge. Drawing on the Biocultural Diversity (BCD) concept, that addresses the close interlinkage between biological and cultural diversity, we developed a conceptual framework adapted to the urban setting, highlighting the three dimensions where these interactions manifest: Lived BCD, Materialized BCD and Stewardship of BCD. These three dimensions were the foundation to develop and operationalize an indicator-based decision tool, which was tested in Lisbon's twelve parks. Besides proven feasible and useful, the tool allowed to unearth self-exclusion processes. Motivations to visit UGS, and their enjoyed and disliked features, were analysed in 33 parks of four European cities, and related with their structural diversity. Motivations for visit were highly variable and though mostly based on social interactions or physical activities, the most appreciated features were related with the park itself and nature, a result consistent across cities. Parks with lower structural diversity, serving neighbourhoods of lower socioeconomic condition displayed less motivations and enjoyments. One of the benefits of visiting greenspaces is psychological restoration and the study of Lisbon parks showed that this was mainly driven by user's perceptions, rather than by biodiversity itself, but mediation analysis showed that the effect of proportion of broadleaf species in biodiversity perception was completely mediated by the perception of trees diversity.

Overall, this thesis contributed to highlight the usefulness of the BCD concept in urban settings, by developing a conceptual framework and a decision support tool, that revealed environmental justice issues that otherwise would have remained hidden, and by making a major contribution to clarify the mechanisms underlying the influence of urban biodiversity in mental well-being and to contribute to policy at the planning level.

Keywords: Urban green spaces; biocultural diversity; indicators; decision support tool; environmental justice; motivations; well-being; perceived restorativeness; biodiversity perception; biological diversity; functional diversity; visual traits; mediation

RESUMO

Os espaços verdes urbanos (EVUs) exercem funções importantes para a melhoria da qualidade de vida nas cidades. Entre outras, ajudam a melhorar a qualidade ar e a combater o efeito de ilha de calor, além de proporcionarem oportunidades de lazer e recreio, de livre acesso à generalidade da população. Também a atividade física ou o simples contacto com a natureza contribuem para a saúde e bem-estar físico e mental dos utilizadores dos EVUs. Mas estes não são apenas espaços verdes, neutros e desprovidos de significado. Cada EVU está inserido num contexto sociocultural determinado que lhe confere dinâmica, ambiência e identidade próprias, com as quais as pessoas se relacionam, atribuem significado e criam laços afetivos. Os EVUs são espaços de liberdade e de encontro, intencional ou fortuito, onde diferentes modos de vida e atividade se cruzam num espaço comum. Esta convivência, ainda que indireta e superficial, contribui para criar laços e promover a tolerância e coesão social.

Os EVU servem múltiplas funções de acordo com a sua tipologia e o local onde se inserem, e a sua gestão deve contemplar a necessidade de proporcionar não só soluções ecológicas adequadas à manutenção de ecossistemas saudáveis e funcionais, mas também atender às necessidades específicas dos utilizadores do local em que se insere, tendo ainda em consideração a sua posição e contribuição para a rede de espaços verdes (infraestrutura verde) da cidade. O planeamento e gestão dos EVUs devem, assim, integrar conceitos das ciências naturais e sociais, apoiando-se em conhecimento de base científica nestas áreas de conhecimento, de modo a oferecer espaços que cumpram a função a que se destinam, sendo ainda ecologicamente saudáveis e equilibrados, inclusivos e contemplando as necessidades dos seus utilizadores. O conceito de diversidade biocultural (Biocultural Diversity ou BCD), inicialmente descrito em relação a populações indígenas, reflete a profunda interconexão entre as pessoas e a natureza, expressa nos múltiplos modos como as pessoas convivem e co-evoluem com o meio natural, modificando-se mutuamente num sistema altamente dinâmico e interligado.

Tendo por base o conceito de BCD, os objetivos desta tese foram:

- adaptar este conceito ao meio urbano de modo a que possa ser utilizado no apoio à decisão, através do desenvolvimento de uma ferramenta baseada em indicadores de fácil quantificação; e
- tendo por base avaliações rigorosas da diversidade biológica, estudar a inter-relação pessoas-natureza, as suas manifestações nos EVUs e como esta interação com a natureza influencia o bem-estar dos utilizadores dos EVU.

A tese inicia por desenvolver a adaptação do conceito de BCD ao meio urbano. Este enquadramento, desenvolvido no capítulo 2, assenta na diversidade de modos como a interação entre pessoas e a natureza se manifesta, representada em três dimensões denominadas por BCD Vivida (Lived BCD), BCD Materializada (Materialized BCD) e Gestão Participada da BCD (Stewardship of BCD). A BCD Vivida refere-se ao modo como as pessoas convivem com a natureza e a experienciam e, através dessas experiências, vivências, percepções e significados, moldam e são moldados pela natureza. Na sua interação com os EVUs, decisores e utilizadores deixam marcas, materializadas no espaço através de objetos discretos (BCD Materializada), profundamente imbuídas do contexto sociocultural vigente à época. Esta BCD Materializada está patente na própria conceção do espaço, nas comunidades biológicas, elementos culturais e arquitetónicos instalados, ou mesmo em simples caminhos informais. A interação com o espaço pode assumir contornos mais pró-ativos e participativos que se traduzem num envolvimento mais consciente na proteção e conservação do espaço, contemplado na dimensão de Gestão Participada da BCD (Stewardship of BCD).

Para que o conceito de BCD possa ser útil e utilizada no planeamento e gestão dos EVU tem que ser traduzido num instrumento de apoio à decisão, concreta e acionável, facilmente mensurável e entendível pelos decisores. O capítulo 3 apresenta o desenvolvimento dessa ferramenta, com uma proposta de indicadores baseados nas três dimensões da BCD que medem diversos atributos (temas) considerados essenciais conhecer quando se planeia e gere EVUs numa perspetiva simultaneamente ecológica e social. Esta ferramenta utiliza um sistema de avaliação em dois passos que permite uniformizar e avaliar todos os indicadores, quantitativos e qualitativos, numa escala de 1 a 5. Este processo permite que a ferramenta possa ser aplicada e adaptada a qualquer tipologia de EV, em qualquer contexto, e seja facilmente interpretável através da visualização dos resultados em gráficos ou mapas. O instrumento foi testado, e a sua eficácia demonstrada com a avaliação de diversos indicadores, em doze parques urbanos de Lisboa. Nesta análise ficou patente a diferença no desempenho dos vários espaços ao nível dos indicadores testados e a existência de processos de auto-exclusão, que de outro modo teriam passado despercebidos.

Planear e gerir EVUs para que sejam usados e vivenciados de modo relevante e frutuoso por pessoas de diversos contextos socioculturais, implica conhecer as motivações para visitar os EV, quais as características mais apreciadas e os fatores de perturbação experienciados durante a visita, entre outros. Esta questão é explorada no capítulo 4 que estende o estudo a 33 parques

urbanos de quatro cidades europeias, Helsínquia, Berlim, Bucareste a Lisboa, num gradiente Norte-Sul e Este-Oeste. Da entrevista a 1474 visitantes ressaiu uma grande variedade de motivações que levam as pessoas a visitar os parques, com as cidades a exhibir diferentes padrões. Apesar das motivações serem maioritariamente baseadas em temas relacionados com a atividade humana, como fazer exercício ou estar com amigos, p.e., com apenas uma pequena percentagem de visitantes a referir temas relacionados com o espaço em si ou a natureza, estes dois aspetos foram os mais apreciados pela generalidade das pessoas, nas quatro cidades, e independentemente do motivo da visita. Os parques foram analisados do ponto de vista da sua diversidade estrutural, avaliada através de um conjunto de itens: número de biótopos, estrutura da vegetação, comodidades e serviços disponíveis, e elementos artificiais. Os parques com maior diversidade estrutural encontravam-se, por norma, localizados no centro das cidades, onde o estrato socioeconómico é mais elevado, e apresentaram um maior número de motivações associadas e um maior número de aspetos apreciados. Em contrapartida, os parques com menor diversidade estrutural, localizados mais na periferia das cidades, em vizinhanças de condição socioeconómica mais desfavorecida, apresentaram menor número de motivações para visitar e aspetos apreciados, sendo a sua localização a motivação mais importante para serem visitados.

A melhoria da qualidade de vida proporcionada pelos EVUs passa pela capacidade de oferecer um ambiente conducente ao alívio do stress e restauro psicológico e, sendo a natureza e o espaço em si os elementos mais apreciados pelos visitantes, interessa saber quais as características dos EVUs, em particular as relacionadas com a diversidade biológica, responsáveis por proporcionar bem-estar mental, assunto abordado no capítulo 5. Os resultados dos inquéritos nos doze parques de Lisboa, relativos às perceções associadas ao espaço, à biodiversidade existente, à ligação afetiva ao local e ao restauro psicológico proporcionado pela visita (BCD Vivida) foram analisados em conjunto com as características biofísicas do espaço, nomeadamente ao nível da diversidade biológica em relação a riqueza de espécies e atributos funcionais (BCD Materializada). Concluiu-se que o restauro psicológico foi determinado mais pelas perceções, nomeadamente da biodiversidade existente e da ligação afetiva ao local, do que propriamente pela características biofísicas do espaço sendo que, destas, apenas uma elevada proporção de árvores de folha perene contribuiu de modo significativo para uma maior perceção de restauro. Este resultado levou a que se questionasse se a perceção da biodiversidade correspondia à biodiversidade medida, quantificada em termos de diversidade da paisagem, de riqueza de espécies de árvores, borboletas e/ou aves, e de diversidade de atributos visuais das árvores. Mais uma vez, à exceção da proporção de espécies de árvores de folha perene, nenhuma outra métrica

contribuiu para a percepção de biodiversidade sendo esta determinada pela percepção da diversidade de árvores e aves. No entanto, quando se utilizaram análises de mediação verificou-se que esta percepção de diversidade de árvores mediava completamente o efeito da proporção de folhosas na percepção da biodiversidade. O que significa que as pessoas reconhecem a diversidade de formatos de folhas, associam-na à diversidade de espécies de árvores e é esta percepção de diversidade de árvores que determina a percepção de biodiversidade existente no EV.

Esta tese contribuiu assim com o enquadramento teórico da BCD em contexto urbano e desenvolveu uma ferramenta que operacionaliza esse conceito. A aplicação do conceito de BCD ao estudo de EVUs em Lisboa e outras cidades europeias permitiu demonstrar a utilidade do conceito, e contribuiu para o esclarecimento dos mecanismos associados ao efeito da visitação de EVs e da sua biodiversidade no restauro psicológico e por conseguinte do bem-estar dos seus utilizadores. Permitiu ainda revelar questões de (in)justiça ambiental relacionada com o diferente acesso a EVs de qualidade e aos efeitos benéficos daí derivados, informação chave na definição de políticas de planeamento de espaços verdes no contexto urbano.

Palavras-chave: Espaços verdes urbanos; diversidade biocultural; indicadores; ferramenta de apoio à decisão; justiça ambiental; motivações; bem-estar; restauro psicológico; percepção da biodiversidade; biodiversidade; diversidade funcional; traits visuais; mediação

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CHAPTER 1

General introduction



1.1 Urbanisation and its impacts on biodiversity and human well-being

Throughout ages, human societies tended to organize in settlements in pursue of economic development and better quality of life. The urbanization process has been particularly important in the past decades and is expected to continue in the foreseen future, at a particular fast pace in developing countries. Globally more than 70% of the human population is expected to be living in cities by 2050 (Figure1.1) (Haase et al., 2018).

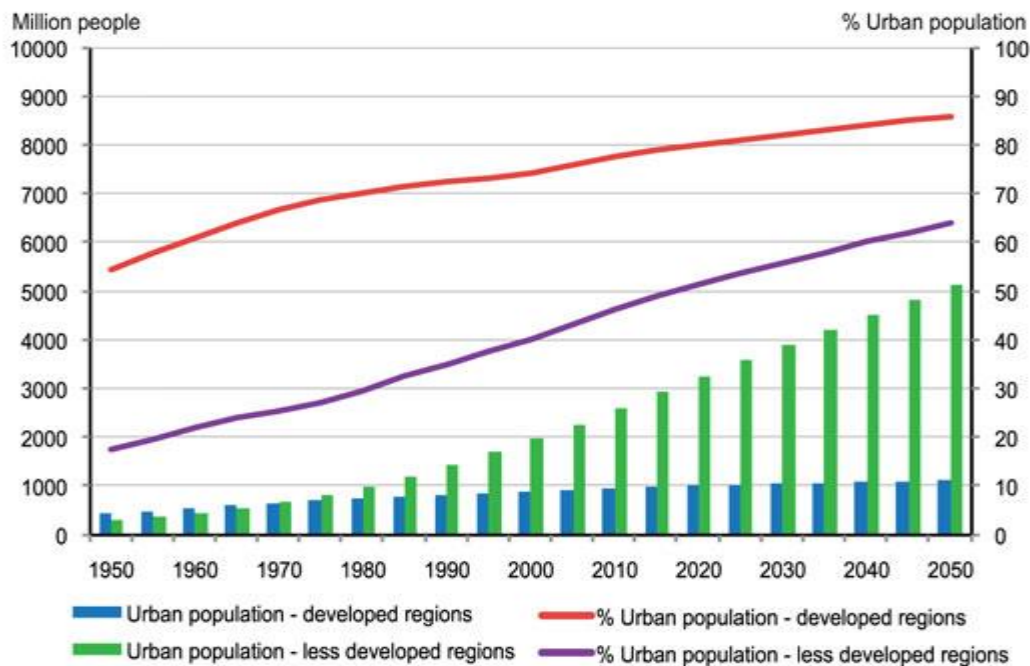


Figure 1.1 - Growth in urban population 1950 to 2010 and projections up to 2050 (source, United Nations, Department of Economic and Social Affairs, Population Division, 2012)

The growth of cities places major pressures on ecosystems, with increasing demands for land, fresh water, food resources, energy and raw materials. It also poses additional pressure on the capacity of ecosystems to accommodate the consequent production of waste and pollution (Grimm et al., 2008; Elmqvist et al., 2013). The most direct impact of cities on biodiversity is the change in land cover associated with agricultural land-use conversion and deforestation. Urban growth also fragments the natural habitats and, by increasing the distance between the remaining patches, reduces gene flow among leading to their isolation. More sensitive species depending on larger and more natural patches of habitat, tend to disappear contributing to biotic homogenization (McDonald et al., 2013; Muller et al., 2013). Urbanization also creates areas of disturbed habitat suitable to the establishment of exotic, and often invasive, species which may outcompete native ones and lead to decreased diversity of their associated communities (Gaertner et al. 2017). Numerous urban invasive species are known across the globe, particularly

of vascular plants (e.g. *Ailanthus altissima* or *Cortaderia selloana*), but examples of other taxa are also found such as beetles (e.g. *Rhynchophorus ferrugineus*), butterflies (e.g. *Pararge aegeria*), amphibians (e.g. *Xenopus laevis*), birds (e.g. *Psittacula krameri*) and mammals (e.g. *Rattus norvegicus*) (e.g., Muller et al., 2013; Vimercati et al., 2017)

The conversion of vegetated surfaces to hard-made surfaces further modifies heat and gases exchanges between the surface and the atmosphere, leading to higher temperatures in and near urban areas than in surrounding regions, the so-called “urban heat island effect”, and altered precipitation patterns or “urban rainfall effect” (Braham et al., 1981; Liu and Niyogi, 2019). These two effects together will have significant impacts on net primary production, functions of ecosystems, and biodiversity.

While offering better opportunities to live and thrive, inhabiting cities poses major challenges to urban dwellers. Increased levels of air and noise pollution, increased temperatures and poor sanitation, have direct impacts in human physical and mental health and well-being (Chen and Kan, 2008; Stansfeld, Haines and Brown, 2000). Air pollution and increased temperatures lead to higher incidences of respiratory and cardiovascular diseases in urban areas (D’Amato, 2011), while chronic exposure to environmental noise can disrupt sleep, cause anxiety, tension, and illness (Fritschi et al., 2011). All these, along with crowding, hustle, sights, untidiness and many other factors, contribute to overload people with stimulus drawing attention and awareness. This can lead to increased stress and the need to seek relief in quiet, private spaces, which on the long term can promote social isolation and impair mental health and well-being (House et al., 1988; Nieminen et al., 2010). Urban areas are reported to have significantly higher rates of mental disorders than rural areas (Peen et al., 2010; Vassos et al., 2012).

The urbanization process also involves major changes in social structures, in the ways people relate to each other, the environment and ruling institutions (Redman, 2011). Ongoing globalization and migration of people from different settings and cultural backgrounds impose demographic and lifestyle changes. Different cultures come into contact, with the cultural repertoire of both migrants and hosts, including their attitudes towards nature and environmental issues (Carter et al., 2013), being modified by various degrees and strategies of acculturation (Esses, 2018). Social bonds and relationships are transformed, and often weaker, with potential consequences for social cohesion and social resilience (White and Guest, 2003).

To balance the increasing pressure of growing cities with the long term protection of the environment while being inclusive, culturally diverse and economically equitable is one of the

major societal challenges (WHO, 2016; Kabisch et al., 2016) as recognized in one of the 17 United Nations Sustainable Development Goals (SDG) for 2030 (UN, 2016), further elaborated in the New Urban Agenda (NUA, 2017). SDG11 (Sustainable Cities and Communities) envisages more inclusive, resilient and sustainable future cities, and urges governing institutions to, amongst others, promote the access to basic services, reduce the environmental impact of cities through a sustainable, participatory and inclusive urban planning and management, and provide universal access to safe, inclusive and accessible green public spaces, in particular to often disregarded groups, as women or elderly people.

1.2 Contribution of urban greenspaces for biological diversity and human well-being

Urban and peri-urban greenspaces (UGS) are the biodiversity repositories of cities and key contributors to address some of the challenges associated with urban livelihood through the provision of numerous ecosystem services (McPhearson et al., 2015; Simon et al., 2018). UGS improve the environmental quality through the attenuation of air and noise pollution and microclimate regulation, protect soils from erosion and help control flooding (Breuste et al., 2017). Some plants, mostly trees, remove gaseous pollutants and particulate matter from the atmosphere improving air quality in cities and directly contributing to human health. Gases are removed from the air primarily by uptake via leaf stomata, while particulate matter removal occurs mainly via interception with the plant surface (Nowak et al., 2006). Beside pollutants, trees also absorb carbon dioxide (CO₂) during photosynthesis and store it as biomass, contributing for the decrease of greenhouse gases concentration in the atmosphere (Nowak et al., 2013), with younger specimens of fast growing species, performing better than their more mature and slower-growing counterparts (McPherson, 1999; *id.*, 2013). Plant species also provide shade, create humidity and absorb heat from the air by evapotranspiration (Ennos, 2012), while preventing built surfaces and pavements from absorbing solar radiation, thus contributing to regulate local temperatures, buffer the effects of urban heat islands and mitigate the adverse effects of increased temperature in human health (McMichael et al., 2003). At the local level, temperature reduction depends on tree characteristics and related functional traits, namely foliage thickness, leaf colour lightness, thickness and texture (Lin and Lin, 2010). Green spaces further have the ability to mitigate noise in urban areas by exerting a buffer effect that can reduce noise to the human ear up to 9Db (Ozdemir et al., 2014), with the capacity of noise attenuation being related with the structure and type of vegetation forming the sound barrier. Vegetation with larger canopies, denser and larger evergreen leaves are more effective at reducing noise (Gratani and Varone, 2013; Yang et al., 2013).

Green spaces also provide easily accessible recreational opportunities, which are usually free, with recreation being one of the most recognized and valued cultural services (Gomez-Baggethun et al., 2013). From taking a walk and enjoy the fresh air, practice sports, play with the children, do a picnic, or just relaxing, parks and other greenspaces offer a range of opportunities for everyone to enjoy. Besides promoting an active life style, with direct consequences in physical and physiological health (Elands et al., 2018; Kabisch et al., 2015; Lovell et al., 2014), the enjoyment of meaningful activities can give city dwellers a sense of relief and escape from urban life with direct implications in stress relief and mental well-being (Gomez-Baggethun et al., 2013).

Recreational UGS are places of mingling where groups of different ages, backgrounds or interests can co-exist and observe each other. Even with little or no direct interaction, co-existence in the same space may promote tolerance for social-cultural diversity and stimulate the sense of community and social cohesion (Cattell et al., 2008; Peters, 2010). Social interaction in green spaces provide opportunities to create bonding ties and a sense of belonging to the community and contributes to assign meaning and significance to the place. The regular interaction with a meaningful place fosters the development of emotional bonds between individuals and the socio-biophysical environment and this sense of place is central to nature conservation and human well-being (Cattel et al., 2008; Elands et al., 2018).

Well-being is a dynamic, subjective process (Dodge et al., 2012) and people visiting greenspaces derive well-being in multiple ways. Some appreciate a chance for reflection and restoration in quiet spaces, deriving satisfaction from a spiritual connection or a sense of belonging, while other enjoy observing others' activities and derive pleasure from their casual nods and smiles. Some enjoy the continuity of experience and rely on experiencing the familiar and expected, while new experiences in vibrant spaces may be a source of enjoyment for other. Multiple, complex and subjective values and meanings are thus assigned to a shared space and its unique biodiversity constellation, and one's well-being may occur at expenses of other or even of the ecosystem integrity, with the inverse also being valid. Experiences promoting well-being for one individual or group may provide well-being for others or be beneficial for the ecosystem. Recreational greenspaces are thus not neutral, nor just nature or a simple container of human activity. The physical and social environments do not exist independently of each other. Any environment is the result of the continuing interaction between natural and man-made components, social processes, and the relationships between individuals and groups (Yen and

Syme, 1999). Within this perspective, the Urban Green Infrastructure (UGI), with its multitude of UGS typologies, from urban forests to schoolyards, urban parks and derelict lands (brownfields), street trees, community or allotment gardens, green roofs, green facades or bioswales, cannot any longer be addressed simply as an *‘inter-connected network of protected land and water that supports native species, maintains natural ecological processes, sustains air and water resources and contributes to the health and quality of life for America’s communities and people’*, as earlier defined in late 90’s (Benedict and McMahon, 2006), but rather as a spatially interconnected network of socio-ecological places with variable functions and meanings, requiring, as such, diversified and integrative planning and management approaches and solutions. This implies that *“in order to successfully protect and enhance biodiversity, the focus should be not only on biodiversity as an ecological or biophysical concept, but also on the social processes that determine success and failure of biodiversity conservation and management efforts, as well as on the relationship with the social and institutional context in which biological diversity develops”* (Elands et al. 2015).

Traditionally, ecologists have focused on understanding the natural world unbiased by how humans interact with it. ES, especially the cultural, are not provided by ecosystems alone but generated by complex human-nature interactions (Fischer and Eastwood, 2016). People interact with and use biodiversity in many ways and the nature of those interactions will depend on species ecology but also on people’s opportunities, behaviours and perceptions (Gaston et al., 2018). Though the linkage between the human interaction with nature and the array of its positive benefits is well-established (Keniger et al., 2013), much less is known about the specific ecological, social or structural attributes of green spaces which produce these effects (Marselle et al., 2019; Petersen et al., 2019). Key to determining how these benefits are achieved is a better understanding of the form, frequency, and duration of people’s interactions with greenspaces’ nature (Shanahan et al., 2015) and how they perceive and value biodiversity and its benefits. Studies addressing valuation of biodiversity via perceived benefits as psychological well-being, physical health or quality of life, did not provide universal patterns. While slightly more than half of the effects showed positive relations with biodiversity, the remaining showed negative or mixed relations (Botzat et al., 2016). These inconsistent results may be due to a lack of uniformity both on the definition of biodiversity itself and on the methods used to measure it, and the inclusion of a variety of benefits which can be dependent on different elements of urban nature, or scales of biodiversity. Pure ecological knowledge is thus not enough to assist decision making and, in spite of all existing information on urban ecosystem services and its

operationalization, there is still a need for further and deeper integration of ecological and social sciences knowledge (Pickett et al., 2016; Groffman et al., 2017). Further research is needed to link strategies that address human wellbeing and biodiversity conservation simultaneously and develop adequate context-sensitive tools to assist decision-making. Urban ecology studies in Portugal are still emerging and refer mostly to ecosystem services evaluation (Graça et al., 2017a,b; Mascarenhas et al., 2016, Mexia et al., 2018), preferences and benefits perception (Fonseca et al., 2010; Madureira et al., 2015, 2018), access, motivations and uses (Gómez et al., 2014, Luz et al., 2019), perception of thermal comfort (Oliveira et al., 2014; Grilo et al., 2020) or atmospheric benefits (Matos et al., 2019, Miranda et al., 2017). Studies on the role of biodiversity on well-being or on biodiversity perception are inexistent.

1.3 Biological and Cultural Diversity: the need for an integrated framework in urban contexts

The Biocultural Diversity (BCD) concept, by considering the intrinsic connectedness between biological and cultural diversity (Posey, 1999), brings together the interrelated aspects of the diversity of life and helps to explain human-nature interactions and the co-evolution of nature and culture (Maffi, 2005). The BCD concept was firstly introduced in late 1980s to describe the “inextricable link” between biological and cultural diversity manifested in the unique ways indigenous and traditional peoples perceive, use, and manage their natural resources (Declaration of Belém, Brazil, 1988). Though initially focusing on ecoregional hotspots and the problematics of its progressive deterioration, the BCD concept was soon extended to other “non-traditional” people in developing countries (Cocks, 2006) and later adopted in other parts of the world, including in the most developed and human-impacted societies (Agnoletti and Emanuelli, 2016).

The BCD concept proved to be useful to study and explore the human-nature interconnectedness in, e.g., cultural landscapes (Hong et al., 2014). Although with an initial focus in rural settings, BCD can be easily recognized in urban ecosystems (Vierikko et al., 2016) where biodiversity is inherently culturally shaped and a reflection of historical political settings and culturally informed ways of thinking and living. The BCD concept “*builds upon the idea that nature is not something that exists ‘out there’, but is socially constructed*” and that “*biological diversity and cultural diversity are intertwined—they are ‘made’ together and imply each other, they are inextricably linked*” (Buizer et al., 2016).

1.4. Thesis Goal and Structure

1.4.1 Thesis objectives and research questions

The ultimate goal of this thesis is to expand knowledge to effectively contribute to ecological and social sustainability in cities by addressing the interrelationship between people and nature in urban greenspaces and how it influences their well-being. The four result-based chapters of this thesis answer to the following research questions:

RQ1. How can we link nature and culture to ensure integrated planning and management strategies of green spaces in cities?

Drawing on the inherent connection between nature and culture, on Luisa Maffi's concept of biocultural diversity (2005), and on the recognition of existing mutual dependencies between various forms of life (Biological diversity) and human diversity (Cultural diversity) we focused not only in the human-nature interactions themselves, but how those interactions manifest in the ways people live, experience and shape nature, to develop a conceptual framework for urban BCD.

RQ2. How can the BCD framework be operationalized to effectively support decision-making in urban planning?

An adequate framework to address the UGI complexity and integrate the interactions and feedbacks between humans and ecosystems is of paramount relevance but, to effectively assist and support decision-making, it needs be translated into tools that structure information for rapid communication and assimilation. This is the key role of indicators and the development of an indicator-based system under the BCD lenses offers a context-sensitive decision support tool to deliver quality greenspaces.

RQ3. Which are the motivations of citizens to visit and value urban parks?

Delivering quality greenspaces that can be experienced in meaningful ways by different people and groups is a key point in UGI planning and management. It is thus important to explore how different socio-cultural groups interact with, use and value greenspaces.

RQ4. Which is the contribution of biodiversity to well-being of urban parks visitors?

Knowing visitors' motivations, how they enjoy, experience and value the space with its own biodiversity and structural elements, and how these contribute to their well-being, allow to

establish patterns, uncover hidden processes, understand needs and multiple demands, and gain an essential perspective for a sound and informed decision-making.

1.4.2 Overview of the thesis structure

This thesis does not follow the conventional format of a PhD thesis, rather being presented in a paper-format, including a compilation of four papers, two submitted as first author and two published as co-author in international peer reviewed journals. Each of these papers correspond to a specific chapter (Chapters 2-5), in which specific objectives are addressed and conclusions drawn, being preceded by this introductory chapter (Chapter 1), where the thesis aim is contextualised on the basis of state-of-art literature, and concluded by outlining the main conclusions and identifying the limitations to the study and recommendations for further research. (Chapter 6).

Chapter 2 contains a review of the relevant literature on the biocultural diversity concept and further expands the theoretical and conceptual thinking of BCD in the urban context. An indicator-based system to operationalize the BCD concept in cities and guide strategic planning and decision-making is then described in Chapter 3. In the following chapters a more practical approach is followed by focusing on the human-nature interactions in urban parks at the European (Chapter 4) and national (Chapter 5) scales.

The list of papers composing this thesis is as follows and a statement describes my personal contribution for each:

CHAPTER 2 – Biocultural diversity: a novel concept to assess human-nature interrelations, nature conservation and stewardship in cities

Elands, B., K. Vierikko, E. Andersson, L. Fischer, **P. Gonçalves**, D. Haase, I. Kowarik, A.C. Luz, J. Niemelä, M. Santos-Reis, K.F. Wiersum
Urban Forestry & Urban Greening, vol. 40:29-34 (2019)

<https://doi.org/10.1016/j.ufug.2018.04.006>

Actively contributed to the BCD framework development in the frame of EU FP7 (ENV.2013.6.2-5- 603567) GREEN SURGE project (2013-2017) (<https://greensurge.eu/>) working package 2, including the paper outline and revision.

CHAPTER 3 – Biocultural diversity indicators in urban context: guidance for strategic planning and decision-making

P. Gonçalves, K. Vierikko, B. Elands, D. Haase, A.C. Luz, M. Santos-Reis

Submitted to Environmental and Sustainability Indicators in August 2020

Led the development of the indicator-system and the operationalization scheme, performed the data collection and analysis, and wrote the paper

CHAPTER 4 – Biocultural diversity (BCD) in European cities - interactions between motivations, experiences and environment in public parks

K. Vierikko, **P. Gonçalves**, D. Haase, B. Elands, C. Ioja, M. Jaatsi, M. Pieniniemi, J. Lindgren, F. Grilo, M. Santos-Reis, J. Niemelä, V. Yli-Pelkonen

Urban Forestry & Urban Greening, 48:126501 (2020)

<https://doi.org/10.1016/j.ufug.2019.126501>

Contributed to the experimental design, performed Lisbon's data collection, classification and descriptive analyses, and actively contributed to the paper's outline, writing and revision.

CHAPTER 5 – What's biodiversity got to do with it? Biodiversity, its perception, and restorativeness in urban greenspaces

P. Gonçalves, F. Grilo, R. Mendes, K. Vierikko, B. Elands, T. Marques, M. Santos-Reis

Submitted to Ecology and Society in June 2020. Accepted with minor revisions in August 2020

Main responsible for the experimental design, data collection and analysis, paper outline and writing process.

1.5. Research Context, Study Areas and Methods

1.5.1. Research Context

This thesis was developed in the frame of GREEN SURGE, a collaborative project between twenty-four partners in eleven European countries, funded by the European Commission Seventh Framework (ENV.2013.6.2-5- 603567), involving twenty cities. The project main objectives were to: Identify, develop and test ways of linking green spaces, biodiversity, people and green economy to meet major urban challenges (land use conflicts, climate change adaptation, demographic changes, and human health and wellbeing); and provide a sound evidence base for Urban Green Infrastructure (UGI) planning and implementation, exploring the innovation potential, and linking environmental, social and economic services with local communities.

Research conducted for this thesis was developed in the frame of working package 2 ‘Assessment of biocultural diversity’, led by Helsinki and Wageningen Universities, with the role of *“first developing a conceptual framework including (urban) biological diversity and cultural diversity as well as their mutual interaction, evaluating methods and identifying good practices, and then using the framework for assessing BCD, with particular emphasis on the involvement of local communities in assessments”*.

The BCD framework was developed during the project’s online and on-site meetings and involved mainly the Helsinki, Wageningen, Lisbon, Stockholm and Berlin teams, while the indicators development was led by the Lisbon team in close collaboration with Helsinki’s team and inputs of Berlin and Wageningen teams. Urban greenspaces in Lisbon, Helsinki, Berlin and Bucharest were then studied under the BCD lenses.

1.5.2. Study Areas

The four studied cities represent a North-South and East-West gradient, with different climates, urban growth patterns and greenspace availability (Davies et al., 2015). **Helsinki** has a humid continental climate with cold winters and mild summers, an overall low population density (2.8 inhab/km²) with a high proportion of greenspace (47%) and 25.51m²/inhab of recreational greenspace; **Berlin**, with a temperate oceanic climate characterized by warm and sometimes humid summers and cool winters also has a low population density (3.8 inhab/km²) and a large percentage of green areas (40%) but a lower availability of recreational greenspace (16.82m²/inhab); **Bucharest** with a continental climate is the city with higher population density (9,2inhab/km²) and lower recreational greenspace availability (3%; 3.5m²/inhab) (Ioja et al., 2011); and **Lisbon**, with a Mediterranean climate with hot summers and mild rainy days, has an intermediate population density (6.5 inhab/km²) with 24% of greenspace providing 18.5m² of recreational greenspace per inhabitant.

The city of Lisbon, the main place-based focus of this thesis, confined by the river Tagus in its southern and eastern limits, has expanded along the river and into the interior in a crown shape, growing in a steady pace until the 1940s-1950s. By this time many new neighbourhoods and large avenues (*Avenidas Novas*) began to be built. After the 1970s-1980s, the city experienced a very sharp growth with the urban fabric sprawling into rural areas, occupying former farms (*Quintas*) and woodlands (*Matas*), which designations are still present in parks, places and streets toponymies (Figure 1.2).

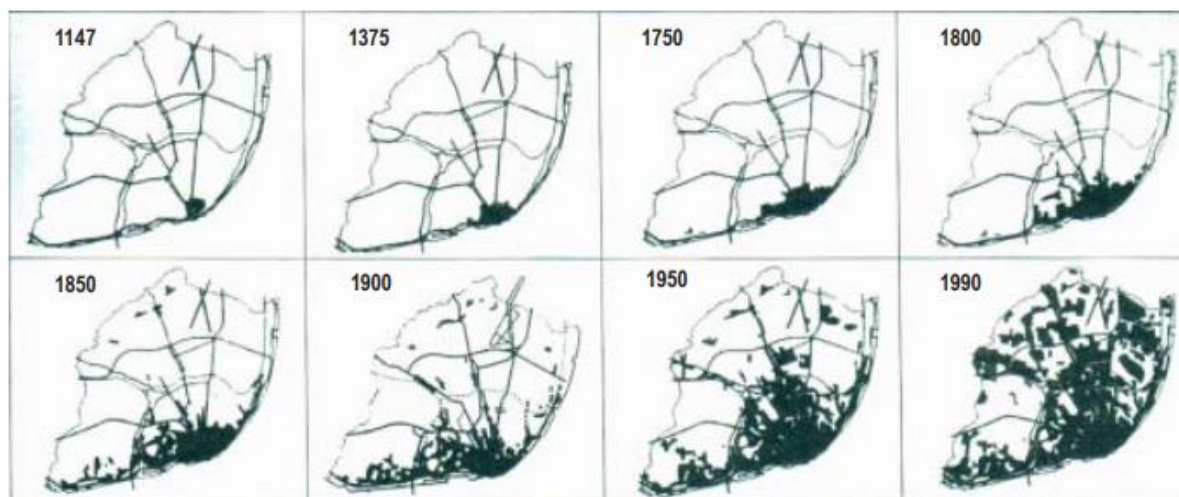


Figure 1.2 - Evolution of urban sprawl in Lisbon until the 1990s (source: Barata Salgueiro (2001) *Lisboa, periferia e centralidades*. Celta Editora, Oeiras. pp.33).

Nowadays, Lisbon municipality has most of its total area (8545 ha) covered by urban fabric of varying density, with urban green spaces (UGS) occupying only around 24% (2013 ha) of which nearly 900 ha correspond to a large forested area (Parque Florestal de Monsanto), planted in the 1940s by the afforestation of former crop and pasture fields, to both ameliorate the city climate and create a monumental leisure park at the likeness of Bois de Boulogne in Paris (Soares and Castel-Branco, 2007). Of the remaining green area, 446 ha are occupied by parks, either public or private, from large urban parks, botanical and zoological gardens, to neighbourhood parks, with the other being occupied mainly by agricultural and semi-natural areas (530 ha) and derelict lands (140 ha) (EEA, Urban Atlas). Urban parks represent therefore the dominant typology of Lisbon UGI (Figure 1.3) and are expected to be the major contributor for the city nature and biodiversity.

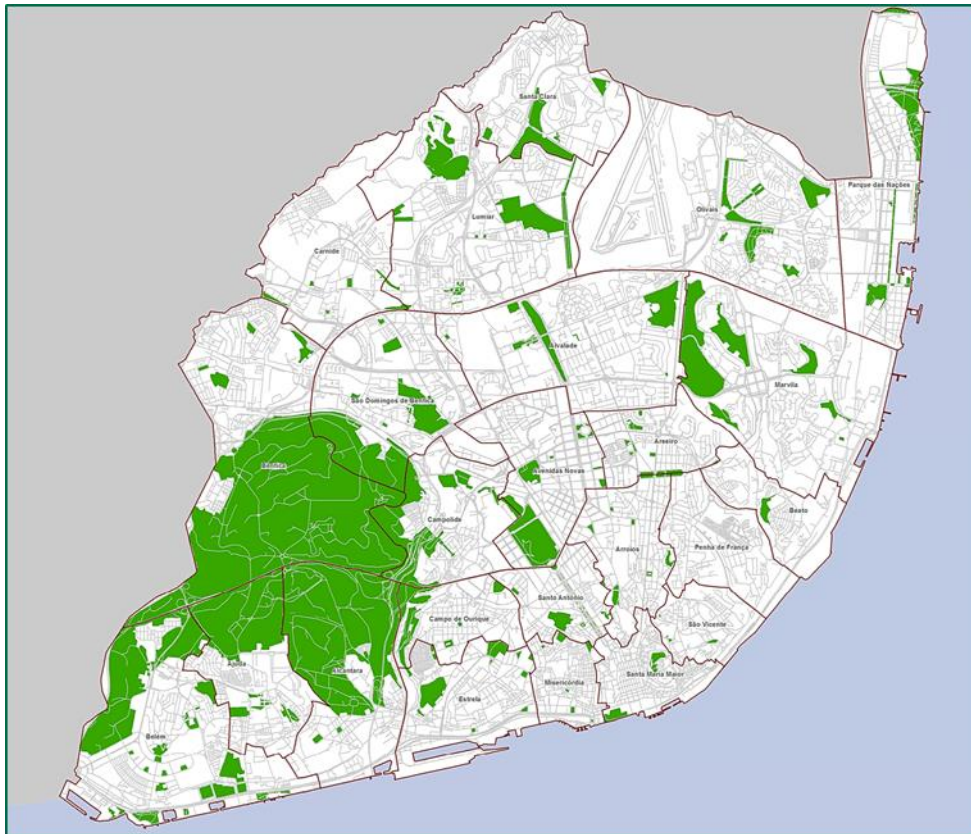


Figure 1.3 - Urban parks of Lisbon depicted in green (source: Câmara Municipal de Lisboa).

1.5.3. Methods

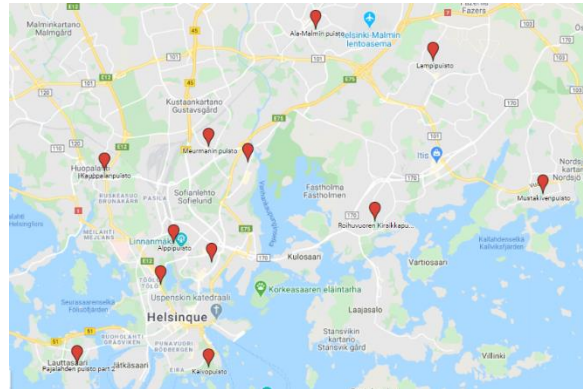
Two sampling approaches were used in this thesis: face-to-face questionnaires to assess motivations and experiences of visitors in urban parks, as well as how they perceived biodiversity and its benefits for well-being; and field surveys to assess parks' biological diversity, and the presence and conservation status of facilities, amenities and artificial elements.

The questionnaires (Annexes 1 and 2) were developed in collaboration with Helsinki team and applied to thirty-three parks, twelve in Lisbon and Helsinki, six in Bucharest and three in Berlin (Chapter 4). We selected recreational parks of public and free access, with varying designs and amenities/ facilities supply, located in a gradient of neighbourhood matrixes or urbanization densities, from contiguous green to grey, in different socio-economic contexts. Furthermore, Lisbon's parks were older than 50 years to assure a completely developed vegetation structure as the experiment also involved a multi-taxa field sampling. The location of all thirty-three parks is depicted in Figure 1.4 and can be assessed [here](#). Detailed information on Lisbon parks is given in Table 1.1., with images representative of each Lisbon park displayed in Annex 3.

a. Berlin



b. Helsinki



c. Lisbon



d. Bucharest



Figure 1.4 – Location of the thirty-three parks studied in a. Berlin, b. Helsinki, c. Bucharest and d. Lisbon along with its location in Europe

Table 1.1 - Characteristics of Lisbon parks according to their age, origin, design and neighbourhood socio-economic strata.

Park	Park construction	Park age (years)	Origin / design	Date of urbanization	Socio-economic strata
Jardim da Estrela	1840s	>100	English design	1800s	High-Medium
Jardins Gulbenkian	1960s	50	Modern Portuguese design	1900s	High-Medium
Mata de Benfica	1910s	>100	Former farms	1900s	Medium-Low
Tapada das Necessidades	1740s	> 100	English design/ former game reserve	1800s	High-Medium
Mata de Alvalade	1950s	50	Former planted woodlands	1940s	Medium-High
Quinta das Conchas (mata)	1900s	> 100	Former planted woodlands	1990s	Medium-Low
Vale Fundão	1970s	50	Former planted woodlands	1960s-1970s	Low
Vale do Silêncio	1950s	60	Former planted woodlands	1940s-1960s	Medium-Low
Parque do Calhau	1940s	70	Planted forest	NA	Low
Keil do Amaral	1940s	70	Planted forest	NA	High-Medium
Montes Claros	1940s	70	Planted forest	NA	High-Medium
São Domingos de Benfica	1940s	70	Planted forest	NA	Medium-Low

The questionnaires were mostly based on open questions addressing themes as frequency, duration and motivation to visit, activities done while visiting, positive and negative experiences, perception of existing biodiversity and of well-being derived from visiting the park, along with other asking visitor's socio-demographic characteristics and cultural background. The questionnaires in Lisbon included an extra item assessing Perceived Restorativeness whose results are the core of Chapter 5.

The biodiversity assessments in Lisbon's parks followed a multi-taxa approach by sampling vascular plants, trees, butterflies and birds, whose details can be found in that chapter. Briefly, a stratified sampling scheme based on cover types' occupancy areas was used with each taxa being assessed with standard sampling protocols.

A survey tool adapted from the Neighbourhood Green Space Tool (NGST) (Gidlow et al., 2012) was used to assess overall parks' condition, namely the type and conservation status of facilities and amenities, or the presence of natural and cultural salient features (Annex 4).

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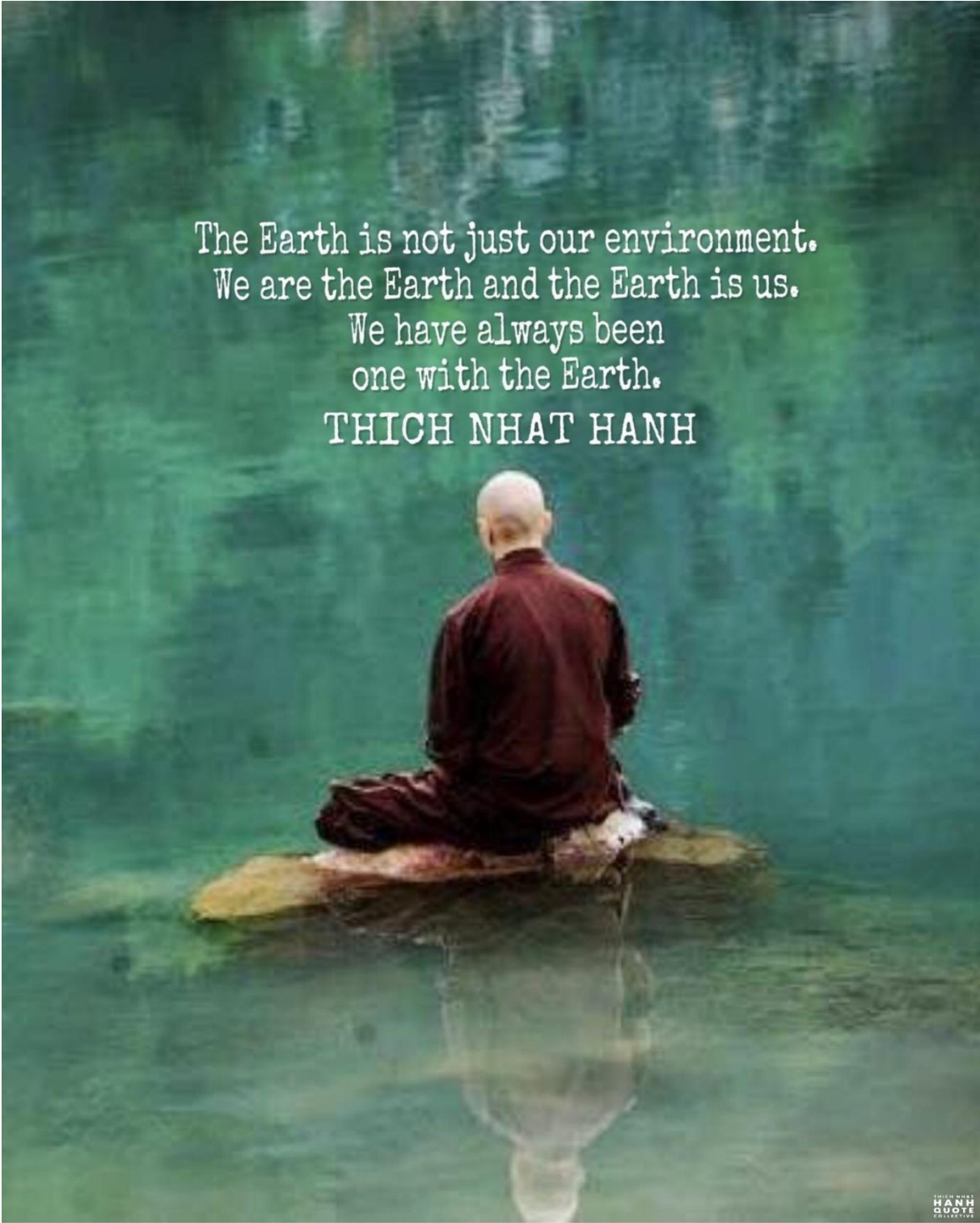
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A Buddhist monk with a shaved head, wearing maroon robes, is seen from behind, sitting in a meditative lotus position on a large, flat rock in the middle of a calm, green pond. The water is still, reflecting the monk and the surrounding greenery. The background is a dense, lush green forest. Overlaid on the upper half of the image is a quote in a white, typewriter-style font. The quote reads: "The Earth is not just our environment. We are the Earth and the Earth is us. We have always been one with the Earth." followed by the name "THICH NHAT HANH" in all caps.

The Earth is not just our environment.
We are the Earth and the Earth is us.
We have always been
one with the Earth.
THICH NHAT HANH

THICH NHAT
HANH
QUOTE
COLLECTIVE

CHAPTER 2

Biocultural diversity: a novel concept to assess human-nature interrelations, nature conservation and stewardship in cities

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Biocultural diversity: a novel concept to assess human-nature interrelations, nature conservation and stewardship in cities

2.1. Biocultural diversity: an appealing concept

2.1.1. Its origins

The way we think, feel and act regarding nature is fundamentally cultural determined. Throughout history the interaction between societies and nature has resulted in a variety of world views, cosmologies and narratives that reflect relations and relationships among plants, animals and people and the supernatural. This is reflected in the concept of biocultural diversity (BCD), which was developed in the 1990s in order to denote the diversity of life in all its manifestations – biological, cultural and linguistic – which co-evolved within complex socio-ecological systems (Maffi, 2005, 2012). It is based on the notion that cultural expressions resonate in a variety of rules, knowledge and practices to maintain venerated natural places and to make sense of and use biodiversity in a culturally informed and informing manner. This is expressed by the Declaration of Belem, that characterizes BCD as “*humankind’s accumulated reserve of learned responses to the environment that make co-existence between man and nature and self-recognition possible*” (UNESCO, 1992).

The concept was a response to global concerns regarding the disappearance of tropical forests and other fragile ecosystems, the extinction of many plant and animal species and the disruption of indigenous cultures around the world. These concerns resulted in the establishment of a global coalition for BCD, which emphasized the historical continuity of the cultures of indigenous people and its relation to their sustainable practices in living with their natural environment (Maffi, 2005; Posey and Dutfield, 1996). It was formalized in 1992 by the UN Convention on Biological Diversity that identified the need to maintain not only biodiversity at the genetic, species and landscape scale, but also the biodiversity-related knowledge, innovations and practices of indigenous people. Since then, many research activities resulted in the growing recognition of BCD as an expression of how cultural practices (e.g. worldviews, storytelling, livelihoods, norms and institutions) reflect and influence relations among plants, animals and people (Posey, 1999; Pretty et al., 2009). It also resulted in gradual shifts in the understanding of the significance of the concept.

2.1.2. From a ‘crisis narrative’ to a ‘dynamic narrative’

The original perspective of studies on BCD emphasized the dual loss of local cultures and wilderness. It was characterized as “*a product of crisis narrative*” (Brosius and Hitchner, 2010:143). This interpretation highlights modernization as the main threat to nature conservation (Pilgrim et al., 2007; Pretty et al., 2009). Several of the original biocultural studies focused on the identification of so-called ecoregional hotspots characterised by a unique combination of biodiversity and linguistic diversity (Loh and Harmon, 2005). While it is true that many indigenous and tribal groups have developed protective regimes towards their natural environment, the idea that they have always acted as nature conservationists has become under dispute. Opponents argued that culture is dynamic and that BCD is not inevitably lost with modernization (e.g. Cocks and Wiersum, 2014). The initial interpretation was also criticized for its conservation implications; it became characterized as “*representing nothing less than a new regime of enclosure (...) by establishing a set of comprehensive blueprints for the future of the planet*” (Brosius and Hitchner, 2010, p. 153). Those blueprints gave little input for the dynamics of practices of people living with biodiversity. Consequently, rather than relying only on professional practices that tend to be based on ecosystem thinking, in which living with biodiversity is subordinate or even excluded, there was a call for a more inclusive nature conservation aiming at the stimulation of local-level biocultural practices (Brosius and Hitchner, 2010). In response to cultural dynamics the co-evolution of people and nature may result in new forms of BCD, e.g. in the form of agrobiodiversity (Kareiva et al., 2007; Pretty, 2002).

2.1.3. From ecoregional hotspots to urban areas

Although it is true that BCD is critical to indigenous communities that live in natural areas, the original concept of biocultural diversity was also criticized as tending “*to privilege only one part of humanity – those small, diverse indigenous communities living in places of high biodiversity*” and as implying that “*places less diverse are sacrifice zones*” (Brosius and Hitchner, 2010: 143). The recognition of BCD being also a feature of cultural landscapes, where biodiversity was modulated over centuries by traditional agricultural practices, extended the focus of BCD studies to the modern societies in Europe (Pungetti, 2013; Taylor and Lennon, 2011; White, 2004). In 2014, the Florence declaration on the links between biological and cultural diversity in Europe recognised that “*the current state of biological and cultural diversity in Europe results from a combination of historical and ongoing environmental and land use processes and cultural heritage*” and that “*the predominantly biocultural and multifunctional European landscape assimilates economic, social, cultural and environmental processes in time and space*” (Agnoletti and Rotherham, 2015: 3156).

This acknowledgement resulted in increased attention to the cultural interactions with biodiversity in modern urban areas. These are often overlooked as urban areas have traditionally been conceived of as antipodes of nature. It was gradually recognised that urban green areas can be considered as a cultural landscape embodying a specific type of co-evolution between nature and culture. This is illustrated by the ‘four natures-approach’, introduced by Kowarik in 1992 (cf. Kowarik, 2018), which articulates the variety in human-driven transformations of natural landscapes: (i) remnants of pristine ecosystems, such as forests and wetlands, (ii) patches of ancient agrarian landscapes, (iii) designed urban greenspaces ranging from parks to garden and allotment complexes and recreational areas, and (iv) novel urban ecosystems that arise by chance or as a side-effect of other developments (wastelands, derelict industrial sites, etc.). This diversity in urban landscapes is reflected in a wealth of biodiversity studies that revealed a large variety of either organically evolved or specifically designed assemblages of urban biodiversity and their relevance for biodiversity conservation (e.g. Barthel et al., 2005; Goddard et al., 2010; ; Kowarik, 2011; Muller and Werner, 2010; Niemela, 1999; Puppim de Oliveira et al., 2011). Hereby, species may be either preadapted, or can adapt genetically or behaviourally, to urban environments (McDonnell and Hahs, 2015). Specific assemblages of urban biodiversity are increasingly culturally appreciated (Millard, 2010).

This has resulted in the development of culturally interpreted (novel) wilderness concepts (Kowarik, 2018; Threlfall and Kendal, 2018; Wiersum, 2017) and efforts to stimulate a greener economy (Moreno-Penaranda, 2013). Despite this rich variety of urban natures, many people in urbanised societies live without having close contact with nature. Researchers even warn, echoing the ‘crisis narrative’, for the ‘extinction of experience’, arguing that due to the loss of interaction with nature, ecological knowledge, positive attitudes towards nature protection and pro-environmental behaviour will decline (Soga and Gaston, 2016). In line with the dynamic conceptualisation of BCD, the combatting of the ‘extinction of experience’ in urban living with biodiversity does not only involve the conservation of historic forms of cultural interaction with biodiversity, but also the development of novel BCD practices.

These may not only be developed by professional organisations, but also by non-professional (urban) residents (Elands et al., 2015; Groth and Corijn, 2005). Building on this line of thought of ongoing biocultural dynamics, Elands and Van Koppen (2012:181) introduced the term ‘biocultural creatives’: “*groups of people who, driven by an engagement with society and nature,*

create new cultural models and practices for interaction with biodiversity”. In order to understand the diversity of local practices it is important to recognise the different cultural orientations and related knowledge and value frameworks of people, as well as the variation in how they have set up their stewardship arrangements for maintaining BCD. As future societies will largely diverge from today’s ones, the cultural perspective and its dynamics on living with (urban) nature needs careful attention.

2.1.4. Biocultural diversity in cities

As illustrated by the different approaches to studying BCD, the concept is open to different interpretations. The newly evolving perspectives relating BCD to acculturated urban landscapes formed the starting points for the EU FP7 GREEN SURGE project on linking people and green space in urban environments. The project identified BCD as a key concept for (i) understanding the integration between biological variety in the Urban Green Infrastructure (UGI) and the cultural specificities of the users of UGI, and (ii) developing innovative approaches to planning and governance of UGI (Vierikko et al., 2017a).

Considering the prevailing processes of socio-cultural transitions in European cities the GREEN SURGE approach towards assessing BCD was not only based on its interpretation as an inextricable link between nature and culture, but also as the outcome of not only green urban heritage but also of the ongoing processes of urban transformation. Hence, the GREEN SURGE approach was based on the argumentation that *“If biocultural diversity can be associated with dynamic social processes, then the issue is not only how to preserve or restore culture practices and values, but also how to modify, adapt and create culture in ways that reconnect people with and enhance the diversity of nature.”* (after Elands and Van Koppen, 2012: 184). The GREEN SURGE project thus aimed at the further development of theoretical and conceptual thinking of BCD in the urban context.

2.2. Assessing urban biocultural diversity

The urban green infrastructure (UGI), consisting of e.g. parks, derelict lands, urban gardens, canals and green roofs, is of utmost importance for both the use and well-being of the residents in the embedding cities and the functioning and survival of plants and animals. UGI, as indicated by this definition, is not an ecological network existing independently and in parallel to social life and activities; it is coconstructed by people and ecosystem dynamics in multiple ways: *“By its emphasis on diversity, biocultural diversity can account for the many ways in which people*

live with green areas in the urban landscape, acknowledges the different knowledges this involves, and can reveal conflicts and ambivalence that may be at stake” (Buizer et al., 2016: 7). The BCD concept focuses on the interrelationships and interdependencies between people and nature, and, as expressed in terms like ‘humans-in-nature’, considers humans as agents of ecosystem change (Buizer et al., 2016; Vierikko et al., 2017b). This becomes particularly articulated through the practices by which people develop a relationship with specific places they live, work or recreate in. They are also articulated in the specific constellations of the urban ecosystems that develop in reaction on these practices. Both cultural and utilitarian (productive, regulatory) services of biodiversity feature in the daily practices by which various cultural groups enjoy, understand and protect biodiversity and thus sustain a specific distribution and richness (poverty) of species at place. Human practices are embedded in a complex set of perceptions and values (Botzat et al., 2016). Nature’s response is embedded in the complex biophysical human-made and human-influenced setting of an urban ecosystem (Niemela, 2011).

Although in general people value green places positively, different cultural groups can differ in their valuation and understanding of biodiversity— which is, however, largely unexplored (Botzat et al., 2016; but see Fischer et al., 2018a). Some urban green spaces might have unique or universal values in respect to their interaction with nature, but most urban green spaces have multiple values assigned by the different groups of people interacting with specific spaces (Stephenson, 2008). As reflected in the diversity in urban green spaces the presence of such multiple values is especially relevant in urban societies in which a variety of cultural groups with different ethnic background, religion, lifestyles, etc. use and connect with public green (e.g. Kloek et al., 2013). This diversity is steadily increasing and altering by ongoing processes of immigration and *trans*-cultural exchange. This results in cultural hybridization and increasing heterogeneity of socio-demographic (age, household types, etc.), ethnic, religious and perceptual characteristics of green space users. Such dynamics indicate that culture is neither one-dimensional nor static, but multidimensional and dynamic. Although it is widely acknowledged that the diversity in which cultural groups live with biodiversity in green spaces is a key determinant for the maintenance and adaptation capacity of social-ecological systems (Andersson and Barthel, 2016; Folke, 2006), diversity can also be a source of disputes and conflicts (Vierikko et al., 2017a). The experiences of a particular urban green space by one group might be at the expense of possibilities for ‘outsiders’ to use it in an alternative culturally embedded manner or may be at the expense of the integrity (up to the survival) of the ecosystem. This raises justice and equity questions of ‘who benefits’ or ‘who loses’, not only from a social,

but also from an ecological perspective (Buizer et al., 2016). Thus, the concept of BCD can highlight both potential opportunities as well as vulnerabilities for the management and conservation of urban green spaces.

Through the interaction with urban green, people develop a bond with it and it becomes a meaningful 'place'. The process of place bonding is dynamic and relational and comes into being as people interact with particular spaces. This interaction might lead to a stronger engagement with urban green in the form of environment stewardship (Mathevet et al., 2017), involving taking responsibility for the sustainable use and conservation of specific biocultural manifestations. Through 'civic ecology practices' (Krasny and Tidball, 2012), citizens create and maintain bioculturally significant places through nature volunteering, urban gardening, public participation in green space development, protesting against development plans in nature areas and the self-governance of urban nature (Buijs et al., 2016; Mattijssen et al., 2018). Such local stewardship is supplemented by the professional landscape designs and the city government's responsibility for maintenance of the entire UGI with its complex of biocultural assemblages (Elands et al., 2015). In doing so, professional managers should be cognizant about the variety of socio-cultural values of different urban groups and how this is related to a variety of local practices in place attachment and place making. They should also recognize that place making by one group may exclude uses and values of other groups and that place-making is inherently political as it involves power differences between groups of people. In dealing with such conflicts and searching for trade-offs through the creation of new forms of biocultural hybridity, professional managers of UGI must recognise the importance of engagement with different social groups, recognize the diversity in cultural and intangible values and the need to interact with local stakeholders about this diversity and strive for the development of 'commonly accepted frameworks' (Chan et al., 2012).

Thus, in its studies to relate the concept of BCD to the UGI in European cities the GREEN SURGE program took the notion of 'humans-in-nature' (Folke, 2006) as a starting point and acknowledged the variety of cultural values assigned to urban green. It considered that this diversity of values and perceptions is reflected not only in a high diversity in biophysical manifestations of BCD, but also in a variety of practices for the day-to-day use of urban green spaces including the place-making activities of specific (groups of) people (Fischer et al., 2018b). The diversity is also reflected in a variety of biocultural memory carriers, such as artistic objects, oral traditions or monuments (Andersson and Barthel, 2016) and in the diversity in the contents

of policy or management plans for urban green (Elands et al., 2015). The cultural expressions and policy statements represent two types of biocultural manifestations: they both express how, as humans, we look at nature from a cultural perspective and how we value it being, at the same time, part of the ecosystem ‘city’ ourselves.

We developed a conceptual framework for studying the multi-dimensional features of BCD (Vierikko et al., 2017a) (Figure 2.1). The core idea of the BCD concept is that biodiversity and cultural diversity are inherently connected: for that reason the framework, in contradiction with the social-ecological system framework, does not distinguish between them. The figure depicts three layers: materialized, lived and stewardship, being departure points from which BCD can be studied. Changes in one layer automatically impact the other two layers. The figure illustrates that both established and innovative forms of BCD can exist next to another transversally; moreover, the governance of BCD often integrates past, current and future UGI practices. Each of the layers of this conceptual framework does not only refer to a specific dimension of BCD, but also requires specific methods for BCD assessment.

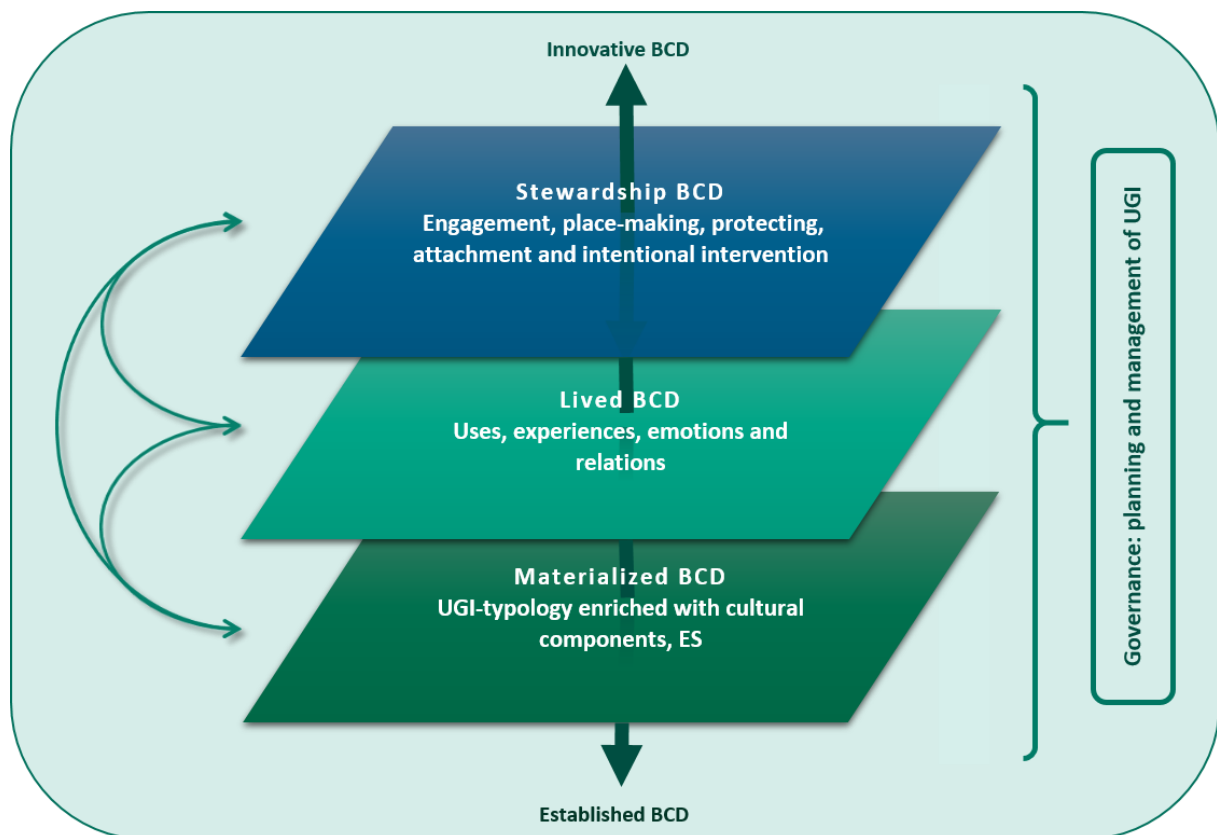


Figure 2.1 - Conceptual framework for the study on and governance of biocultural diversity in cities.

At the heart of framework is *“lived BCD”* as this relates to the day-to-day practices of people experiencing green places, encompassing both biological and cultural features. There is a growing recognition of the emergent, co-produced outcome of human-nature interactions. Lived BCD is concerned with the perceived and experienced qualities. These are mediated by our senses and minds, and concern complex systems of values, norms, traditions, knowledge and sensory perceptions. Different scientific approaches and conceptualizations emphasize different aspects and factors to be considered in assessing lived BCD. Under some circumstances knowledge and active cognition may serve as imperative indicators, in other situations relational and embodied perspectives may be more informative. Data collection and analyses are context-sensitive and require attention to qualitative methods of research, e.g. sense of place research, narrative analysis, environmental history and artistic research that are based on qualitative interviews, interpretive reading and observational studies. This qualitative assessment can be complemented by more quantitative methods, e.g. questionnaire surveys, public participation geographical systems (PPGIS), mobile apps for self-reporting, and visitor counts can be used to assess how different groups make use of different bioculturally specific places. Whereas the quantitative methods tend to answer the question what, where, and who, these qualitative methods may focus more on the why and how.

Through lived BCD practices, the world around us is being produced and reproduced. *“Materialized BCD”* is the tangible articulation of these (re)production processes. Materialized BCD is primarily concerned with the identification and quantification of the biophysical expressions of BCD in the form of different types of spontaneous and domesticated ecological communities and related cultural or technical artefacts of the various components of UGI. The identification of such features is based on the ontological assumption that these discrete objects exist (and are managed) regardless of our perception, and that they can be measured, quantified and monitored. Such tangible BCD lends itself relatively well to large-scale monitoring and cross-case translation and replication, even though the features and indicators that are most relevant in a specific case may vary. Methods for data collection include a combination of (remotely sensed or locally sampled) surveys on different scales of biodiversity, cultural landscapes and biocultural heritage, etc. Data sources and collection methods include census data, surveys, inventories and historical records. While arguably objects can be said to have individual, independent identities, they also include additional levels of meaning that we attach to them, which is something more akin to and expressly addressed under *“lived BCD”*.

While lived BCD in some ways can be said to be more passive and primarily mediated through perceptions on the culturally-embedded relevance of different assemblages of biodiversity, “*stewardship of BCD*” is an active, conscious engagement in the shaping of such assemblages. This engagement reflects a bonding. From a scientific point of view, the analysis of stewardship of BCD overlaps with the analysis of lived BCD in its interest in motivations, values, actions, norms, etc. In addition, it highlights knowledge in its different forms and how knowledge informs and influences the motivations to actively maintain the esteemed BCD or to further develop it in a process of co-production. Moreover, it emphasizes the bonding with nature that arises from it, and as such it is the ultimate consequence of the ‘humans-in-nature’ principle (see also Vierikko et al., 2017b). Assessing stewardship needs attention to both individuals and to group processes, and shares the qualitative—quantitative duality of the assessment of lived BCD. Scientific themes of relevance include social movements and social organization, local ecological knowledge, environmental psychology, etc. The methods for data collection include interviews, document analysis, observational studies, (observational) surveys and cognitive studies.

In this framework, BCD is not conceived of as a definite concept providing prescriptions of what to see (e.g. threatened biocultural heritage in need of conservation) but as a reflexive and sensitising concept that can be used to assess different values and knowledge of people that reflect how they live with biodiversity in cities (Buizer et al., 2016; Turnhout et al., 2013). It recognizes urban biocultural diversity as embracing both heritage values and expressions of newly evolving forms of living with biodiversity. It also recognizes the diversity in professional and laymen’s practices in actively engaging with biodiversity in a variety of stewardship systems. Thus, it calls attention to the diversity in ontological and epistemological interpretations of the concept of biocultural diversity and the moral and political implications in developing increased awareness of the multiple expressions of urban biocultural diversity as both a heritage-based and a dynamic phenomenon.

2.3. Implications for UGI-policy makers, planners, managers

Formal governance has several important roles in cultivating and supporting BCD. First, it is deeply involved in the stewardship aspect of BCD through professional planning, design and maintenance of UGI. Second, it creates or shapes many of the conditions that set the boundaries for BCD. Given the anchoring of BCD in formal governance and considering the GREEN SURGE notion of BCD as a reflexive concept that pays tribute to the diversity in contextual

situations in respect of how people live with and act as stewards for biodiversity, we provide the following recommendations for policy makers and professional planners and managers:

- Use BCD as a tool not only to preserve, restore or stimulate cultural practices and values that support biodiversity, but also to recognize and make space for the inherent socio-cultural diversity in people's living with biodiversity and in actively engaging with its stewardship. In doing so, attention must be given to the compatibility and conflicts between the various manifestations of BCD, the related value-embedded practices, and to their dynamic nature.
- Engage with biodiversity as something more than (threatened) species and ecosystems and explicitly include the human domain, e.g. by involving heritage species or urban green that reflects our long history of co-evolution of living with different ecological communities.
- Use BCD dynamically, going beyond manifestations of historic urban landscapes reflecting urban heritage to include also ongoing processes of cultural dynamics and urban transitions.
- Be aware of the multiple contributors to BCD dynamics and the broad range of opportunities these create for making biodiversity and green spaces more meaningful to people. Urban green spaces, like other cultural landscapes, have multiple layers of place identity. The cultural interactions with biodiversity in such multi-identity landscapes is informed by shifting artistic trends and values, ongoing storytelling and other processes of actively making sense of the space specific groups of urban people live in.
- Recognize diversity and dynamics within cultural values and their reciprocal connections to diverse ways of living with and relating to urban biodiversity, and of place-specific stewardship arrangements. This diversity offers a rich source of inspiration for how to maintain and how to further stimulate the preservation and development of bioculturally significant urban spaces. However, note that it may also lead to conflicts between different socio-cultural groups and perspectives over the desired nature of specific urban spaces.
- Base policy, planning and management of urban green spaces on an inclusive approach that does not only consider threats to BCD, but that also acknowledges the diversity in place-specific expressions of living with biodiversity and in stewardship arrangements for maintaining BCD as well as in creating new types of biocultural manifestations in response to urban dynamics.
- Be aware that BCD living and stewardship practices are highly diverse; they may not only differ between different cultural groups, but also between professionals and lay people. As

such, BCD is not ‘neutral’, but a concept that recognizes the political nature of UGI planning and management.

These recommendations can be translated into effective practice through governance approaches such as biocultural design (Davidson- Hunt et al., 2012), biocultural creativity (Elands and Van Koppen, 2012) and mosaic governance (Buijs et al., 2017; Buijs et al., 2018). These approaches aim to stimulate endogenous innovation within local communities and to promote diversity in active citizenship practices.

Thus, the notion of BCD offers to transcend and move us beyond ‘crisis narrative’ of urban areas as man-made biotopes almost devoid of nature. Instead, it offers a ‘dynamic narrative’ that acknowledges the diversity and dynamics in co-evolutionary interactions between people and nature in urban areas and the hybridity in the multiple manifestations of urban BCD.

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**IF A MAN
KNOWS NOT
TO WHICH PORT
HE SAILS,
NO WIND
IS FAVORABLE.**

Lucius Annaeus Seneca



CHAPTER 3

Biocultural diversity in urban context: an indicator-based support decision tool to guide planning and management of green infrastructure

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P. Gonçalves, K. Vierikko, B. Elands, D. Haase, A. C. Luz, F. Grilo, C. Branquinho, M.Santos-Reis (2020) Biocultural diversity in urban context: an indicator-based support decision tool to guide planning and management of green infrastructure. Submitted to *Landscape and Urban Planning*

Biocultural diversity in urban context: an indicator-based decision support tool to guide planning and management of green infrastructure

Abstract

In this paper, we propose an innovative indicator-based tool to operationalize the biocultural diversity (BCD) framework in urban contexts, deriving from its three conceptual layers – materialized, lived and stewardship. Indicators proposed are bundled in themes representing essential components when assessing and analyzing urban BCD from a contextual and sensitizing perspective. The set of indicators highlight key features of socio-cultural and ecological systems, their links and interactions, both material and non-material, to capture the essence of biocultural diversity at site-level. By offering a uniform scoring system with the possibility to set site-specific benchmarks, these can be used in any type of greenspace of any city, while allowing different communities/neighbourhoods/city councils to embrace different approaches to meet their objectives towards larger scale goals. Twelve urban parks in Lisbon were used as a test-bed for the indicator-based tool and proved its feasibility to gather an overall snapshot of all parks and to demonstrate the possibility to deepen the study to only two parks uncovering self-exclusion processes that otherwise would have remained hidden. The BCD tool brings together essential information scattered over several quality and good practices assessment tools and protocols and, by including indicators specifically addressing governance and stewardship, offers a policy-driven instrument able to capture trade-offs and/or synergies between ecological, social and political domains.

3.1 Introduction

Urbanization has expanded in the past decades and is expected to continue so in the foreseen future, with more than 70% of the human population predicted to be living in cities by 2050 (Haase et al., 2018). Cities growth is posing major pressures to ecosystems and societies (Cortinovis et al., 2019; Yin et al., 2016) and to balance the increasing pressure of growing cities with the long-term protection of the environment while being inclusive, culturally diverse and economically equitable is one of the major societal challenges as recognized by the United Nations (UN). The Sustainable Development Goal (SDG) 11 for 2030, envisages more inclusive, resilient and sustainable cities, and urges governing institutions to, amongst other, promote the access of population to basic services, reduce environmental impacts through a sustainable, participatory and inclusive urban planning and management, and provide universal access to

safe, inclusive and accessible green public spaces. The role of urban greenspaces (UGS) in improving cities quality of life through their contribution to ecosystem services and human well-being is vastly supported (Gómez-Baggethun et al., 2013). UGS improve the environmental quality through, e.g., the attenuation of air and noise pollution or microclimate regulation (Grilo et al., 2020), provide access to recreation and relaxation opportunities, further contributing for physical and mental health (Chiesura, 2004; Kabisch et al., 2015; Lovell et al., 2014). UGS also offer places of mingling where different groups can get together fostering tolerance and social cohesion (Cattell et al., 2008; Peters, 2010).

UGS encompasses a multitude of typologies, from urban forests to schoolyards, urban parks and derelict lands (brownfields), street trees, community or allotment gardens, green roofs, green facades or bioswales, performing variable ecological and social functions. Research, planning and management of this spatially interconnected multifunctional network to cope with ecological and social challenges of growing cities, need to consider and incorporate the complex interactions and feedbacks between the natural and cultural realms (Groffman et al., 2017; Pickett et al., 2016). Developing multi-dimensional spatially explicit indicators to assist and inform decision-making, negotiate trade-offs, implement management plans and assess their outcomes is of paramount relevance and require a deep integration of ecological and social concepts and knowledge.

UGS are embedded in dynamic social contexts which make each UGS unique. An approach relying on context-sensitive indicator tools and supported in a conceptual framework is necessary, as most valuation toolkits lack to address specific needs (Van Oistaijen et al., 2020). By putting its emphasis on the diversity of human-nature interrelations, the Biocultural Diversity concept (BCD) may offer an integrative and unifying perspective to assist this demand. Drawing on this inherent connection between nature and culture, Elands and co-authors (2018) developed a conceptual framework addressing human-nature interrelations in urban context, and proposed that BCD manifests in three mutually influencing dimensions (layers of information): *Materialized, Lived and Stewardship of BCD*. *Lived BCD*, at the heart of the framework, embraces the ways people perceive, experience and value UGS and their culturally-embedded biological assemblages. It is related with processes mediated by senses and minds, involving systems of values, norms, traditions, knowledge and sensory perceptions. Through these experiences and practices of lived BCD, greenspaces come to existence in tangible biophysical expressions. *Materialized BCD* concerns thus to discrete objects that exist regardless the

perceptions about them and can be quantified and measured. *Stewardship of BCD* represents an active and conscious engagement with the space and its shaping.

This framework can not only shed light on the diverse ways people live with nature and its biodiversity and which values they attach to it, but also on the compatibilities and conflicts between these various manifestations of lived BCD. As strategic planning often takes the biophysical environment as starting point, without reflecting enough on the inseparable cultural meanings attached to it, the notion of materialized BCD is important to practitioners and policymakers as it directly recognizes the cultural nature of greenspaces. These three layers offers city planners and UGI managers a rich source of information for how to maintain and further stimulate the preservation and development of biocultural significant urban greenspaces (Vierikko et al., 2016).

The multi-layered information about UGS are departure points to analyze it through the lenses of BCD. Yet, to be truly useful to inform strategic planning and decision-making, each layer must be translated into concrete, measurable and comparable information. The objective of this paper is therefore to operationalize the urban BCD framework through the development of an indicator-based tool to serve both as a research and a decision-support tool to inform BCD analysis in the urban context. With this proposal we aim to fill the plea for indicators to study biocultural diversity (Harmon et al., 2010) and the need for an integrated and unifying methodological approach to advance our understanding and analysis of complex urban socio-ecological systems, that acknowledge and incorporate the diversity of meanings and contexts and inform multiple modes and scales of decision-making (McPhearson et al., 2016a, b).

3.2. A multi-layered set of urban green space BCD indicators

The translation of the BCD framework into an objective and concrete assessment or planning tool is challenging because indicators should be quantifiable while referring to a concept that cannot be measured against some general standard. BCD is less a definitive concept, with clear definition of attributes or fixed benchmarks, and more a sensitizing concept (Buizer et al., 2016) that lack such specification of attributes and precise reference values. While definitive concepts provide prescriptions of what to see, sensitizing concepts only provide a general sense of guidance, of what is relevant, and merely suggest directions along which to look (Blumer, 1954).

We translated the three BCD dimensions into themes that signal to those directions representing the areas we considered essential to address when studying and analyzing UGS through the BCD lenses. Those themes took into consideration the need to foster and promote the preservation and active co-creation of bioculturally significant urban greenspaces. This implies an equal access to environmentally sound and inclusive greenspaces, planned and managed to fulfil its intended purpose for that specific place and people (Greenspace Scotland, 2008). A quality greenspace is one that meet the needs of people, place and environment. The indicators and metrics to inform on the themes were then selected in view the above considerations, the definitions of biological and cultural diversity, their areas of interdependence (Persic and Martin, 2008) and their roles in promoting ecological quality and human well-being. The areas of interdependence can be represented in material culture (e.g. objects created from and/ or representing biodiversity), knowledge and technology (e.g. knowledge about places and ecological relations and its transmission) or social relations with others, places and institutions (e.g. place attachment and governance).

The indicators were chosen to provide mostly basic and easily available place-based information, that is: i) biological, social and politically relevant, ii) clear and readily understandable and interpretable by public and policy makers, and iii) integrative and sensitive to management practices (Brown, 2009; Cairns, 1993). They encompass instrumental and contextual indicators (Rapport and Hildén, 2013) and foresee thus the use of both quantitative and qualitative data, obtained either by site-based samplings and assessments or in existing documentation made available by municipalities and other stakeholders. For each indicator, one or more metrics are suggested, conceived to be as much as possible easily measurable and interpretable under objective criteria, providing basic but meaningful information usable in municipalities' monitoring schemes and decision processes. A wide-range of indicators with diverse metrics, data sources and scale of analysis, offers multiple options to study UGS according to site socio-ecological specificities, evaluation purpose and extent and resources availability, through the selection of an adequate set of indicators covering as much possible the three BCD layers and several themes.

In total, we propose 14 themes, with a variable number of indicators per theme (Table 3.1): four for *Materialized BCD*, that include standard measurements of biological, functional and landscape diversity to assess ecological function, and the assessment of biophysical and biocultural features that create place identity and may promote or hinder welcomeness of space;

six for *Lived BCD*, which indicators address the diversity of socio-cultural identities, how people relate and interact with the physical space and with others, their practices, experiences and perceptions and how these perpetuate in time; and four for *Stewardship of BCD*, with indicators related with active participation in governance processes, on how people engage with the space and take responsibility for it through civic ecological practices. All layers are closely interlinked and, as such, depending on the perspective, some dimensions/themes and indicators may be placed in a dimension/theme other than the one to which they were allocated. In Supplementary material we provide detailed information for each proposed indicator regarding their theoretical rationale (Annex 5), and the candidate metrics, units of measure and link to the BCD concept (Annex 6).

Table 3.1 – Proposed themes and indicators to operationalize the BCD framework

<i>Layer</i>	<i>Themes</i>	<i>Indicators</i>
MATERIALIZED	UGS biophysical attributes	Spatial heterogeneity; Vegetation structure; Biological diversity; Functional diversity; Tree health and regeneration
	Welcomeness	Physical accessibility; Infrastructure and Amenities; Cleanliness/Neglect; Security
	Signs of memory carriers and socio-cultural symbols	Biological salient features; Cultural artefacts; Biocultural artefacts; Signs of prior use; Relicts and Remnants
	Neighbourhood physical attributes	Permeability; Complementarity; Park provision
LIVED	User group diversity (social identities)	Socio-demographic and other differentiation; Ethnicity/urban subcultures; Residence
	Neighbourhood socio-cultural attributes	Socio-demographic characterization; Local economy; Crime rate; Health status
	Space usage	Visitation rate; Frequency and duration; Uses and motivations to use; Social activities
	Interactions	Human-human interactions; Human-nature interactions
	Meanings, perceptions and values of users	Safety; Inclusiveness; Perceived UGS qualities; Biodiversity and Ecosystem services; Sense of place; Wellbeing; Conflict
	Memory carriers of place	Place memory; Reputation; Digital external memory; Local Ecological Knowledge (LEK); LEK transfer and exchange
STEWARDSHIP	Property-right regime	Conditions to access; Specific rules and norms
	Governance	Stakeholders; Opportunities and barriers;
	Civic practices	Stakeholders' activities; Citizen science; Civic ecologic/environmental practices; Engagement
	Management	Ecological practices

The suggested indicators measure elements of BCD that are strongly interrelated and mutually influencing. Their number is rather large as it relies in disaggregated information that, though potentially more difficult to obtain, interpret and share, have the advantage of providing clear place-based information on what is influencing the system and how or why. Aggregated information as in indexes, such as e.g., the UN-City Prosperity Index (CPI), offer a generalized perspective that can only indicate that something is happening, not giving information on the causes nor being open to the various viewpoints and perspectives (Wong, 2015). Indexes may obscure important information in the underlying data or may fail to recognize the complexity of the dimension of interest. In such cases, data in their raw, disaggregated form are often more useful than when clothed in a composite measure. The use of disaggregated indicators allows

these to be selected and referred to the specific issue under analysis, as will be demonstrated in the next section.

An underlying principle common to all diversity measurements is that they are teleological – that is, they are carried out for a specific purpose. A biocultural approach assumes a place-based definition of locally relevant goals, grounded on local cultural context, its values, perceptions and needs (Sterling, et al., 2017). As such, the proposed indicators are not meant to provide precise measurements of BCD with benchmarks to achieve, but a way of organizing and understanding information in contextual way, that offer a guidance to discuss and analyze the interaction between people, place and biodiversity and a foundation where to base policy decisions. Contextual indicators describe wider contexts, e.g. social or environmental, useful to understand how a phenomenon operates in each context (Hinks, 2014) and BCD indicators are therefore to be used for a specific purpose and context determined by “what, for what and for whom”.

3.3. How to operationalize the BCD indicators

The process begins by a clear statement of the purpose and precise objectives of the study and desired outcomes. Yet, different planning and management policies have different goals, different stakeholders seek different outcomes for their neighbourhood, and different user groups use and value greenspace in differing ways and seek differing qualities, functions and experiences. There are also questions on how to establish the relative importance of competing objectives. The way to tackle this problem is to fully engage stakeholders, from the problem definition to all stages of implementation, including the indicators selection. This allows for alternative understandings of the problem, and the identification of competing interests, priorities and constraints. Only when the problem is framed and articulated in a concise manner and an ‘agreement’ (of both institutional and local players) is reached, on what it is that should be sustained, it is possible to identify or interpret any indicators and apply more formal analytical tools. The need to involve all parties securing value, through direct or indirect use, in transparent decision-making process is widely supported, as the parties are more likely to actively engage in the process and solutions commonly agreed, and more prone to be implemented and well-accepted (Buijs et al., 2018; Gavin et al., 2018; Sterling et al. 2017).

This imply the broad use of participatory processes to decide which indicators are to be used, for whose objectives, of whom and what for, evaluated how and by whom. Greenspaces are often multi-functional in nature, serving a range of functions and parties. The first step of the process starts by building partnerships and collaborations between all parties securing value from the greenspace, including communities and stakeholders embracing people, place, environmental and economic value, and agreeing on discussion and decision models. This first step is by itself informative on Governance and Civic practices themes of the Stewardship layer as it will inform on existing actors and their ability to participate, engage, and have a real voice in the decision process. The participants can then agree on a discussion model, either workshops, focus groups or other commonly used participatory methodologies (Mayoux 2001, 2006) to clearly define the purpose and objectives of the study, characterize the problem and questions under analysis, discuss the current and future states, identify goals and desired outcomes, while defining the indicators, scale and time frame of the analysis and its monitoring frequency. Indicators are not only useful to measure progress but also to identify problems and set management goals. Goals and outcomes may be articulated as baselines or targets to achieve, or simply a direction where to move and indicators will be selected accordingly. Depending on the purpose, context and what the indicator is measuring, its relevance, robustness and sensitivity to change may vary.

Indicators chosen should be relevant for the question under analysis, aligned with city's strategic vision but reflecting the specific urban setting with its people, place and environmental values, and be sensitive to the changes induced by municipal policies and actions taken to address the question. To conciliate cities' strategic vision, usually aligned with broader regional, national and international goals and guidelines, with local needs and visions of optimal futures, requires negotiations between all concerned parties, preferably based on well-established and transparent decision methodologies, as no single solution will maximize the benefits for all groups. This can be achieved with any of the commonly used support decision system as Multi-Criteria Analysis (MCA), Analytical Hierarchy Process (AHP), Delphi methods, Q-methodology, World Café or any other (Castro & Urios 2016; Saaty 1987), to be discussed and agreed by the participants. This decision process is also useful to assess the importance and relevance of the indicators for the different parties, negotiate priorities and give weights to the indicators if wanted. It is essential for the participants to understand the terms and concepts involved, comprehend both the meaning of the indicators, and also what is measuring and what kind of information it provides. Moreover, that stakeholders themselves can initiate and/or use this set of indicators to monitor the progress and effectiveness of measures taken.

The indicators selection must be carefully balanced. If fewer indicators are generally better, mostly for time and resources consuming reasons, too many indicators may become too complex and difficult to implement. Yet, and though being commonly accepted to agree in a minimum set with the lowest number of indicators necessary, it is advisable to consider as much as possible the use of indicators from all themes as they, though apparently not relevant, may provide complementary information important to contextualize the issue. Restraining the number of indicators due to limitations on information or resources availability can drive to weaknesses in the snapshot of the current situation prior to any intervention, fail uncover hidden aspects and lead to biased interpretations. The lack of information may not necessarily represent a shortfall of the process. For each indicator we suggest one or more metrics, of different levels of detail and resources investment, conceived to be as much as possible easily measurable and interpretable under objective criteria. With several possibilities available it is likely to find a suitable one but even though, the lack of data it is not necessarily constraining or impeditive of proceeding with the process. A lack of information may be informative by itself, expressing that some problem or deficiency needs to be addressed. Furthermore, this tool is not an end-product but rather expandable and improvable at any time and in any way, with indicators issued from the participatory processes. In addition, depending on the importance and relevance given to each indicator during negotiations, some potential indicators lacking information may be dropped under agreement. The number and type of indicators to be selected will thus vary as a function of the GS typology, the project scope and what, in each circumstance, is considered important for the parts.

To make sense and convey a meaningful message, each indicator must be scored through a rating system that translates the indicator value to an interpretation of its meaning regarding the question under appreciation and compares it to the desired outcomes. This scoring system involves two steps. The first transforms all variables into a quantitative variable, for which we propose a 5-point scale or a 5-classes grouping depending on data type and structure. Quantitative variables may be rescaled to a 5-point scale using the indicator highest and lowest values or using any other appropriate method as linear interpolation (Lu et al., 2016), or grouped in 5 categories, classes or generally accepted strata as for e.g. age, education. Qualitative variables can be inductively classified into 5 groups, while those based on self-assessment Likert scales or scoring scales e.g. for site quality, can be directly used in the next step. The second step involves rating each indicator in a 5-point scoring scale that translate the indicator value to an

interpretation of its performance regarding the question under appreciation. Scoring criteria are based on UGS typology and intended function, locally and in the overall socio-ecological network, and the perspective from which it is analysed considering the purpose of the analysis. As an example, depending on whether the desired function for a greenspace is to maximize the number of species representative of city's biodiversity, to serve as a repository of native species for educational purposes, or to maximize aesthetical appreciation, a naturalness metric would score higher in the first and second cases and, probably, lower in the third situation. Criteria must be as much objective and accurate as possible, to maximize comparability and minimize subjectivities of personal interpretations (Wong, 2003), while being adjustable. Urban greenspaces are highly dynamic systems. Changes in its biophysical structure and/or surroundings influence the way people use, perceive and experience the space and indicators should be able to reflect this. People and cities' need change over time, so do the desired outcomes, and criteria need to be revised and adjusted accordingly. This two-step 5-point scoring system allow to convert all indicators, independent of its nature, into a single, quantitative, uniform and thus comparable value. Also, is easily understood and usable by lay people, and allow to assess temporal trends by scoring how it was in the past and foreseen in the future.

Scoring criteria define the meaning to assign the indicator while the score measures how well it performs in regard of that meaning. This involves the comparison with some standard of measurement, expected value or reference. When dealing with biocultural indicators there is no a priori defined reference values or general standards to which compare to and the indicator is scored as it would imply an assumption on how a UGS should be or should be experienced. Reference values refer to the objectives and desired outcomes negotiated during the decision process and the indicator score measures how the indicator is performing in relation to that specific outcome. This allows to establish *called benchmarks* (Ammons, 2014), representing the target to achieve in a vision of the community and local government desired future.

As mentioned above those negotiation processes will have to consider the strategic vision, major planning options and existing rules and norms, quality standards for recreational greenspaces or for organic production in allotment gardens, along with current knowledge on social and ecological sciences, namely climate change adaptation, landscape preferences, ecological functioning, affordances or place making theories. In the absence of negotiation processes, as in those conducted by the municipalities to e.g. establish a knowledge baseline or assess where the UGSs stand regarding the city's strategic vision, these can be used to establish the so-called

ratified values, a “value attributed by institutions acting in the name of the community and public interest” (Cassatella, 2011; p.110) and use these as references. This reference system allows to establish *performance benchmarks* (Ammons, 2014) to which greenspaces are compared, considering not only the UGS under analysis but also where it stands and its functions in the broad context of its neighbourhood and that of the green infrastructure. Yet, it should be noted that these institutional criteria may fail to address user’s needs and result in solutions disconnected from the local reality.

Another possibility is to use a reference site or a narrative of an ideal space as an example of best practices and desired outcomes, and then the scores assess how distant the UGS under analysis is from the reference site; a reference in the outcomes not in the solutions adopted to reach those outcomes. To assume the solution as a reference risk the standardization of what and how a greenspace should be, and the transposition of success solutions to other places decontextualized from the local reality, needs and desires. This kind of reference allows establishing “best practices” benchmarks where a site is compared to an outstanding performer, to analyse the circumstances that account for better results and seek ways to adapt practices and make them suitable for its own use.

Either way, scores assess how the indicator behaves regarding the chosen reference and, by establishing local benchmarks, the indicators can be compared between sites and even cities, not in absolute value but how they behave regarding the locally established benchmarks. When existing, benchmarks are framed by the question itself and the scenario envisaged by planners and the community, and the indicators will inform on where they are in relation to that locally defined goal. Provided that the same question is assessed with the same set of indicators and metrics, scored under the same agreed rating criteria, this tool can be used across scales as indicators are being scored under a common system.

In summary, to each metric it is necessary to define scales and/or classes which to allocate metric’s measurement, and scoring criteria, defined and agreed among partners or stakeholders, according to context, question raised and desired outcomes, if any. With rating scales defined, each metric can be scored accordingly. If wanted, scores can be weighted according to schemes reflecting locally defined goals and then graphed for visualization or analysed with adequate methods. Scores weighting however must have been agreed during the negotiation process based on their relevance and importance. Weighting an indicator, when not done through sound

governance processes, involves a pre-assumption of its importance and may be subject to arbitrary and subjective judgement or lack of transparency (Wong, 2003). Even so, using weights can significantly alter overall scores and drive the attention to a few “heavier” indicators that blur the overall picture. With all indicators translated to a 1 to 5 score it will then be easy to visualize the results either with spider graphs or in a GIS, as showed in the next section. Though several indicators not being of spatial base they always refer to a specific place and can be represented in a qualitative GIS. These visualizations turn the indicators and their interplay easily understandable and adequate to further analysis, interpretation and sharing.

The overall process and its steps is depicted in Figure 3.1

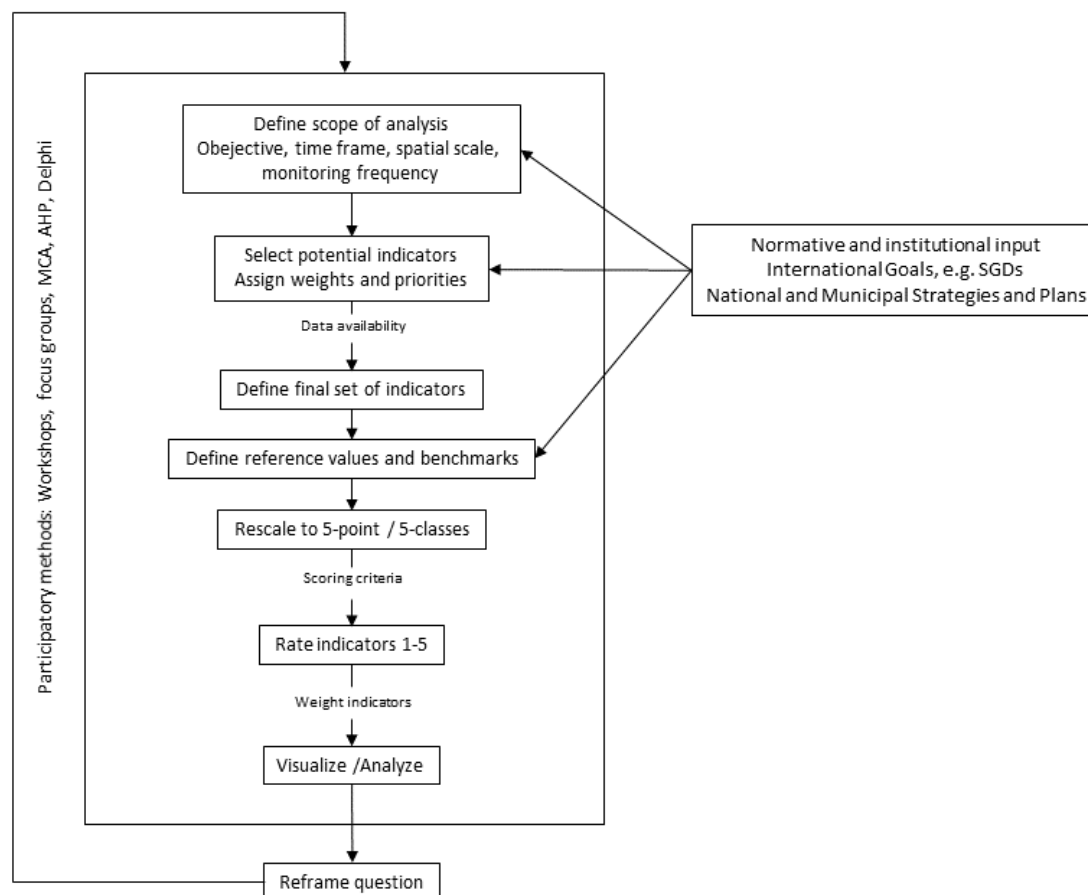


Figure 3.1 – Flowchart of the indicator-based process

3.4. From theory to practice: application of BCD indicators to Lisbon UGSs

Twelve urban parks in Lisbon (Portugal), representing a gradient of urbanization density and variety of designs, facilities and neighbourhoods, were used as a test-bed of BCD indicators in

the frame of GREENSURGE project (<https://greensurge.eu/>). The study involved, amongst other, multi-taxa biodiversity sampling and face-to-face questionnaires to park users addressing motivations to visit the parks and perceived benefits from those visits. The details for park selection and sampling methodologies are available in Vierikko et al. (2020) and Gonçalves et al. (submitted). For demonstrating the usefulness of BCD indicators here we departed from the question “*are the studied parks addressing the needs of their users and neighbourhoods?*” assuming a social function of recreation and mental restoration, and an environmental function of mitigate the urban heat island effect. These were the assumptions supporting the scoring criteria used to rate parks, with the best performer of each indicator being the reference for the others. Metrics, scaling systems and scoring criteria are shown in table 3.2, with data sources, raw data and scores for all parks being provided in supplementary information (Annex 7 and 8).

Table 3.2 – Indicators used to test the tool with metrics, scaling and classifications used to re-scale each in a 5-point scale, and scoring criteria to rate the indicator

Theme Indicator Metric	Scale/Classes	Scoring criteria
UGS biophysical attributes Vegetation structure Canopy cover (<i>COV</i>)	Mean canopy cover rescaled to 1-5	1 – Lower cover - lower mitigation to 5 - Higher cover-higher mitigation
Welcomeness Cleanliness and maintenance Cleanliness (<i>CLN</i>)	1- No signs of litter/ dog poop to 5 - Visible litter/dog poop; overloaded trash bins	1 - Visible litter - Very unclear, inviting and unwelcoming; 5 - No signs of litter - very clean, inviting and welcoming
Neighbourhood characteristics Complementarity Complementary in 300mt (<i>CPL</i>)	1 - Absence of complementary GS to 5 - High provision of complementary GS	1-Poor provision of complementary features; 5 - Very good provision of complementary features
User group diversity vs Neighbourhood cultural characteristics Socio-demographic and other differentiation Age and education (<i>AGE, EDU</i>) strata	Absolute difference between strata percentages rescaled 1 to 5 1 – No difference between users' and neighbourhood age/education strata to 5 – Very large difference between users' and neighbourhood age/education strata	1 – Neighbourhood not reflected in users - Potential high self-exclusion processes to 5 - Neighbourhood reflected in users - No self-exclusion processes
Meanings, perceptions and values of users Satisfaction with space Complaints about UGS (<i>SAT</i>)	Number of referred annoyances per visitor interviewed rescaled 1 to 5 1 - low percentage of complaints to 5 - High percentage of complaints	1 – Lower satisfaction with space to 5 - Higher satisfaction with the space
Sense of place Is this place special? (<i>SPE</i>)	Percentage of users referring connection with place rescaled 1 to 5 1 - Low percentage of users to 5 - High percentage of users referring connection with place	1 - Lower emotional bond to the place 5 - Higher emotional bond to the place
Wellbeing Perceived Restorativeness (<i>PR</i>)	Weighted average score (1-5) of the Perceived Restorativeness Scale 1 - Low PR score to 5 - High PR score	1 - Lower perception of psychological restoration to 5 - Higher perception of psychological restoration

As we assumed an environmental function of cooling the temperature and reduce the urban heat island effect the higher canopy cover the higher the score attributed. If, on the other hand, the interest was just the park's recreational and mental restoration function, the scoring criteria would have been based on landscape preferences or affordances theories referring the preference for a mixture of open and closed areas (Jiang et al. 2015); thus, the scoring criteria would score

the extremes of openness and closeness as low and a proportionate mixture of open and closed covers as the highest.

To be easily understood by decision-makers the final scores may be visualized using a coloured results matrix, as in table 3.3, or a GIS map, as in Figure 3.2.

Table 3.3 – Result matrix (columns – Parks; rows – Indicators) for the twelve parks in Lisbon: 1 – Mata de Benfica; 2 – Mata de São Domingos de Benfica; 3 – Parque Recreativo do Calhau; 4 – Miradouro de Montes Claros; 5 – Alameda Keil do Amaral; 6 - Tapada das Necessidades; 7 – Jardim da Estrela; 8 – Jardins Gulbenkian; 9 – Mata da Quinta das Conchas; 10 – Mata de Alvalade; 11 – Parque Urbano de Vale do Silêncio; 12 – Parque Urbano do Vale Fundão; COV – Canopy cover; CLN – Cleanliness; CPL – Complementarity; AGE / EDU – Representation of neighbourhood’s age and education; SAT – satisfaction with space; SPE – Connection with place; PR – Perceived restorativeness

Scores color code

1	2	3	4	5
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Park Ind	1	2	3	4	5	6	7	8	9	10	11	12
COV	3	4	4	4	3	2	3	3	4	3	4	2
CLN	4	4	4	4	4	3	4	4	2	3	4	2
CPL	3	1	1	4	3	1	2	4	4	4	3	2
AGE	3	2	4	4	1	3	4	2	4	1	4	1
EDU	4	3	4	4	1	3	4	2	3	4	4	2
SAT	2	3	3	4	4	1	4	4	2	1	2	1
SPE	3	3	3	1	4	4	4	3	4	2	4	1
PR	2	3	4	4	4	3	3	4	2	2	3	1

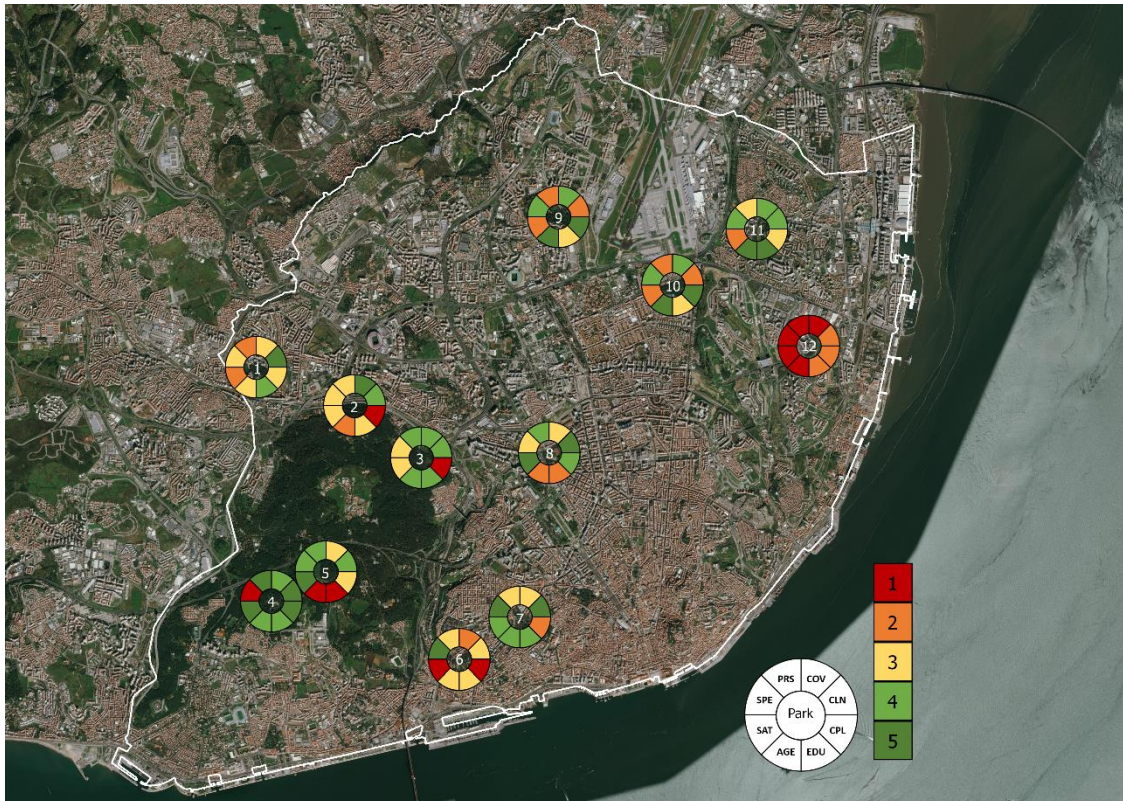


Figure 3.2 – Map visualization of the twelve parks with scores represented by a color pattern.

This colouring system allows to rapidly visualize how parks perform in the various indicators assessed and which aspects are in need of intervention. Although a more profound analysis of observed differences is out of scope of this work, one park (VFundão) stands out by its clear low scores in all indicators, namely on those comparing demographic strata of users and neighbourhood suggesting self-exclusion phenomena. Another park (Gulbenkian) also displayed low scores in those indicators, in spite of being a very well-known high quality park in Lisbon (Luz et al. 2019). As such, we re-initiated the process, adding other indicators to understand why these two parks were not fulfilling the neighbourhood needs. For this analysis we added indicators related with spatial heterogeneity, biological diversity, infrastructure and amenities, security, biological salient features and cultural artefacts, frequency and duration of visit, human-human interactions, and reputation. Site quality was assumed as a site offering a clean and safe welcoming environment with adequate number of well-maintained amenities and facilities and these were the assumptions considered to set the scoring criteria for these indicators, considering the overall range of the twelve parks. Data, scaling and scoring criteria for these indicators are available in supplementary information (Annex 3).

Gulbenkian, located in a wealthy neighbourhood, is a very well-known and one of the most visited parks in Lisbon (Luz et al., 2019). It offers a very well-kept, highly diverse environment with numerous amenities of excellent quality, providing high levels of well-being and place attachment (Figure 3.3). On the contrary, VFundão, located in a low socio-economic status neighbourhood, scores much lower in all indicators related with space layout and quality, the same being observed for stated well-being and connection with place. This park is clearly not addressing the needs of its users, revealed by a very low satisfaction level, nor accomplishing its role of a place for mental restoration; however, it plays a very important social role as a place of meeting and being together, as shown by much frequent visits and higher rates of active interaction between users (Figure 3.3).

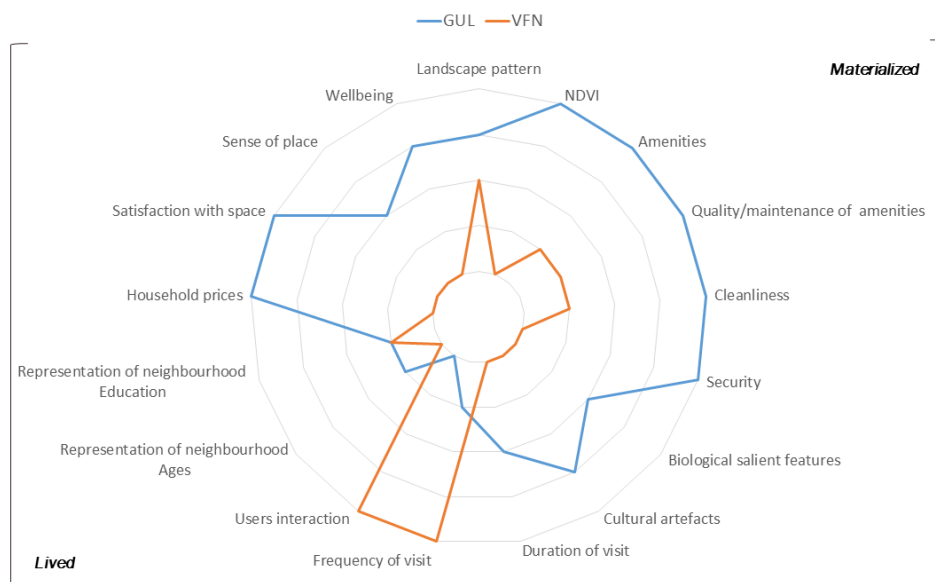


Figure 3.3 - Application of BCD indicators for two urban parks in Lisbon (GUL – Gulbenkian; VFN – VFundão)

In spite of the major differences in most indicators, both parks score low in what concerns the representation of neighbourhood's demographic classes in park's visitors. While VFundão is mainly used by elderly and less educated people, lacking a representation of the young educated adults from the neighbourhood, Gulbenkian is mainly visited by young, highly educated adults, not being visited by the older and less educated people inhabiting in the neighbourhood. To discard the possibility of the observed result being the result of a preponderance of visitors not coming from the neighbourhood, we used the "Distance to home/work" indicator that showed that 70% of the interviewees lived at less than 1km away and kept fairly the same education levels distribution (data in Annex 8). This suggests self-exclusion processes in both parks, in

VFundão likely due to the lack of facilities and attractive features, and in Gulbenkian probably due to a non-belonging feeling. It became apparent that both parks are not addressing their neighbourhood needs and if for VFundão the self-exclusion phenomena raises issues related with space welcomeness, which should be addressed by the city council, for Gulbenkian the complementarity indicator shows the existence of other UGS that could be fulfilling the needs of the population.

The two analysis here exemplified demonstrate the usefulness of BCD indicators to evaluate the performance of already established urban recreational parks, but this indicator-based tool is designed and meant to be used in any kind of urban greenspace to address site-specific questions.

3.5. Discussion and conclusions

This article proposes a new indicator-based tool intended to facilitate UGSs strategic planning and decision making in compliance with the [United Nations \(UN\) Sustainable Development Goal 11 - Make cities and human settlements inclusive, safe, resilient and sustainable](#). Making cities sustainable involves, among other actions, investment in creating green public spaces and improving urban planning and management in participatory and inclusive ways. Moreover, as part of a mosaic governance approach, the challenge is to “*combine the planning-based, long-term vision for spatial greenspace networks with local people’s enthusiasm and dedication manifested in locally embedded - but usually not spatially interconnected - initiatives from active citizens*” (Buijs et al., 2018). As quoted by Arslan et al. (2016, pp), to monitor progress regarding SDG 11, “*there is a need for globally-identified and comparable indicators that can translate information obtained through evaluation into information relevant to policy-making and planning at the neighbourhood level*”. These challenges align well with the BCD conceptual framework proposed by Elands and colleagues (2018) and was the underlying motivation for this study. By achieving our initial goal and being able to test it in practice, we believe to have contributed to reach a scientifically justified development and application.

This indicator-based tool has a few key characteristics. It is teleological: It presupposes the existence of an underlying research question “of what, for what and for whom” upon which the choice and selection of indicators, metrics, scales and scoring criteria are based. Though being informative on its own, indicators are not supposed to be used individually and isolated but in conjunction with others for a complete and integrative view of the UGS, not only at the local scale but considering also their location and function in the Urban Green Infrastructure. The

fundamental point is to integrate the information of all relevant indicators to identify synergies and/or conflicts and then weight and negotiate trade-offs. It is not prescriptive or intended to provide solutions but instead offers conceptual guidance and communicates priorities while recognizing that processes will develop differently in different cities, neighbourhoods and UGS typologies. When existing, benchmarks are framed by the question itself and the scenario envisaged by planners and the community, and the indicators will inform on where they are in relation to the locally defined goals and desired outcomes. This tool moves thus from a pure technical and normative approach of “generating the right indicators and then tailoring the solution in order to get the indicators ‘back on track’” (Scerri & James 2010) to a more reflexive constructivist approach that considers that nature is not something out there, it is socially constructed and co-created (Buizer et al., 2016) and its planning and management needs to be adjusted to the local realities.

This tool brings together essential information scattered over several tools and offers a policy-driven instrument able to capture trade-offs and/or synergies between ecological, social and political domains. By suggesting detailed indicators for each dimension, that are mostly part of either cities’ monitoring systems or outputs of modern city governance, and given the possibility to establish its own benchmarks, this BCD tool can be used to compare multiple greenspaces in a city helping to address e.g. environmental justice and equity situations, or even to compare greenspaces of different cities. The operationalization includes both top-down as well as bottom-up indicators and assessment ideas in a framework that is at any time and in any way expandable and improvable. Although proposing informational criteria to respond at the neighbourhood or city level, this approach can be used and comparable at a regional or even global scale, if common defined goals and agreed scaling and scoring systems are uniformed among cities to make clear what means what to whom. The next step to prove the tool’s feasibility to study UGS through the lenses of BCD is, thus, to analyse UGS in several European cities to evaluate how it performs in different local contexts. This new tool may thus represent a powerful and holistic planning and decision support instrument that fulfils the demand of bringing together existing concepts and developing tools to assist decision-making processes towards more livable, equitable, sustainable and resilient cities.

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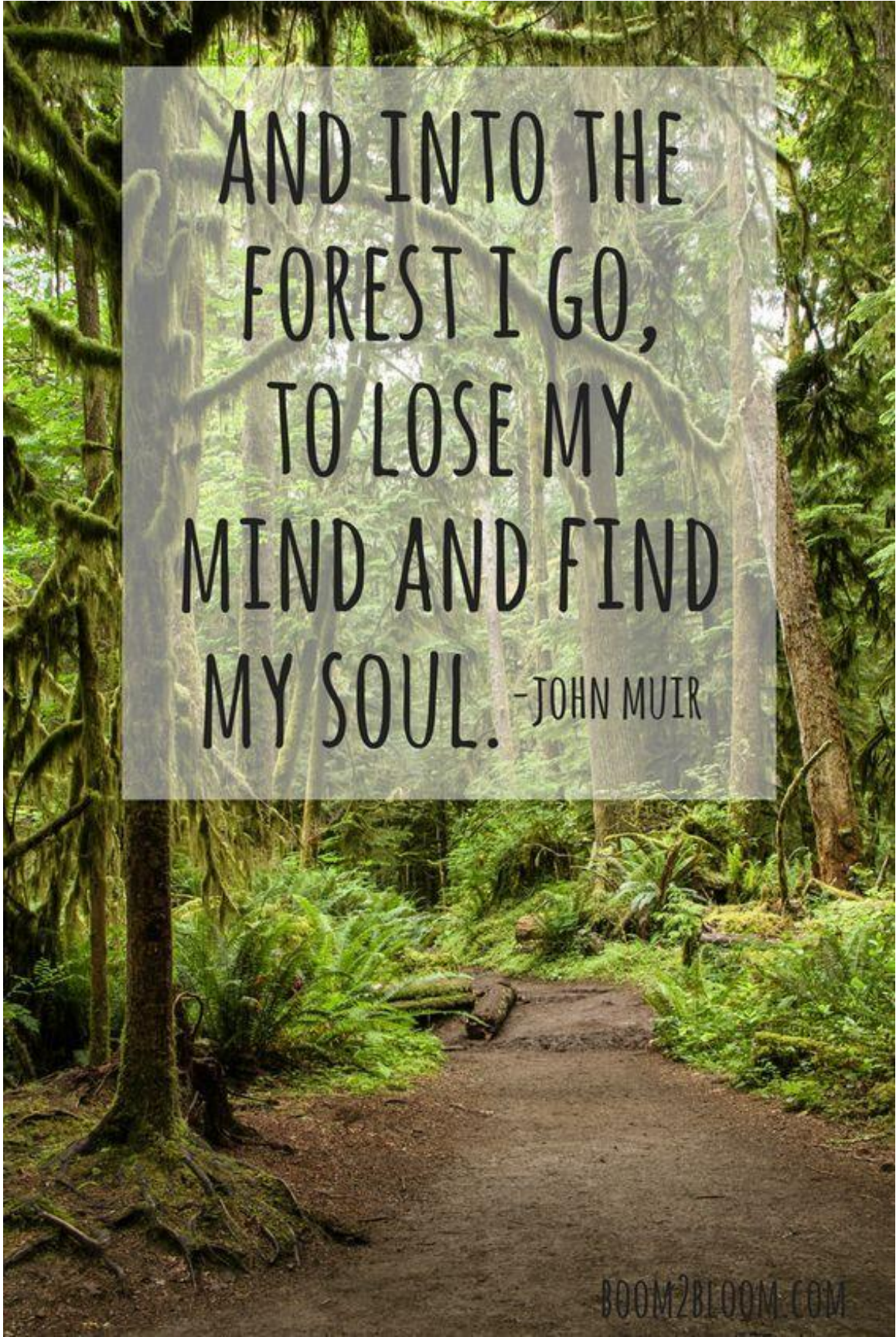
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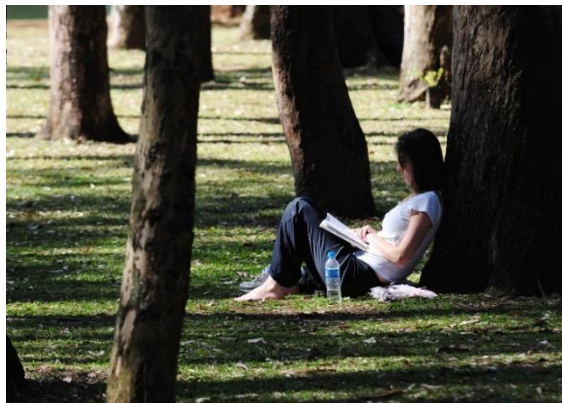
AND INTO THE
FOREST I GO,
TO LOSE MY
MIND AND FIND
MY SOUL. -JOHN MUIR

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CHAPTER 4

Biocultural diversity (BCD) in European cities – Interactions between motivations, experiences and environment in public parks

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Abstract

Urban green spaces (UGS) provide multiple benefits, and public parks in particular have a key role in supporting ecological and social sustainability in cities, contributing to human-nature interactions. We studied the interrelationships between uses, experiences and the environment by adopting a novel concept of urban biocultural diversity (BCD). The concept identifies three interlinked spheres of urban BCD: materialised, lived and stewardship. We conducted place-based research in 33 parks located in four European capitals: Helsinki, Berlin, Bucharest and Lisbon. A total of 1474 visitors were interviewed concerning their motivations to use the park and their experiences during the visit. Using an open-ended survey, we revealed more than 50 motivations for park use and over 100 features people enjoyed during their visits. On the other hand, visitors mentioned far fewer things that disturbed them (60). We revealed that despite the fact motivations to use parks were strongly human oriented, visitors widely enjoyed the environmental characteristics of parks, and especially nature. We found that parks located in neighbourhoods with low socio-economic status and outside the central area of the city were structurally less diverse than parks located in the city core. The structurally diverse parks enhanced motivations to use them, and increased overall enjoyments of the environment. We revealed clear differences in motivations and enjoyments between cities, implying that the day-to-day practices of people using and experiencing nature varies between cities.

4.1. Introduction

4.1.1. The importance of urban green spaces for cities and citizens

Our world is facing rapid urbanisation. Nowadays urban residents spend most of their time in human-constructed environments (Matz et al., 2015). Consumer-oriented lifestyles in densely built-up urban areas do not support multi-sensory engagement with the natural environment, e.g. listening to birds or following seasonal changes (Pretty et al., 2009; Puppim de Oliveira et al., 2011; Soga and Gaston, 2016; Stokols, 2018). Urban green spaces (UGS) such as forests, public parks or community gardens provide diverse opportunities for residents to interact with nature, and for human-oriented activities such as exercise, relaxing or meet other people (Elands et al., 2018a; Kabisch et al., 2014; Vertovec, 2007). The benefits of UGS are widely acknowledged as they contribute to climate change adaptation, local biodiversity conservation, social cohesion and the well-being of residents (Bertram and Rehdanz, 2015; Bratman et al., 2012; Hansen and Pauleit, 2014; Hartig et al., 2014; Kabisch et al., 2014; Nielsen et al., 2014; Pauleit et al., 2017). The ways in which cities and their green spaces are planned and developed have a considerable effect on the accessibility to use and enjoy the benefits provided by UGS. With a decreasing

amount of free spaces in densely-built growing cities, urban planners and policy-makers address the importance of planning concepts such as urban green infrastructure (UGI) and strategies for multifunctional UGS (Hansen and Pauleit, 2014; Pauleit et al., 2017).

Multifunctionality of parks represents the capacity of UGS to provide several ecological, socio-cultural and economic benefits concurrently, while avoiding conflicts and trade-offs (Hansen et al., 2016; Sussams et al., 2014). Park characteristics such as vegetation structure, facilities and services have a key role in supplying multifunctionality (Konijnendijk et al., 2013; McCormack et al., 2010; Schetke et al., 2016; Voigt et al., 2014). However, green spaces have often been introduced as undifferentiated and uniform spaces, focusing on facilities and services, with little attention paid to the level of vegetation structure or biodiversity of parks (Ives et al., 2017). Recent studies have revealed that diverse vegetation can make green spaces more attractive and restorative (Fuller et al., 2007; Hoyle et al., 2017, 2019), and biotope and plant species richness of UGS is highly appreciated (Fischer et al., 2018a; Voigt and Wurster, 2015). However, on-site experiences (either positive or negative) are also dependent on the specific context of visits (Qiu et al., 2013). Each green space is located in a specific urban context and has unique environmental characteristics that influence how people use, experience or perceive its benefits (Hoyle et al., 2019). Although there are several studies focusing on human-biodiversity interactions within parks, comparatively little is known about the different motives to use green spaces in relation to the on-site experiences of visitors. It is unclear how activities such as walking a dog, meeting friends or relaxing are connected with actual experiences, and what the role of park characteristics in these interconnections is (e.g. Botzat et al., 2016; Dallimer et al., 2012; Fischer et al., 2018a; Palliwoda et al., 2017). A biocultural diversity (BCD) approach offers a novel way to study these relationships and the multifunctionality of UGS.

4.1.2. Biocultural diversity and urban green spaces

To analyse multi-dimensional relationships between people and nature in cities, a framework of biocultural diversity (BCD) for the urban context has been developed (Elands et al., 2018b; Vierikko et al., 2017a). Originally, the concept of BCD was developed in the 1990s in order to denote the diversity of life in all its manifestations – biological, cultural and linguistic – which co-evolve within complex socio-ecological systems (Maffi, 2012). BCD focuses on interrelationships and interdependencies between people and nature, and diverse ways in which people live with nature (Buizer et al., 2016). Elands et al. (2018b) and Vierikko et al. (2017a)

identified three interlinked spheres for human-nature relationships: materialised, lived and stewardship. Lived BCD is the central sphere as it refers to the day-to-day practices of people using and experiencing nature in cities. It concerns interrelationships between people and nature, as well as perceived and experienced nature, while acknowledging *diversity* as an inherent entity of BCD (Vierikko et al., 2017b). While lived BCD is primarily mediated through experiences and perceptions, stewardship BCD is an active, conscious engagement in the shaping of such assemblages (Elands et al., 2018b). Materialised BCD primarily refers to the tangible expressions of human-nature interactions and socio-ecological processes (Elands et al., 2018b). Cultural landscapes, of which we have many in Europe, where biodiversity was modulated over centuries by traditional agricultural practices, is one example of materialised BCD (Elands et al., 2018b; Pungetti, 2013; Taylor and Lennon, 2011; White, 2004). Structural characteristics such as vegetation, cultural artefacts and facilities manifest the human-nature relationship of a single UGS. However, materialised BCD is more than a sum of its measured tangible elements; it also relates to the history of UGS, articulating previous political, socio-cultural and economic conditions (Byrne and Wolch, 2009; Millard, 2010).

As our study is aimed at giving a more explicit picture of the relationships between motivations, experiences and park characteristics, our focus is on lived and materialised BCD and not on active engagement with nature (stewardship BCD). Lived BCD in our study refers to motivations to use parks and experiences during the park visit. We were especially interested in the *diversity* of motivations and experiences, and the interlinkages between them. Materialised BCD was studied through structural characteristics of parks (biotopes, vegetation, facilities, cultural artefacts), taking the surrounding urban context into account. As our study wants to study motives and experiences during the actual park visit, we chose a place-based research approach to analyse lived and materialised BCD in public parks (Balvanera et al., 2017; Buizer et al., 2016; Elands et al., 2015; Vierikko et al., 2016). The place-based focus was further strengthened by the selection of a variety of parks within four European cities that cover a geographical range from north(-east) to south(-west), including very different development paths and histories of the cities. We defined a park as a publicly accessible green area within a city that is intended for recreational use by urban dwellers and includes a wide range of biophysical and cultural elements, such as trees, shrubs, flowering plants, mown lawns, playgrounds, water bodies and sculptures (Cvejic et al., 2015). The main objectives of this study are:

- What are main motivations to use parks and how are they connected with actual experiences?

- Do motivations and experiences change along with the structural characteristics of parks?
- Do interlinkages of motivations and experiences differ between cities?

Figure 4.1 visualises the interrelations between our main analytical concepts.

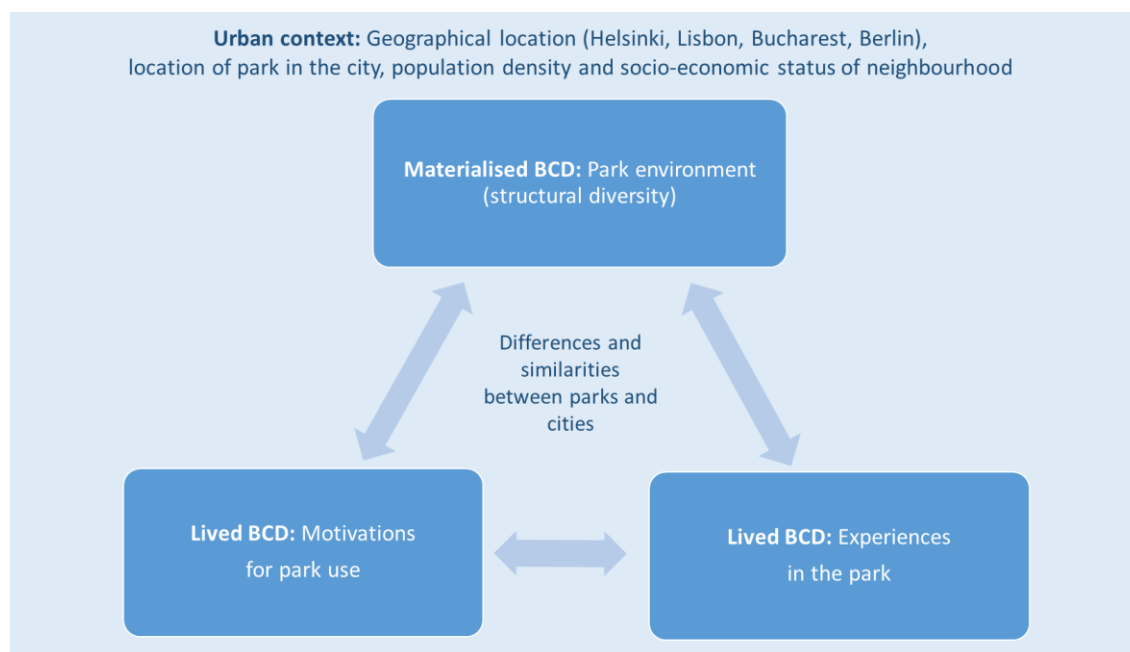


Figure 4.1 - Framework for park visitor research, inspired by the biocultural diversity approach as developed by Elands et al. (2018a, 2018b) and Vierikko et al. (2017a). Every park is located in a unique urban context, has specific characteristics (materialised BCD) and is used and experienced in a variety of ways (Lived BCD).

4.2. Methods

4.2.1. Materialised BCD: Park characteristics

The research was conducted in 33 publicly accessible parks in four European capitals: Helsinki (Finland), Berlin (Germany), Bucharest (Romania) and Lisbon (Portugal), as part of the EU FP7 GREENSURGE research project (2013–2017). The methodological design was developed by the Universities of Helsinki (UH) and Lisbon (FCUL) and also applied by teams at Humboldt University Berlin (HUB) and the University of Bucharest (UB). The studied parks needed to fulfil certain criteria: they are publicly accessible, intended for recreational use, and include a variety of biophysical and other structural characteristics. The studied parks represent a gradient of urbanisation and cover a variety of designs, facilities and neighbourhoods, from city centre to suburbs, except in Berlin where all the studied parks were situated in the dense urban area. Furthermore, the selected parks needed to represent neighbourhoods with varying socioeconomic status. Due to the limited resources available (labour and financial), in Berlin and Bucharest fewer parks were selected: three parks in Berlin and six in Bucharest. The specific

location of all the studied parks can be found on the Google map: (https://drive.google.com/open?id=1u68fx_gi52YodcK9o8cj7ujWoCs&usp=sharing).

We investigated the structural diversity of parks by measuring the number of biotopes, facilities, services and artificial elements, and estimating density of vegetation structure. We then gave a qualitative value (low – medium – high) for each structural characteristic relative to the size of park, except for biotopes (Table 4.1). Moreover, we identified the locations of the studied parks along the gradient from city centre towards the periphery, the population density and the socioeconomic status of the surrounding neighbourhoods (Table 4.1). Tangible characteristics and the surrounding urban contexts at park level are presented in Annex 9.

Table 4.1. Four structural characteristics (biotopes, vegetation structure, facilities & services, artificial elements) identified in 33 parks describing structural diversity of park and three variables (population density, socio-economic status, gradient) for surrounding urban context, and description of values used in analyses.

Structural diversity	Value	Description of value
<i>Biotopes:</i>		
Woody patch, wetland, meadow, lawn, flower-bed, water pond	0-6	The number of biotopes in the park
<i>Vegetation structure:</i>		
Vertical and structural density of vegetation	1	Low vegetation with sparse density (few trees)
	2	Medium dense with some large trees and shrubs
	3	Dense and multi-layered vegetation
<i>Facilities & services:</i>		
Benches, cafes, playground, sport equipment, dog area, social games	1	Park has few benches or other facilities
	2	Park has many benches and few other facilities
	3	Park has many different kinds of facilities & services
<i>Artificial elements:</i>		
Artistic works, buildings, constructed water elements, statues	1	Park has few artificial elements
	2	Park has some artificial elements
	3	Park has many different artificial elements
Urban context	Value	Description of value
<i>Population density:</i>		
Permanent residents living nearby the park	2378-23233	Population density (n/km ²) within 500 m radius of the park
<i>Socio-economic status:</i>		
Overall socio-economic status of neighbourhood the park is situated based on general statistics of average income	1	Low
	2	Medium-low
	3	Medium
	4	Medium-high
	5	High
<i>Gradient:</i>		
Distance from die park to the central area of city	1	Central area
	2	Semi-central
	3	Suburb or periphery

4.2.2. Exploring lived BCD of parks

We conducted an on-site questionnaire with open-ended questions with visitors in the 33 studied parks. The survey followed a qualitative approach with open questions allowing respondents to express their motivations and experiences in their own words, which are commonly lost with pre-determined response categories. Our questionnaire was based on earlier studies in the field of place-based research (Vierikko and Yli-Pelkonen, 2019). By choosing an on-site study method, the researcher is part of the actual experience and the responses reflect the respondents' multiple experiences in real-life situations (Elands et al., 2018b). We conducted the survey in Helsinki and Lisbon in the summer of 2015, and in Berlin and Bucharest in the summer of 2016. We interviewed visitors during weekdays and weekends, while avoiding extreme weather conditions (rainy, hot ($> 30\text{ }^{\circ}\text{C}$) and cold ($< 10\text{ }^{\circ}\text{C}$)) and times of public events in the parks. We approached park visitors of different ages (over 13 years) and gender, and identified ethnicity to achieve a truly representative sample of park visitors. Foreign tourists were excluded, and we only interviewed people who currently lived in the relevant country. We asked if the park visitors would like to respond to the survey and briefly explained the research. In total, 1474 visitors accepted the invitation to respond to the survey.

The questionnaire covered several topics regarding the motivation for visit, frequency of park use, experiences, perceived biodiversity and well-being, as well as the visitor's socio-demographic and cultural background, e.g. gender, age, marital status, education level and birth country. However, for the purpose of this paper, the analyses were limited to motivations and park experiences. Table 4.2 shows how the open questions were formulated and answers interpreted. The responses were content-analysed by local researchers in each study country. Different motivations and experiences were then coded under descriptive themes. The themes were inductively developed based on the answers. The themes and codings of open answers were agreed and synchronised between research teams in different cities. Detailed results of motivations and experiences at park level are provided in Annex 10. We computed correlations among variables by using Spearman's non-parametric test. Statistically significant differences between different types of parks and cities were tested using the Kruskal-Wallis non-parametric test. All statistical testing was performed using IBM SPSS Statistics 24 and R Studio.

Table 4.2. Characteristics of questionnaire with respect to park use and experience.

Question asked by interviewer	Type of question and coding the answer	Categorizing the answers
In terms of today, why did you come to (what you are planning to do in) the park?	Open-ended: respondent could mention more than one motivation for coming in their own words. All mentioned reasons were coded as 0 (not mentioned) or 1 (mentioned) for every respondent.	All mentioned motivations were grouped under the themes that were inductively developed and synchronized among researchers in four cities.
What do you enjoy when you visit?	Open-ended: respondent could mention several things they enjoyed in their own words. All mentioned enjoyable aspects were coded as 0 (not mentioned) or 1 (mentioned) for every respondent.	All mentioned enjoyments were grouped under the themes that were inductively developed and synchronized among researchers in four cities.
Is/was there anything that disturbs/ disturbed you during your visit?	Open-ended: respondent could mention several things that disturbed them. All mentioned disturbing things were coded as 0 (not mentioned) or 1 (mentioned) for every respondent.	All mentioned disturbing factors were grouped under the themes that were inductively developed and synchronized among researchers in four cities.

4.3. Results

4.3.1. Motivations and linkages with experiences

Overall, park visitors mentioned over 50 different motivations for their visit. We grouped them under nine themes: (1) social relations, (2) mobility-based recreation, (3) stationary-based recreation, (4) relaxation & well-being, (5) park characteristics, (6) nature-related, (7) facilities & services, (8) location of park, and (9) weather (Table 4.3).

People were mostly motivated by mobility-based recreation (n=515), such as walking a dog, exercise, walking in the park (Table 4.3, Figure 4.2). Social relations (meeting friends or having a picnic) were the second most important motivation for park use (n=370). Crossing the park on the way to somewhere else or using the park due to close-to-home location were also mentioned quite often (n=282). The park visitors frequently expressed multiple motivations for their arrival, ranging between 1 to 7 reasons, and on average having 1.4 reasons. ‘Walk & talk’ (with friend/spouse) was an example of a social relation linked with mobility-based recreation. Many respondents mentioned multiple reasons such as ‘meeting friends, playing and relaxing’ or ‘good weather, relaxing and nice to watch people’. In all three of these examples social relations were involved, but from different aspects: the first two examples described the park as a place to meet friends or other familiar people, while the latter was related to social life at the park.

Further analysis of the different themes of motivations and experiences revealed two key domains: human and environment. We grouped the first four themes under the human domain, which included motivations that emerged from personal properties or social dimensions following theories of place meaning and sense of place (Sixsmith, 1986; Gustafsson, 2001). Park

characteristics, nature-related, facilities and services were grouped under the environment domain as they represent tangible or intangible (e.g. clean air) characteristics of the park.

Only 212 visitors (12%) mentioned environment-based motivations for their visit, and within this domain, 74 people mentioned nature-related motivations for their visit. '*Watching birds*' or '*feeding ducks*' were commonly mentioned nature-related activities and '*breathing fresh air*' can be understood as a nature-based benefit provided by the park. Environment-based motivations were linked with relaxation at the park in general, but often also with the specific location of the park. The location of the park and weather were frequently mentioned together.

Regarding the enjoyed experiences of respondents during their visit, overall, more than 100 different tangible and intangible features were mentioned. Similarly to motivations, we grouped the enjoyed aspects under nine themes and two domains (Table 4.3). Categorising motivations and enjoyments under the same themes helped us to reveal interlinkages between human- and environment-based motivations and enjoyments (see Figure 4.3). The park visitors strongly expressed enjoying the tangible characteristics of the parks. Almost half of all respondents (n=729) mentioned enjoying the nature or special natural elements at the park, such as vegetation, trees, flowerbeds and birds, but also naturalness, overall greenness and seasonal changes in the trees. Specific park characteristics such as beauty, cleanliness, design or park size and more intangible characteristics such as '*diverse*' or '*atmosphere*' were comparatively often mentioned by the park visitors (n=677).

Table 4.3. Nine themes of motivations for park use and enjoyments during the visit and examples of mentions (n=1474).

	Theme	Human-based motivations	Human-based enjoyments
Human domain	Social relations	Spend time with friends, see friends, meet someone, play with children, go on a date, picnic, enjoy company, watch other people	People, a lot of people, different people, company, meeting place, park life, sense of community, cultures, pray together, absence of certain groups, have fun (with others), watch other people, relaxed people in a good mood, young and old people
	Mobility-based recreation	Walk the dog, exercise, sport, train, walk, outdoor recreation, play (e.g. football), fly a helicopter, catch Pokemon	Walk the dog, play, run, cycle, sports
	Stationary-based recreation	To eat (lunch/ice cream), drink (beer/coffee), listen music, work, lie down, study, read, sit	Sit, read (a good book)
	Relaxation & well-being	To relax, stroll, refresh, memories, escape something, recover from hangover, smoke a joint	Easy to get to, hang around, just be, meditation, refresh, stress relief, empower, freedom, feel satisfied with life, freedom, be alone, relax, no city stress, memories
	Theme	Environment-based motivations	Environment-based enjoyments
Environment domain	Park characteristics	For park itself, atmosphere, enough space around, familiar park, quietness	The whole park, large size, more space, environment, openness, less crowded, landscape, atmosphere, designed park, slides, "true" park, modern park, historical value, dynamic, diversity, harmony, symmetry, speciality, well-managed, not too designed, informal, clean, private, child-friendly, dog friendly, safety, international, Japanese, urban, soundscape, beauty
	Nature-related	To enjoy nature, watch birds, feed ducks, watch horses/ponies, enjoy smells, fresh air	Nature, diverse nature, naturalness, greenness, beauty of nature, park lives along with seasons, vegetation, estate garden, forest, oak forest, trees, singing trees, shrubs, meadow, flowers, lawn, edible plants, mushrooms, sea, lake, pond, brook, water's edge, animals, rocks, small wild area, shadow, clean air, scents of nature, sound of water
	Facilities & services	For (cultural organised) event, cafe services, to buy drugs, look at statues	Playgrounds, sand field, walking route, sport facilities, equipment for children, benches, dog facilities, cultural events, museum, fountain, monuments, art works, music, cafe, urban farming boxes, estate building, water pool, boulevards, pavilion, water tower, toilets, bridges
	Theme	Other motivations	Other enjoyments
Others	Location	Cross the park, walk through, location close-to-home	Central, near home, location, middle of densely built area, good access
	Weather	To enjoy sun, good weather, sunbathing	Sun, good weather, summer

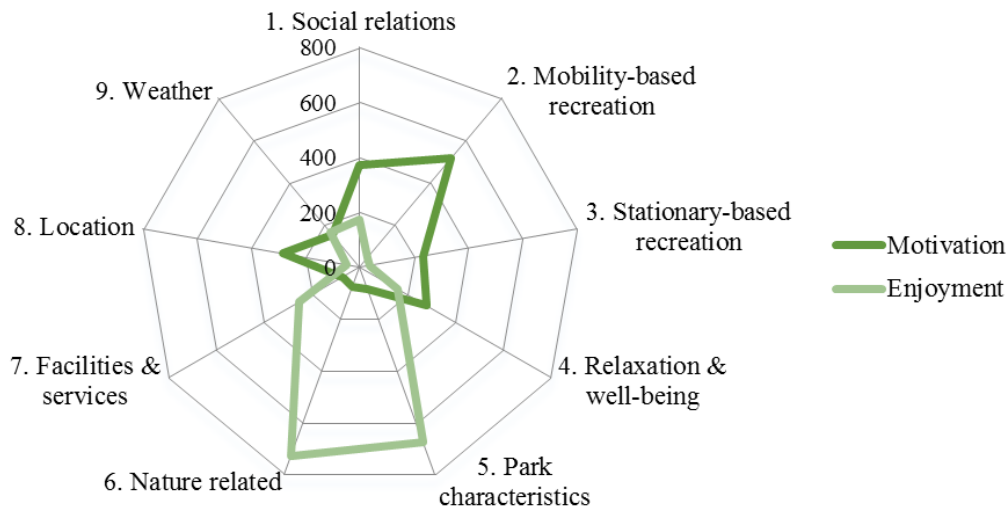


Figure 4.2. Number of visitors who mentioned at least one aspect under the nine themes of motivations (dark green) and enjoyments (bright green) (n = 1474).

The park visitors commonly mentioned more than one thing they enjoyed, varying between 0–13 features. More than half (n=789) mentioned at least two enjoyments, and on average they mentioned 2.1 features. Only 31 visitors (2%) did not enjoy anything in the park.

As Figure 4.2 depicts, motivations for park visits were strongly human-based, while enjoyments were mainly environment-based. Overall, regardless of the reason for their arrival, the great majority of park visitors mentioned enjoying aspects of the environmental domain: park characteristics, nature, or facilities and services; however, to a varying degree under different themes of motivations (Figure 4.3). Facilities and services were enjoyed less (12–35%) than nature (31–54%) or other park characteristics (39–50%) under all motivation themes. Those respondents who were motivated to use the park due to nature enjoyed environmental characteristics more often than other respondents. On the contrary, those whose motivations for visiting were linked to facilities and services enjoyed the nature or park characteristics the least, and more often enjoyed the facilities and services (35%) than visitors mentioning other motivational themes. Relaxation and well-being and mobility-based recreation among human-based motivations were more often linked with enjoyment of nature (54% and 52%), while those who visited for social or stationary-based reasons enjoyed nature to lesser extent (45% and 43%, respectively).

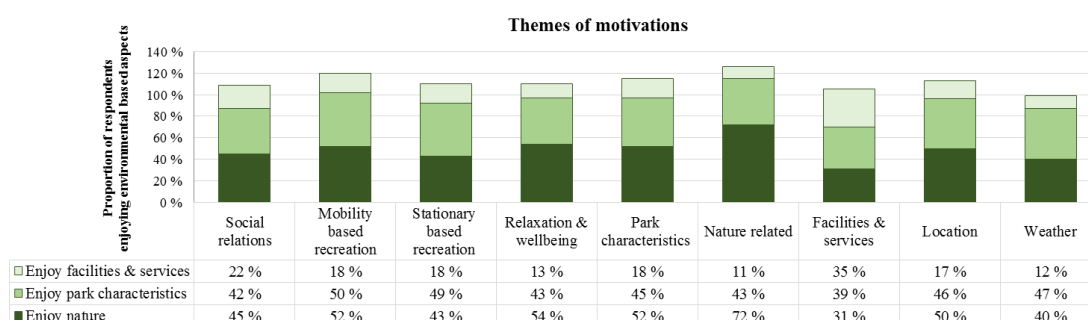


Figure 4.3. Proportion (%) of respondents who enjoyed nature, park characteristics and facilities & services under the different themes of motivations (social relations, mobility-based, stationary-based recreation, relaxation & wellbeing, park characteristics, nature related, facilities & services, location, weather) (N=1474).

Visiting parks generated positive and negative experiences (Table 4.4). Half of the visitors (n=712) were disturbed by something, mostly by other people, poor quality of the park, or a lack of facilities and maintenance in the park. ‘Disturbed by people’ referred to misbehaviour of other visitors (*‘vandalism, drug dealers’*) or solely to the presence of different users, e.g. cyclists or certain social groups. Only 77 visitors were disturbed by nature itself, e.g. lack of specific natural elements (trees) or poor water quality of the lake in the park (Table 4.4).

Table 4.4 - Four types of disturbances, examples of disturbing things and number of visitors (n) mentioning at least one type (n=1474).

Type	Disturbing things	Visitors (n)
People	Cyclists, alcoholics, vandalism, crowded, too many joggers, kids, guardians, some people, disturbing behaviour, other groups, police, restlessness, drug dealing, pickpockets, misbehaviour of others, annoying residents who know it better	323
Park characteristics and management	Dogs excrement, rubbish, bad water quality in the pond, broken glass, fountains that don't work, park degradation, low level of management, no water in the pool, unmown lawn, lack of facilities or services, bad illumination, too quiet, noises	439
Nature-related	Lack of trees, lack of vegetation, lack of shade, (feral) dogs, water quality in lake, mosquitos, insects, geese, rabbits, messy brook	77
Cultural events	Festivals, events, closing the park due to festival	20

To understand linkages between motivations and experiences, we calculated correlations among these variables (Table 4.5). The results revealed that the enjoyments mentioned increased slightly with the mentioned motivations. The mentioned enjoyments increased significantly with

environment-based motivations, but not with human-based motivations for visiting the park. The mention of disturbing factors decreased with human-based motivations to use parks, but increased with weather and location-based motivations. Environment-based motivations correlated positively with location-based motivations, while human-based motivations correlated negatively. Location and weather-based motivations correlated highly positively.

Table 4.5 - Spearman's rho correlations between average number of motivations (Motivations), enjoyments (Enjoyments) and disturbances (Disturbances), proportion of respondents mentioning human- (HumanM), environmental- (EnvironmentM), location- (LocationM) and weather- (WeatherM) based motivations to use parks, proportion of respondents mentioning human- (HumanE), environmental- (EnvironmentE) and nature- (NatureE) based enjoyments at the park level (n=33). EnvironmentE includes nature relations explaining high correlation between these variables.

	Motivations	Enjoyments	Disturbances	HumanM	EnvironmentM	LocationM	WeatherM	HumanE	EnvironmentE	NatureE
Motivations	1.000	0.404*	-0.216	0.340	0.293	-0.248	-0.102	0.116	0.198	0.144
Enjoyments		1.000	-0.103	-0.052	0.679**	0.144	0.058	0.454**	0.329	0.344*
Disturbances			1.000	-0.460**	0.143	0.486**	0.472**	0.064	-0.287	-0.037
HumanM				1.000	-0.334	-0.720**	-0.755**	-0.035	0.104	-0.152
EnvironmentM					1.000	0.381*	0.265	-0.399*	0.121	0.270
LocationM						1.000	0.574**	-0.035	0.048	0.205
WeatherM							1.000	0.092	-0.286	0.036
HumanE								1.000	-0.368*	-0.351*
EnvironmentE									1.000	0.683**
NatureE										1.000

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.2. Relationship between motivations, experiences and park characteristics

We grouped the parks into four types (Figure 4.4) based on their structural diversity (Table 4.1 and Annex 9). The typology might be considered reflective rather than definitive, allowing us to explore whether tangible characteristics of parks are linked with motivations or experiences. The first group, 'parks with low structural diversity', consisted of parks that had 1–2 different biotopes, the vegetation structure was rather simple and there were few facilities and artificial elements. The second group, 'parks with moderate structural diversity', was the largest group (n=12) including parks with few biotopes and a moderate level of vegetation structure, facilities and artificial elements. The third group, 'parks with high/medium-high structural diversity', included six parks that had different biotopes, the vegetation structure was rather diverse, but with a moderate level of facilities and artificial elements. The fourth and final group, 'parks with high structural diversity', consisted of structurally diverse parks in all aspects: biotopes,

vegetation, facilities and artificial elements. These parks often represent old and well-known parks.

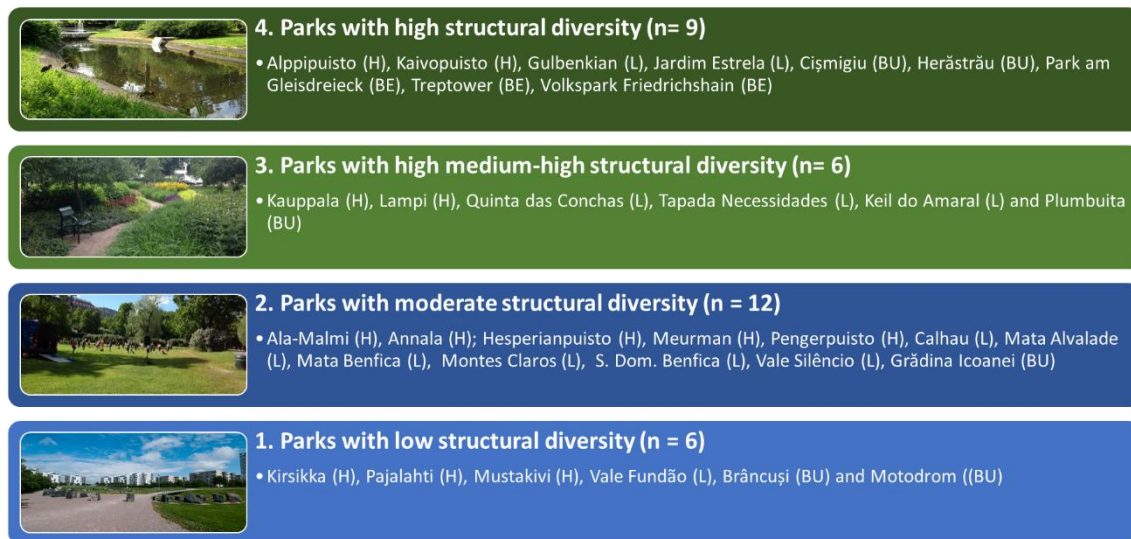


Figure 4.4. Typology of materialised biocultural diversity (BCD) for 33 studied parks in four European cities: Helsinki (H), Berlin (BE), Bucharest (BU) and Lisbon (L).

As our typology was inductively constructed, we checked its internal consistency by means of correlating the typology and its constituting elements (Figure 4.5). Spearman's rho correlation revealed significant and strong positive correlations between the type of park and variables indicating structural diversity: number of biotopes, vegetation structure, facilities and services, and artificial elements. Distance from the central area of the city towards the more decentralised residential areas (gradient) correlated negatively, implying strong differences in quality factors of parks between the city core and the suburbs. In addition, relatively high correlations between park type, age of park and the socio-economic status of the surrounding neighbourhood were found, indicating that the structural diversity of parks is greater in neighbourhoods with high socio-economic status.

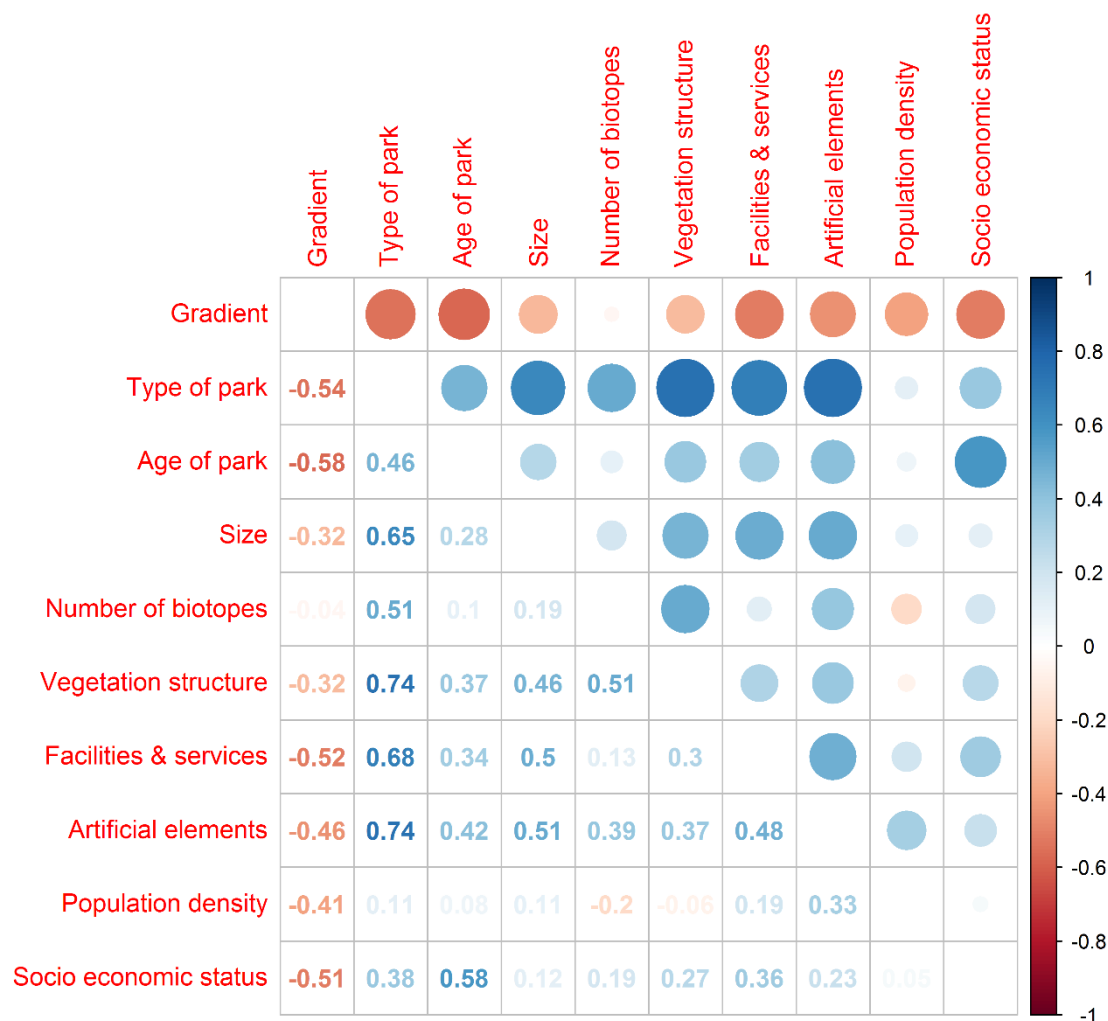


Figure 4.5 - Spearman's rho correlations and significance level between types of parks and park characteristics and surrounding city context: location along the gradient, population density and socio-economic status (n=33).

To reveal the role of structural diversity of parks in motivating people to use them or have positive experiences during their visit, we analysed differences in them between four park types. Although the results of the Kruskal-Wallis non-parametric test did not reveal significant differences between park types, we could detect slight variations among motivations and enjoyments in different types of parks (Figure 4.6A and B). To sum all human-based motivations together, we revealed that motivations increased strongly with structural diversity, being almost 40 per cent (from 86% to 141%) higher in parks with high structural diversity than in parks with low structural diversity. The total sum was higher than 100%, because the same person could give multiple reasons for their visit. Social-based motivations were highest in structurally diverse parks, and relaxation and well-being in parks with medium-high structural diversity. Motivations listed under the environmental domain were most common in parks with moderate or semi-high

structural diversity. Location was the most common motivation to visit parks with low structural diversity. We could detect similar kinds of patterns in environmental-based enjoyments as in human-based motivations; however, the increase between parks with low and high structural diversity was not so strong (from 124% to 148%). Nature-based enjoyments in particular increased with the structural diversity of parks. Location was more commonly mentioned in those parks with low levels of structural diversity than in other types of parks. Human-based enjoyments were rather similar in different parks. Location and weather were rather rarely mentioned enjoyments in all four park types.

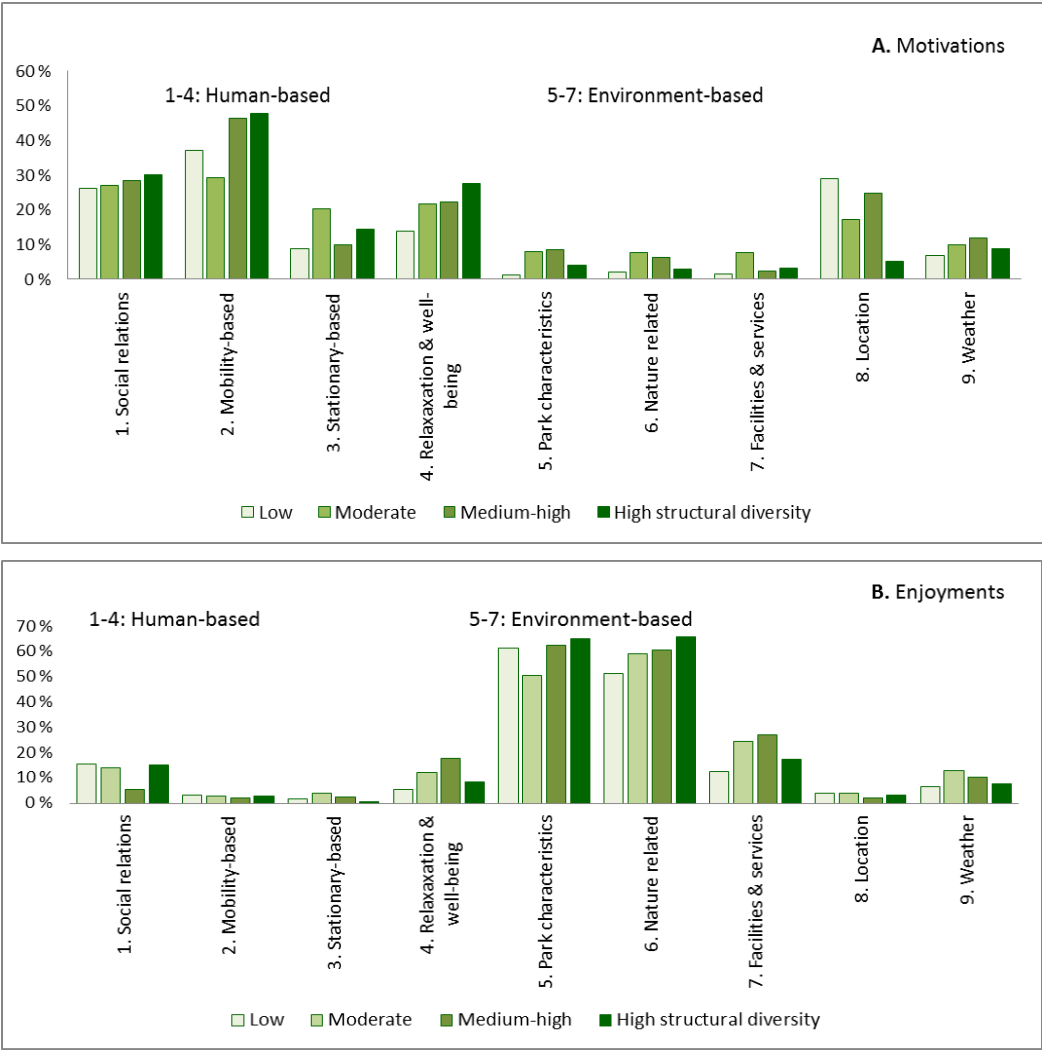


Figure 4.6. Proportions (%) of visitors under different themes (1–9) of motivations (A) and enjoyments (B) in four park types (n=33).

Motivations for using parks and enjoyments during visits differed significantly between cities, based on the Kruskal-Wallis non-parametric test (Figure 4.7A and B). Cities differed in all tested human-based motivations and enjoyments. Pairwise comparisons revealed that certain cities

formed pairs. For example, Berlin and Bucharest were similar in social-related motivations for park use, but Helsinki and Lisbon were different from Berlin and Bucharest. Location as a motivation for park use was similar in the Helsinki-Lisbon pairing and the Berlin-Bucharest pairing, but the importance of location as a motivation for park use differed clearly between the two pairs. Each city had its specific motivation and enjoyment pattern compared to other cities. Bright weather was a commonly mentioned motivation and enjoyed thing in the Helsinki parks. In Lisbon, nature motivated park use more often, and the park visitors enjoyed relaxation and well-being much more often than in the other three cities. In Bucharest, park use was strongly mobility oriented, but visitors enjoyed the nature or park characteristics less often than visitors in other cities. On the contrary, park visitors in Berlin commonly mentioned enjoying variable characteristics of parks.

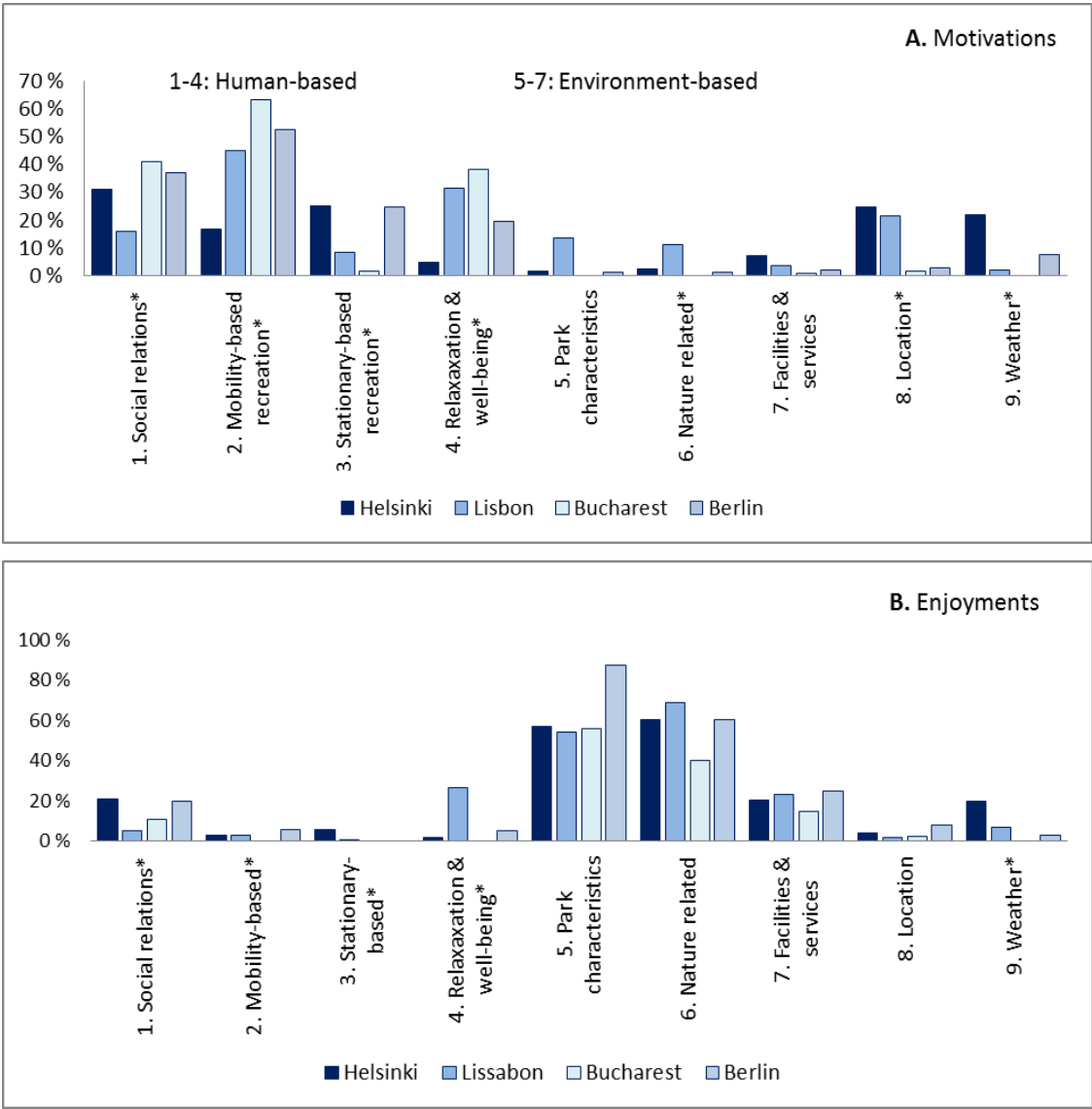


Figure 4.7. Proportion of visitors (%) under the nine themes of motivations (A) and enjoyments (B) in the four cities. Significant differences are indicated with dashes (n=33).

In order to reveal whether the specific components of structural diversity, park size or urban context in which the park was situated were associated with motivations or enjoyments, we tested potential correlations between these variables (Table 4.6). Mentioned motivations, human-based motivations and environment-based enjoyments increased with park size. Biotope richness had a positive correlation with environmental, but a negative correlation with human-based enjoyments.

Vegetation structure correlated positively only with motivations, while artificial elements, facilities and services correlated positively with human-based motivations for park use.

Table 4.6 - Spearman's rho correlations and significance level between variables of structural diversity, surrounding city context (population density and socio-economic status of neighbourhood), motivations and enjoyments (N=33).

Variable	Motivations	Enjoyments	Human based motivation	Environmental based motivation	Human based enjoyments	Environmental based enjoyments	Enjoying nature
Age of park	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Size (ha)	0.349*	n.s.	0.459**	n.s.	n.s.	0.424*	n.s.
Number of biotopes	n.s.	n.s.	n.s.	n.s.	-0.393*	0.412*	n.s.
Vegetation structure	0.394*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Artificial elements	n.s.	n.s.	0.344*	n.s.	n.s.	n.s.	n.s.
Facilities & services	n.s.	n.s.	0.436*	n.s.	n.s.	n.s.	n.s.
Population density (500 m)	n.s.	n.s.	0.552**	n.s.	n.s.	n.s.	n.s.
Socio-economic status of neighbourhood	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

n.s. Not significant

4.4. Discussion and conclusions

4.4.1. Human-based motivations are linked with environment-based enjoyments

Our place-based study revealed that human-based reasons (e.g. walking and talking, jogging, meeting friends, reading, having lunch) motivated people to use the parks. Despite the fact that environmental features were rarely mentioned as a reason for visiting parks, we found that the structural diversity of parks enhanced different human-based motivations for park use. We will address this content later in the discussion. Our study corroborates earlier findings suggesting

that mobility- based recreation (e.g. sports, walking, cycling) along with social activities (e.g. meeting friends, picnicking) are the main things urban parks are used for in Europe, Asia and the Middle East (e.g. Chiesura, 2004; Peters et al., 2010; Schetke et al., 2016; Rall et al., 2017; Fischer et al., 2018b). Fischer et al. (2018b) found that only a minority (15%) of visitors used UGS for purely nature-based reasons. We also noticed that nature as a motivation for visiting the park was rarely mentioned and was usually reduced to a single nature element or animals in parks, such as “*feeding ducks*”, implying that the park visitors were more motivated by some specific feature than the overall nature of the park (Voigt and Wurster, 2015; Vierikko and Yli-Pelkonen, 2019).

Despite the fact that motivations for park use were strongly human-oriented, the majority of park visitors did interact with the local environment through enjoying nature or specific characteristics of the park, supporting the idea that public parks provide opportunities for diverse interaction with nature (Vertovec, 2007; Peters et al., 2010). As we were particularly focusing on diversity of experiences, we counted over 100 aspects that visitors enjoyed during their actual park visits in total. The majority of enjoyments were linked with nature or park characteristics, revealing that park users interact with local environment through multiple senses such as listening (‘*singing trees*’ or ‘*sound of water*’) or smelling (‘*scent of park*’). Interaction with the local environment may strengthen place attachment and stimulate stewardship towards nature (Kyle et al., 2004; Raymond et al., 2010; Ives et al., 2017).

We revealed complex relationships between different themes of motivations for park use and experiences during the park visit. Those who used parks for social reasons were also very much human-oriented with their enjoyments and interacted less with the place itself. Socialbased motivations seemed to decrease negative experiences, also related to other people, indicating that satisfaction or sensitivity towards disturbing factors during the park visit is also dependent on motivations and not only on environmental factors (e.g. management of park). Social motivations for park use have been found to have a positive effect on social cohesion in parks in the UK (Kazmierczak, 2010). Social relations as a motivation did not correlate with the park being located close to home, while weather and environmental-based motivations did, indicating that the majority of visitors who were using parks for social reasons, e.g. meeting friends or having a picnic, preferred a park further away for meeting their human-based needs. These parks, as discussed above, are usually structurally diverse, well-known and located in the central area.

It was not surprising that visitors who visited the park for nature-related or park-characteristics reasons enjoyed nature more overall than those who visited for human-based reasons. We also noted that those who visited for environmental reasons enjoyed their visits overall more than those who were motivated by human-based reasons. Interestingly, visitors whose motivation for park use was weather-based (e.g. sun bathing) or who visited to use facilities or services enjoyed the nature to a lesser extent and also perceived more disturbing factors than visitors who visited the park for the place itself (i.e. park characteristics). Furthermore, we found that those who visited to relax or who actively moved around in the park (e.g. walking a dog) enjoyed nature more often than those who visited mainly for social reasons. Close-to home location and environmental-based motivations were commonly mentioned together implying that nearby UGS has an important role for supporting human-nature interaction (Soga et al., 2014). Our findings supported earlier studies which stated that when park visitors were seeking space to enjoy quietness, nature or fresh air, close-to-home green spaces became more important than parks situated further away (Soga et al., 2014; Vierikko et al., 2017a).

4.4.2. Structural diversity of parks is important for uses and experiences

We revealed that human-based motivations increased clearly in line with the structural diversity of the park, but not with environment-based motivations. We also found that a higher proportion of visitors mentioned enjoying nature in structurally diverse parks. Relaxation motives were more often linked with nature enjoyments than other types of human-based motivations. Previous studies have shown that species richness and structural diversity of UGS matters for perceived benefits, e.g. restoration and well-being (Voigt et al., 2014; Ives et al., 2017). If the park is not diverse in material characteristics, it does not necessarily attract people to visit it (McCormack et al., 2010). Fischer et al. (2018b) discovered in their European-scale study that citizens value plant species richness highly in different types of UGS, indicating that biodiversity matters for positive experiences when using public parks. Kabisch and Haase (2014) found in their case study that the majority of urban residents in Berlin particularly desired structural diversity in green spaces (facilities, large trees, water elements).

We found a positive relationship between human-based motivations, environment-based enjoyments and park size, supporting the theory of urban park geography: the larger the park, the more diverse the human values (Brown, 2008). However, park size did not correlate with nature enjoyments, suggesting that smaller parks can also stimulate nature experiences, and having diverse vegetation and biotopes is more important in developing interactions with the

surrounding environment than the size of the park. Parks with diverse vegetation structure, large trees and many biotopes can offer diverse nature experiences, improve restorative benefits, and enhance human connectedness with local nature (Nisbet et al., 2009; Wood et al., 2018), especially among urban residents who do not have either the opportunity or the willingness to visit large recreational areas or nature areas outside the city. We found a positive correlation between biotope richness and environmental-based enjoyments. Biologically diverse parks can prevent the possible disconnection of residents living in densely populated areas from local nature and its knowledge, protection and conservation (Celis-Diez et al., 2017), especially if their favourite places are in artificial, human-made urban environments without any natural elements (Tyrvaainen et al., 2007).

Our typology of materialised BCD indicated that public parks are neither independent nor neutral spaces from the surrounding urban context, but their tangible characteristics manifest the socio-economic status, as well as the socio-historical context of the surrounding neighbourhood (Byrne and Wolch, 2009). Our findings support arguments that the location of a park (central or peripheral) can influence park uses and perceptions of visitors (Voigt et al., 2014). Furthermore, our findings corroborate earlier results (e.g. de la Barrera et al., 2016), which reveal that parks located away from city centres and in neighbourhoods with low socio-economic status are not necessarily as structurally diverse (having less vegetation, especially fewer trees) as parks in more affluent urban areas. This raises the concern of inequity in UGS planning between different city districts, if high-quality and biologically rich parks are located in the wealthy neighbourhoods (Kabisch and Haase, 2014; Rigolon et al., 2018). Older and larger parks as well as parks with diverse structural characteristics were mainly located in central areas in the studied cities. These parks invited people to use them for several human-based reasons, and especially for social relations (picnicking, meeting other people, playing) and relaxation, and offered visitors a more diverse environment to enjoy than parks situated in neighbourhoods with low socio-economic status.

4.4.3. Cities differed in their park uses and experiences

Cities differed greatly in terms of people's motivations to use them and their experiences during visits. The close to home location was a commonly mentioned motivation for park use in Helsinki and Lisbon (25% and 21%), despite residents in these two capitals are in very different situations in terms of UGS supply – in Lisbon only 19% of land surface is recreational UGS compared to Helsinki with 47% of recreational UGS (Davies et al., 2015; Vierikko et al., 2014).

One interesting difference was that in Helsinki, visitors commonly used parks as shortcuts on their way to somewhere else, while in Lisbon visitors went to parks near their homes to enjoy nature, walk around and relax. On the contrary, nature was a rarely mentioned motivation to use public parks in Helsinki, as the majority (79%) had very good access to their nearest UGS (300 m) and almost half of the residents had easy access to urban forests, which are commonly valued and visited for nature experiences (Neuvonen et al., 2007; Vierikko et al., 2017b; Harlio and Tuhkanen, 2018). In Berlin and Bucharest, social relations linked with mobility- (walking and talking) and stationary-based (picnicking with friends) activities were commonly mentioned motivations for visiting. However, in Bucharest visitors reported far fewer enjoyments than respondents in Berlin, where the majority of visitors enjoyed park characteristics and nature. All three Berlin parks were structurally diverse, supporting local residents' desire for quality factors of parks, as identified by Kabisch and Haase (2014).

4.5. Conclusions and limitations of the study

We applied the BCD concept to explore interactions between people and the environment. The Europe-wide character of this study brought up novel knowledge on the interlinkages between motivations, experiences, parks and surrounding neighbourhoods across the continent, which are highly interesting and have not been reported by previous research. We found that cities differed greatly with their lived BCD, implying that day-to-day practices of people using and experiencing UGS can be very different in different geographical contexts. As we included only three parks in Berlin and five in Bucharest in our study, compared to the 12 parks in Helsinki and Lisbon covering the complete urban gradient, the results should be interpreted with caution. One of the core findings was that even when nature was not the primary reason for visiting a park, it was one of the most commonly enjoyed things, revealing the importance of contact with nature, even if not on purpose, and independently of the type of park. Therefore, it is very important to have biologically diverse public parks in different urban contexts in order to combat the loss of nature experiences (Soga and Gaston, 2016).

We revealed that interaction between uses, experiences and local environments is a complex process influenced by materialised characteristics of parks, but also by the surrounding urban context. Our study showed that urban green spaces are not independent or neutral, but their materialised BCD reflect their surrounding neighbourhoods, as well as the socio-cultural context of the geographical location of the green space. Designing attractive parks with diverse structural elements – especially with high biodiversity – in neighbourhoods with low socioeconomic status

would support local people to use them for multiple reasons, thus enhancing social cohesion and the well-being of different social groups (Cattell et al., 2008; Capaldi et al., 2014; Kuo, 2015). Analysing the relationship between materialised and lived BCD – and taking the local context into account – will help us to design, plan and manage for more just and inclusive UGS and support social justice and diverse interactions between culture(s) and nature in public parks (Madureira and Andresen, 2014; Rodriguez and Di Virgilio, 2016).

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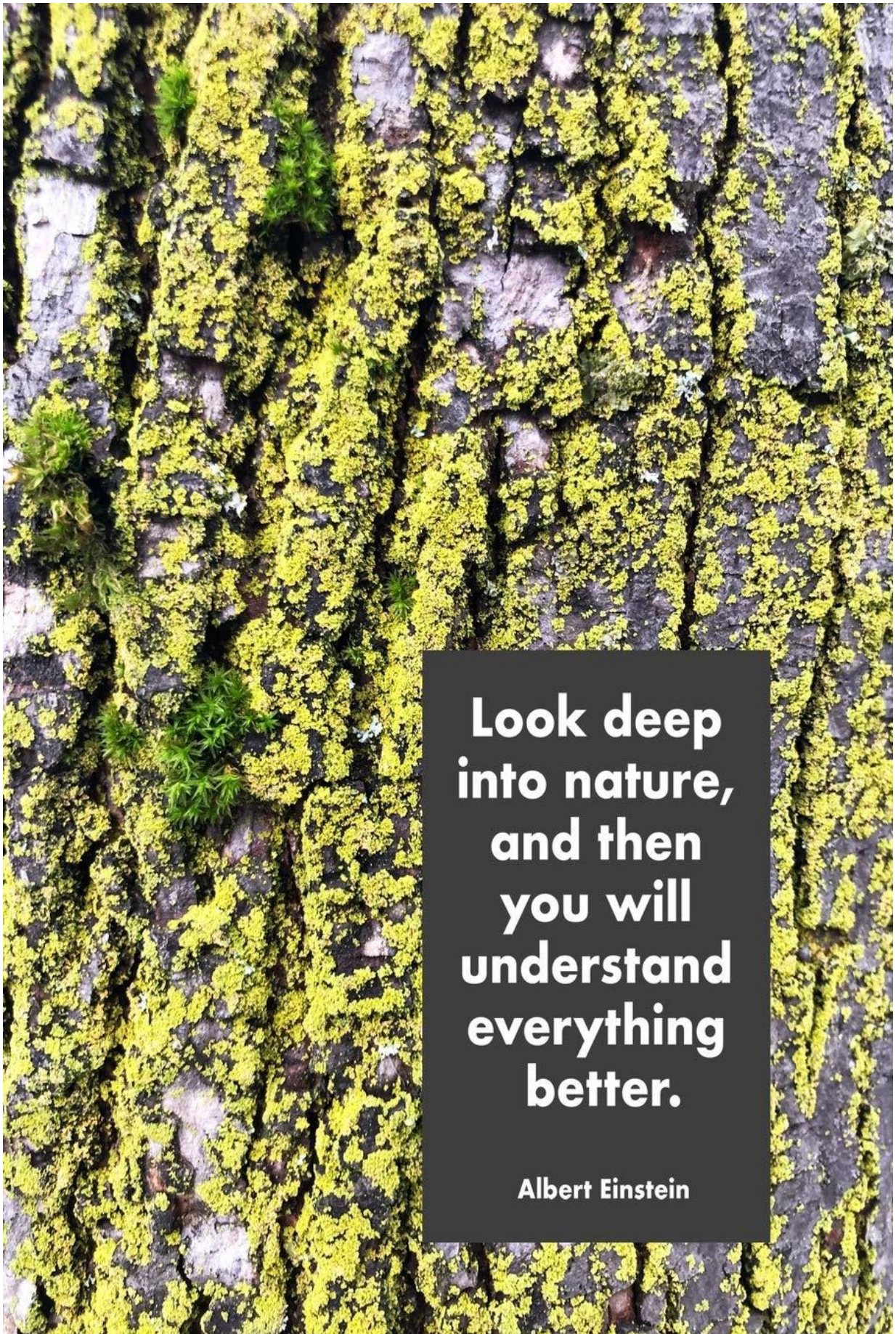
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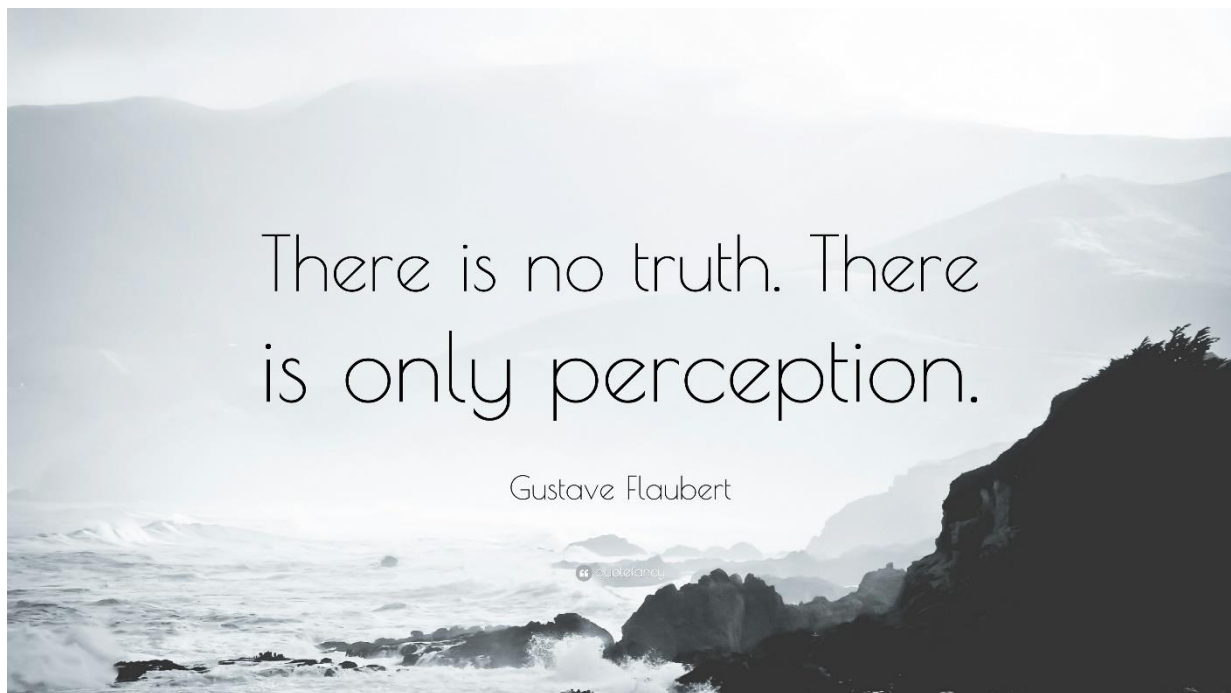
**Look deep
into nature,
and then
you will
understand
everything
better.**

Albert Einstein

CHAPTER 5

What's biodiversity got to do with it? Perceptions of biodiversity and restorativeness in urban parks

P. Gonçalves, F. Grilo, R. Mendes, K. Vierikko, B. Elands, T. Marques, M. Santos-Reis



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What's biodiversity got to do with it? Perceptions of biodiversity and restorativeness in urban parks

Abstract

Understanding the mechanisms underlying the positive influence of urban biodiversity in dwellers' well-being is critical to better inform sustainable management of urban greenspaces (UGS), but studies published to date on the role of biodiversity in mental restoration have provided contradictory results. Both UGS biophysical characteristics and the emotional connection with the place may play a role in mental restoration. Using UGS landscape and biodiversity metrics, and on-site observations and questionnaires to assess site quality and visitors' perceptions, we explore the influence of biodiversity (perceived and measured at different levels), UGS characteristics and visitors profile in mental restoration. Our GLM analysis demonstrates that perception of biodiversity, along with satisfaction and connection to place, were the most important predictors of mental restoration. The proportion of broad-leaf evergreen tree species also had a positive influence in the biodiversity perception and mental restoration. People do perceive existing biodiversity through visual clues as the diversity of leaf forms in broadleaf species, with this process being almost completely mediated by the perception of tree diversity. These findings have direct translation into planning and management practices by acknowledging the importance of biodiversity and, above all, of specific traits namely of evergreen broadleaf species, in promoting restorativeness of urban parks' users, and highlights the importance of using standard ecological methods when assessing biodiversity in urban greenspaces and its influence in human well-being.

Keywords: Biodiversity perception; Biological diversity; Functional diversity; Mediation; Perceived restorativeness

5.1 Introduction

Living in cities can be very stressful. Crowding, high levels of noise, strong artificial lights and odors, pollution, and many other factors, contribute to overloading people with undesired stimuli, with consequences in mental health and well-being (Galea et al. 2005). Interacting with nature may contribute to overcoming those impacts through a wide range of benefits. A reduction of anxiety and stress, improved cognitive ability and self-esteem for instance, or greater happiness and life satisfaction, are just some of the benefits (Frumkin et al. 2017, Hall and Knuth 2019a, 2019b). Mental restoration has been consistently associated with positive aspects of well-being

(Marselle et al. 2019). This process is known as restorativeness, which is defined as the potential of the environment to re-establish certain cognitive capacities related to human information processing (Hartig, 2004).

Natural environments in cities are representative of human intervention in the landscape over time. They can include remnant areas of natural habitats that may be more or less free of human intervention, and man-made or transformed habitats, with a multitude of designs, architectural elements and vegetation constellations. Although natural environments are generally more restorative than urban ones, built elements in urban green spaces (UGS) may also be a source of psychological restoration and well-being (Lindal and Hartig 2013, Hajrasoulih et al. 2018, Weber and Trojan 2018).

UGS, specifically urban parks, are not just repositories of biological diversity nor simple recipients of human activities. Their unique ambiance offer meaning and identity to a space that people experience and value according to their own perceptions of the space and emotions they attached to it. Perceptions are key to interpreting and assigning meaning to the environment. A space recognized as meaningful, and with whom people can identify, induces non-tangible, emotional and cognitive bonds (Tuan, 1975) that positively influence mental restoration and well-being (Ratcliffe and Korpela 2016, Knez et al. 2018). Also, according to constructivist approaches, people construct objects of perception and thought that contribute to the cognitive process and, within this perspective, reality is an interpretation of the environment (Wapner and Demick 2002). This assumption implies a distinction between the experienced and the physical environment and assert the importance of assessing people's perceptions when dealing with mental well-being. The influence of perceptions of naturalness, greenness and aesthetic attractiveness in mental well-being have been described (e.g. Hidalgo et al. 2006, Marselle et al. 2014, Hipp et al. 2016), but to our knowledge, no work has ever jointly addressed the role of biodiversity (here defined as richness of species and variability of species traits), both objective and perceived, and park's physical characteristics in well-being.

In spite of mounting evidence of the positive impact of experiencing nature on mental well-being (Houlden et al. 2018, Menardo et al. 2019), little is known about the specific role of nature's different attributes, namely of biodiversity, nor the mechanisms through which they exert their influence (Botzat et al. 2016, Marselle et al. 2019). Studies addressing the relation between biodiversity and mental well-being are scarce, and often just compare non-urban natural

environments with urbanized environments or assessed nature in terms of naturalness, greenness and other proxies. Only a minority assessed biodiversity with standard ecological methods and metrics (Botzat et al. 2016, Marselle et al. 2019), and results were both mixed and varied across scales, from ecosystems to species level. As an example, in some studies habitat diversity and bird species richness were found positively associated to mental well-being (Fuller et al. 2007, Johansson et al. 2014, Rantakokko et al. 2018, Luck et al. 2011,) while in others, the association was non-significant or inconclusive (Dallimer et al. 2012, Wheeler et al. 2015, Wolf et al. 2017). These contradictions lead to some authors arguing that perceived biodiversity, rather than real biodiversity, was responsible for mental well-being (Dallimer et al. 2012) and questioning the aptitude of lay-people to accurately perceive variations in biodiversity. Associations between perceived biodiversity and mental well-being were described both as positive (Dallimer et al. 2012, Schebella et al. 2019) and non-significant (Marselle 2014, 2016), and the same contradiction was found when testing the ability of lay-people to accurately assess existing biodiversity (Fuller et al. 2007, Lindemann-Mathies and Bose 2008, Dallimer et al. 2012). Some authors argued that large variations at ecosystem level, like habitat heterogeneity or vegetation cover, are more likely to be recognized than subtle variations at species level (Dallimer et al. 2012, Schebella et al. 2019). Many studies on the perception of biodiversity were also based on coarse definitions of biodiversity itself (e.g. greenness, naturalness) rather than on species diversity. Although perceived biodiversity is likely to depend on species visual traits that allow the discrimination of differences (de Vries and Snep 2019), no study has yet explored the influence of visual functional traits on biodiversity perception or on mental well-being. There is, thus, a need to clarify which biodiversity elements are responsible for mental well-being and the mechanisms through which those elements contribute to well-being, and the use of standard metrics of landscape structure and biological and functional diversity is the most effective and accurate way to reach that purpose.

Besides natural elements, the facilities and amenities existent in UGS also contribute to the association between visiting green spaces and mental restoration (Nordh and Østby 2013), with cultural and art elements with high aesthetical value showing important restorative attributes as well (Deng et al. 2020). Yet, integrative studies addressing the influence of both biodiversity and park characteristics in well-being are scarce (Wood et al. 2018).

Consequently, our study aims to understand:

- a- how UGS characteristics, specifically of urban parks (including both park and biodiversity qualities), users' perceptions about those characteristics, their patterns of visitation and connection to place contribute to mental well-being;
- b- how the perception of existing biodiversity is related with objectively quantified biological and functional diversity.

5.2 Methods

Twelve urban parks of public access in Lisbon (Portugal) were studied as part of the EU FP7 GREENSURGE research project (<https://greensurge.eu/>). The parameters used to select the study parks included their location in the city, a diversity of designs and facilities, ≥ 4 ha area and >40 years old to ensure a completely developed vegetation structure (Table 5.1). A map with the location and pictures of each park may be assessed here. More detailed information on parks' characteristics, namely the number of biotopes, vegetation structure, presence of facilities and cultural artefacts, is available in Vierikko et al. (2020).

Table 5.1 - Parks characteristics including age, origin, design and neighbourhood socio-economic strata

Park	Park construction	Origin / design	Date of urbanization
Jardim da Estrela	1840s	English design	1800s
Jardins Gulbenkian	1960s	Modern Portuguese design	1900s
Mata de Benfica	1910s	Former farms	1900s
Tapada das Necessidades	1740s	English design/ former game reserve	1800s
Mata de Alvalade	1950s	Former planted woodlands	1940s
Quinta das Conchas	1900s	Former planted woodlands	1990s
Vale Fundão	1970s	Former planted woodlands	1960s-1970s
Vale do Silêncio	1950s	Former planted woodlands	1940s-1960s
Parque do Calhau	1940s	Planted forest	NA
Keil do Amaral	1940s	Planted forest	NA
Montes Claros	1940s	Planted forest	NA
São Domingos de Benfica	1940s	Planted forest	NA

5.2.1 Data collection

Fifty face-to-face questionnaires were conducted in each park to assess users' perceptions of the parks' meaningfulness and the values of its attributes, as well as biodiversity. The

questionnaires took place early in the morning or late afternoon during weekdays, and during any daytime hours on weekends, avoiding extreme weather conditions ($>30^{\circ}\text{C}$) and public events in the parks. Surveyors searched for respondents through the entire park to include practitioners of all possible activities and visitors of different lengths of stay. In low frequency parks every visitor entering the park was interviewed, while in others every fifth visitor was interviewed. Each visitor approached was briefly explained of the aim of the research and asked for their participation. In total, 610 visitors (44,1% female and 55,9% male) over 18 years and currently living in the city, responded to the questionnaire (each lasting at least 10 min), and 80 refused to participate or did not complete it. The questionnaire covered several topics related to both visits and visitors, with further details available in Vierikko et al. (2020). The topics and the variables used to address them are described in the following section and depicted in Figure 5.1.

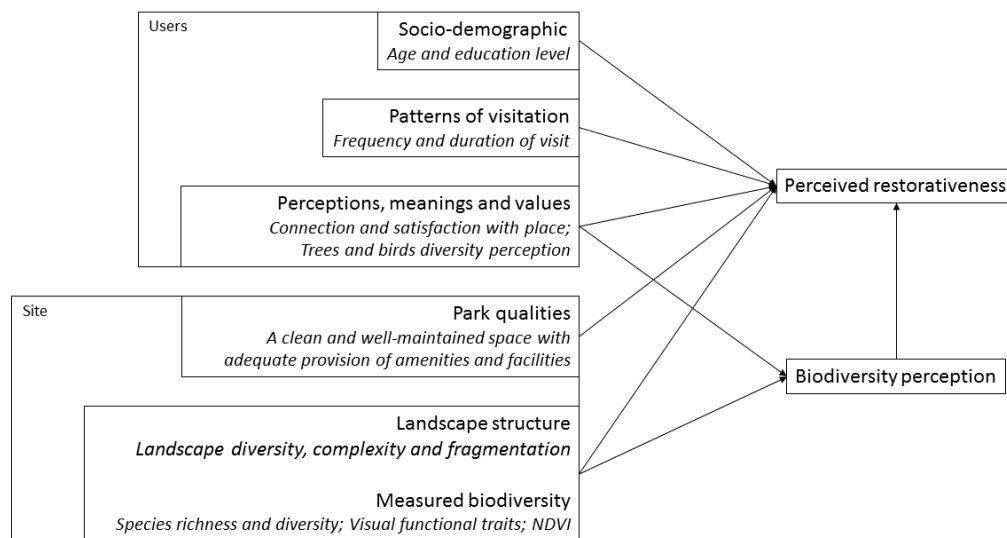


Figure 5.1 – Diagrammatic representation of the approach used to model Perceived Restorativeness (PR) and Biodiversity Perception (BDP).

Perceived restorativeness: In this study, we assessed mental restoration using a reduced version of the Perceived Restorativeness Scale (PRS), a tool developed by Hartig et al. (1997) to assess the restorative qualities of environments based on the Attention Restoration Theory (ART) (Kaplan and Kaplan 1989). This theory posits that nature offers bottom-up stimulus that, by capturing one’s involuntary attention, allows fatigued directed attention to rest and restore. For that, the natural environment must: provide the feeling of being-away, distant from daily routines; provide extent enough to explore and experience the environment; be compatible with

one's needs and desires offering the opportunity to engage in enjoyable and meaningful activities; and be fascinating, attracting direct attention in an effortless manner. We used eight items (Table 5.2) of a PRS survey instrument previously tested (Pasini et al. 2009) and proven as valid in other studies (e.g. Scopelliti et al. 2012, Carrus et al. 2013). Two items of each of the PRS dimensions were used and visitors were asked to score their opinion on a Likert scale from 1 (do not agree) to 5 (completely agree). The individual scores were summed and averaged (final aggregated score) and dealt in subsequent analysis as a continuous variable (Norman 2010), *Perceived Restorativeness (PR)*, a composite measure assessing the four experiential restorative qualities. Internal consistency was confirmed with a Cronbach's alpha of 0.73.

Table 5.2 – Items used to assess perceived restorativeness (PR)

Component	Item
Compatibility	Being in this place is in accordance with my personal interests
	I can do things I like here
Being away	Spending time here gives me a break from my day-to-day routine
	Coming here helps me to get relief from unwanted demands on my attention
Fascination	This place is fascinating
	There is much to explore and discover here
Extent/Coherence	It's like this place has no boundaries
	It is easy to see how things are organized

Biodiversity Perception: To assess overall biodiversity perception visitors were asked their perception of the level of biodiversity, if it was high or not. While most answered “Yes” or “No”, some visitors provided intermediate answers as “So-so”, “Not so much” or “Only plants, not animals”. These were pooled together with negative answers, and *Biodiversity Perception (BDP)* was analyzed as a binary variable. To understand if biodiversity, either real or perceived, was an important attribute to perceived restorativeness, the same taxa was used for comparability of both assessments. Vascular plants, butterflies and birds were chosen as they are the most conspicuous taxa in parks and are easily recognized by lay-people, as seen in citizen-science databases (e.g. iNaturalist <https://www.inaturalist.org/>), and interviewees were also asked to separately score the perceived diversity of each taxa in a scale of 1 (very low) to 5 (very high).

Users' related variables

Patterns of visitation were determined by asking how often respondents used to visit the space and how long they would stay. Frequency of visitation (*Frequency*) was classified in two

categories - occasional (less than once a week) vs. regular visitors (at least once a week). Duration of visit (*Duration*) was classified in five groups with visitors: passing by, spending <30 minutes, between 30 to 90, 90 to 180 and >180 minutes. Users' *Age* and *Education* were asked to obtain basic socio-demographics strata. The perception of satisfaction with space was assessed by the number of *Complaints* reported about parks' maintenance and preservation state. The meaningfulness attributed to the place, as determined by the existence of an emotional connection with, was assessed by asking visitors if the park was *Special* for them ("Yes" or "No").

Site related variables

We evaluated each park's overall quality by assessing a set of on-site conditions including the number and variety of amenities and facilities, their state of preservation, overall cleanliness and absence of incivilities. Each item was scored 1 (low variety/condition of amenities/facilities – visible signs of litter/incivilities) to 5 (high number/condition of amenities/facilities – no visible signs of litter/incivilities) and summed for a final space quality score (*Park_quality*).

Biological characterization of the parks included land cover and structure mapping, biodiversity assessments and visual functional traits of tree species. Parks' land cover was mapped on-site with MapItGIS for Android. Patches were delimited and classified according to cover type, such as trees with or without shrubby understory in various densities, grass/lawn, social areas (e.g., playgrounds, cafeterias or sport courts), water bodies and paths. Patches with tree cover were also classified according to the dominant tree species. A Geographic Information System project was built in QGIS 2.18.18 (QGIS Development Team 2019) and parks' land cover metrics calculated with Fragstats software (McGarigal et al. 2012) using two sets of classifications, one based on cover type and other on tree dominant species. Four metrics measuring landscape fragmentation, complexity, diversity and evenness were computed for both classifications. The Normalized Difference Vegetation Index (*NDVI*) was computed from Sentinel2A images with 10m of spatial resolution, for summer months.

Vegetation assessments followed a stratified sampling scheme based on cover types and their area of occupancy, with transects drawn in the patch centroid along its longest length. The sampled area for each cover type was at least 5% of its occupancy area. Trees were sampled along the transect by using the Point-Centered Quadrat method (Elzinga et al. 2001). Butterflies were sampled along fixed transects covering all different cover types, according to the Manual

of Butterfly Monitoring issued by Butterfly Conservation Europe (Van Swaay et al. 2012). Parks were visited once a month from June to August and all butterflies detected within 2.5 m on either side of the transects and 5 m in front of the observer were identified and recorded. Bird sampling was carried out during the breeding season (April-June), in the first hours after the sunrise, using 10 min point counts, in the park centroid and in a number of extra points proportional to the park size (Sutherland 2006), up to a maximum of three extra points. Species richness, Shannon's diversity and evenness indexes were calculated for each taxa.

Tree visual traits were compiled from various databases, such as the TRY-database at www.try-db.org (Kattge et al. 2011) or the Botanical Information and Ecology Network (BIEN) at biendata.org (Enquist et al. 2016). The traits were used to calculate the tree's functional structure and diversity by means of the Community Weighted Mean (CWM) and the Functional Dispersion (FDis) (Laliberté and Legendre 2010), using the R package "FD" (Laliberté et al. 2014). The CWM provides information on the dominant trait in the community, by calculating trait values weighted by species abundance, and, for categorical traits, it represents the percentage of each trait in the community. FDis reflects the degree of dissimilarity within the community, with a higher value representing a higher diversity of traits in the community. Functional diversity indexes were calculated for leaf type and phenology, flower and fruit showiness, as well as phenology.

All variables collected along with its description, units and *p*-values for univariate analysis are described in Annex 11.

5.2.2 Data analysis

Due to the two-level structure of the data collected (parks and surveys in parks) and the specific characteristics of each park, we conducted an initial Generalized Linear Mixed Model without predictors for both perceived restorativeness (PR) and biodiversity perception (BDP) with park as random effect to account for the variability associated with parks themselves. While for PR there was no variance associated with the park, the variance associated with the park lost significance when variables were added to the BDP model. As such, we proceeded with Generalized Linear Models (GLMs) in ulterior analysis to test the influence of the park's biophysical features on PR and BDP. PR was modelled as a Gamma distribution with an inverse-link, and BDP as binomial with a logit-link. To build the GLMs, the significance of each variable was first assessed in a univariate analysis with those with $P < 0.25$ being selected to proceed to the multivariate analysis (Hosmer and Lemeshow 2000). A Pearson's correlation matrix was

generated and, due to the correlational nature of our data set, we used a very conservative approach to ensure the non-collinearity of the predictors. When correlation was significant ($r > 0.6$), we selected the variable that was least correlated with the remaining, with higher biological or social significance, with lower residual deviance in the univariate analysis or with a Variation Inflation Factor < 10 (Tabachnick and Fidell 1996).

The final set of variables used to build the models for PR and BDP were selected after all the previous assumptions were met and the preliminary univariate analysis were performed (Table 5.3). We used the same set of variables for both models except those related with park quality and patterns of visitation which were not included in BDP model, which was biodiversity focused. For each model, all significant, non-collinear, adequate variables were included in the initial model and a backward stepwise procedure followed to select the best model based on the lowest AIC, with scatterplots checked for residuals adequacy, variance homogeneity, predictors linearity and model goodness-of-fit analysis (Hosmer and Lemeshow 2000). Partial regression and partial correlation coefficients were also calculated to measure, respectively, the influence of each individual predictor in PR, and the strength of that relationship, while keeping other variables constant (Freund et al. 2010).

The absence of significant biodiversity related variables in the final models of both PR and BDP prompted us to investigate if any of the biodiversity metrics influenced either PR or BDP through indirect pathways mediated by users' perceptions. Mediation is a cause-effect model that attempts to explain the intermediary process by which an external event (independent variable) influences the internal psychological significance (dependent variable) through a mediator (Baron and Kenny 1986). The effect of the independent variable on the dependent variable must be reduced or eliminated (partial or complete mediation) when the mediator is held constant to show mediation (Hayes and Rockwood 2017). To qualify for mediation, besides a theoretical support for the proposed mechanism, a significant relationship must occur between the independent variable and the mediator and between the mediator and the dependent variable. Based on the constructivist approach that establishes a distinction between measured and perceived environment, we used the variables *Species richness*, *Trees species richness*, *diversity* and *evenness*, *CWM_broadleaf*, *CWM_evergreen*, *PRDsp* and *NDVI*, and the mediators *BDP*, *PR* and *Tree diversity perception*, to test the role of perceptions in mediating the path between measured and perceived biodiversity (BDP), and between this and perceived restorativeness (PR). The analysis was performed with R package "Psych" (Revelle 2018)

which calculates the partial regressions and tests the existence of mediation by using bootstrap methods to compute confidence intervals.

5.3 Results

The final set of variables used to model PR and BDP is listed in table 5.3.

Table 5.3 – Final set of variables used to model PR and BDP. r – Pearson’s correlation coefficient $p < ‘***’$ 0.01 ‘**’ 0.05. p Univ – p -value of univariate regressions

Variable	Description	Perceived Restorativeness (PR)		Biodiversity Perception (BPD)	
		<i>r</i>	<i>P</i> Univ	Corr	<i>P</i> Univ
Biodiversity and landscape metrics					
Species richness	Total tree, butterfly and bird species	.129**	0.003	.147**	0.001
N_Tree	Tree species richness	0.05	0.238	0.062	0.142
N_Butterfly	Butterfly species richness	.171**	<0.001	.121**	0.004
H_Birds	Shannon diversity index of birds	.087*	0.041	0.041	N Sig
E_Trees	Evenness of tree species	-.188**	<0.001	-0.03	0.004
E_Butterflies	Evenness of butterfly species	0.058	0.167	.148**	0.001
E_Birds	Evenness of bird species	0.058	0.176	-0.023	N Sig
PRDcov	Patch Richness Density of land cover types (lawns, trees, water)	-.099*	0.019	0.048	N Sig
PRDsp	Patch Richness Density of dominant tree species	-.106**	0.012	-0.025	N Sig
SHDIsp	Shannon Diversity Index of dominant tree species	.137**	0.001	.142**	0.041
MSIEIsp	Modified Simpson's Evenness Index of dominant tree species	-0.043	N Sig	-.087*	0.045
CWM_evergreen	Community Weighted Mean of evergreen species	.214**	<0.001	.191**	<0.001
CWM_broadleaf	Community Weighted Mean of broadleaf species	.136**	0.001	.104*	0.014
CWM_fruitshowy	Community Weighted Mean of showy fruits	-0.067	0.118	-.083*	0.051
NDVI	Normalized Difference Vegetation Index in summer	.093*	0.026	.181**	<0.001
Users perceptions					
Complaints	Disturbing features referred by park users	-.177**	<0.001	-0.083	0.053
Special	Connection to place (is this place special? Yes-No)	.177**	<0.001	0.006	N Sig
BDP	Perception of high levels of biodiversity	.286**	<0.001	NA	NA
Tree diversity perception	Perception of diversity of tree species	.161**	<0.001	.410**	<0.001
Bird diversity perception	Perception of diversity of bird species	.137**	0.002	.310**	<0.001
Visiting profile					
Frequency of visit	Classes: Occasional (< 1x/week); Regular (≥ 1x/week)	.092*	0.031	0.012	N Sig
Duration of visit	Classes: Passing by; < 30 min; 30-90 min; 90-180 min; > 180 min	-0.046	0.015	.103*	N sig
Park qualities					
Park quality	Availability and quality of facilities, amenities and space cleanliness	.118**	0.005	NA	NA

Significant positive correlations were observed between perceived restorativeness (PR) and some of the biological diversity indexes such as *Total species richness* ($r=0.129$) and *Butterfly species richness* ($r=0.171$) or *diversity of birds* ($r=0.087$), while a higher *Evenness of tree species* was negatively correlated with PR ($r=-0.188$). Except for the *Diversity of tree patches* (SHDIsp),

which was positively correlated with PR ($r=0.137$) the remaining land cover metrics (*PRDcov*, *PRDsp*) displayed negative correlations with PR ($r=-0.099$, $r=-0.106$). The visual functional traits related with leaf shape (*CWM_broadleaf*) and phenology (*CWM_evergreen*) were also found to be significantly correlated with PR ($r=0.136$; $r=0.214$), with *NDVI* also being positively correlated with PR ($r=0.093$). Users' perceptions on existing biodiversity were all positively correlated with PR (*BDP* $r=0.286$, *Tree diversity perception* $r=0.161$; *Birds diversity perception* $r=0.137$) as well as the *Special* connection with the place ($r=0.177$). On the contrary, the higher the number of complaints regarding the space (*Complaints*) the lower the PR ($r=-0.177$). From the visiting profile only the *Frequency* of visit displayed a significant positive correlation with PR ($r=0.092$). The correlation analysis for biodiversity perception (BDP) also showed some positive associations with diversity indexes such as *Total species richness* ($r=0.147$), *Butterfly species richness* and *Evenness* ($r=0.121$; $r=0.148$) and *Diversity of dominant tree species* (*SHDIsp*; $r=0.142$). *Evenness of tree species* (*MSIEIsp*) was negatively correlated with BDP ($r=-0.087$). *CWM_broadleaf* and *CWM_evergreen* were also positively correlated with BDP ($r=0.104$; $r=0.191$), while *Fruit showiness* was negatively correlated ($r=-0.083$). For users' perceptions only the perceived *Tree* and *Bird diversities* were positively correlated with BDP, both variables showing the higher correlation coefficients ($r=0.410$; $r=0.310$).

From all biodiversity variables, only *Patch Richness Density of cover types* (*PRDcov*) and the *Community Weighted Mean of evergreen species* (*CWM_evergreen*) retained significance in the final model of perceived restorativeness (PR) (Tables 5.3 and 5.4). *PRDcov* is a measure of patch richness but also of landscape fragmentation, with a higher value representing a higher number of smaller patches, while *CWM_evergreen* represents the proportion of evergreen tree species in the park. Perceived restorativeness (PR) was thus negatively influenced by a fragmented landscape with higher number of small patches and positively influenced by a higher proportion of evergreen species. The remaining significant predictors were related with users' pattern of visitation (*Frequency* and *Duration* of visit) and perceptions, with higher frequency and duration of visit having both a positive influence on PR. Perceiving high levels of biodiversity (*BDP*) and having an emotional connection with the place (*Special*) also had a positive effect in PR, while a higher number of complaints about the space (*Complaints*) was associated with lower PR. *Park quality*, measured by the variety and preservation state of facilities and amenities and space cleanliness, also had a positive influence in PR. The variables related to users' perceptions (*Special*, *Complaints* and *BDP*) were the most influential and also the ones with stronger relationship with PR as shown by higher partial regression and correlation values, respectively.

Those measuring *Park quality* and biodiversity (*PRDcov* and *CWM_evergreen*) had lower influence and correlation strength with variables related to visitation patterns; they were also the less influential predictors and with lower correlation values (Table 5.4).

Table 5.4 – GLM for Perceived Restorativeness (scaled variables). p < ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 (BDP – Biodiversity perception; *PRDcov* - Patch Richness Density of cover types; *CWM_evergreen* - Community Weighted Mean of evergreen species)

Predictor	Estimate	Std Error	P	Partial correlations	Partial regressions
Intercept	1.2744	0.0471	< 2e-16 ***		
<i>Perceptions, meanings and values:</i>					
Special	0.0390	0.0102	0.0001 ***	0.164	0.027
Complaints	-0.0271	0.0076	0.0004 ***	-0.142	0.020
BDP	0.0632	0.0116	8.5e-08 ***	0.247	0.061
<i>Patterns of visitation:</i>					
Frequency	0.0380	0.0216	0.079 .	0.073	0.005
Duration	0.0547	0.0202	0.0069 **	0.101	0.010
<i>Park_quality</i>	0.0505	0.0232	0.0298 *	0.111	0.012
<i>Biodiversity and landscape metrics:</i>					
<i>PRDcov</i>	-0.0269	0.0105	0.0109 *	-0.114	0.013
<i>CWM_evergreen</i>	0.0812	0.0287	0.0045 **	0.128	0.016

As the perception of high levels of biodiversity showed to have such an important role in perceived restorativeness, even when in conjunction with other predictors, we built a model for BDP departing from the same set of biodiversity related variables and excluding those related with park quality and patterns of visitation.

Table 5.5 – Generalized Linear Model for biodiversity perception (scaled variables)

	Estimate	Std Error	p	Partial correlations	Partial regressions
Intercept	-8.2456	0.9663	< 2e-16 ***		
Tree perception	5.2074	0.7071	1.78e-13 ***	0.381	0.144
Bird perception	2.5602	0.4964	2.50e-07 ***	0.257	0.066
<i>CWM_evergreen</i>	2.0266	0.5496	0.000227 ***	0.191	0.036

Though many diversity related variables showed significant correlations in the univariate analysis, with the exception of the proportion of evergreen species, none of the other taxonomical, functional or landscape diversity variables were retained in the final model. Biodiversity perception was primarily determined by people’s perceptions of trees and birds’ diversity (Table 5.5), with tree diversity being the most significant predictor and the one with

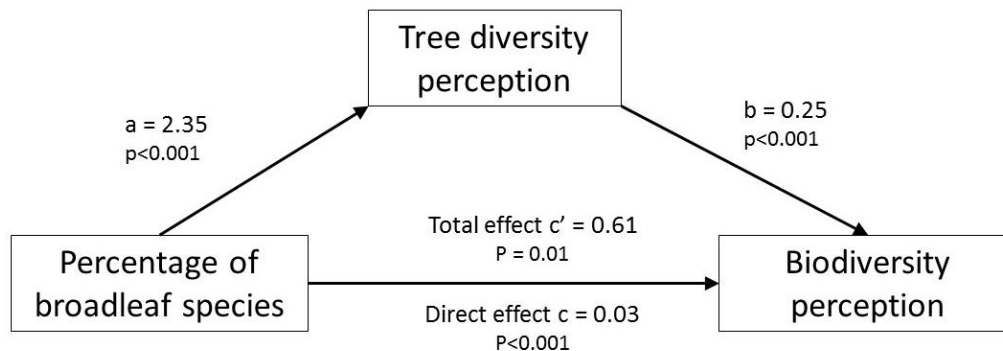
higher influence and stronger correlation, as shown by partial regression and correlation coefficients.

We then tested if any biodiversity metric had an indirect effect in restorativeness through the perception of biodiversity and if this was mediated by the perception of tree species diversity. Due to the correlational nature of BDP and PR we also tested the mediational role of PR in BDP (Table 5.6 and Figure 5.2). As for an indirect effect of biodiversity in restorativeness through biodiversity perception, only partial mediations, between 18% and 32%, were found for *Species richness*, *Tree evenness* and *Percentage of evergreen and broadleaf species*, with *NDVI* showing the higher mediation proportion (53%). The inverse pathway was also tested and partial mediations (15-42%) were found for *Tree species evenness*, *Percentage of broadleaf and evergreen species*, and *NDVI*. Yet, for BDP a full mediation through tree perception was found for the *CWM of broadleaf species*. All other tested mediations according to analysis assumptions (Hayes and Rockwood 2017) were non-significant.

Table 5.6 – Analysis of the mediation role of biodiversity perception and tree diversity perception in the effect of biodiversity metrics on perceived restorativeness (PR) and of perceived restorativeness (PR) and tree perception on biodiversity perception (BDP). CWM_broadleaf - percentage of broadleaf species; CWM_evergreen - percentage of evergreen species; NDVI – Normalized Difference Vegetation Index, a measure of greenness. Direct effect – effect of the independent variable (X) in the dependent variable (Y) when the mediator (M) is held constant; Indirect effect – conjunction of the effect of X on M and the effect of M on Y. Total effect – effect of X on Y without controlling for M. % mediation – percentage of reduction of total effect when M is controlled. CI – confidence interval obtained by bootstrapping. Significant mediations have CIs that do not include zero.

Predictor	Response	Mediator	Direct effect	Indirect effect	Total effect	% mediation	CI
Species richness	PR	BDP	0.26	0.12	0.38	0.32	0.05-0.2
Evenness trees			-0.61	-0.13	-0.74	0.18	-0.23 – -0.05
CWM_broadleaf			0.80	0.22	1.02	0.22	0.04-0.42
CWM_evergreen			0.57	0.17	0.74	0.23	0.09-0.26
NDVI			0.32	0.37	0.69	0.54	0.18-0.6
Species richness	BDP	PR	0.26	0.08	0.34	0.24	0.02-0.15
Evenness trees			-0.22	-0.16	-0.38	0.42	-0.25 – -0.09
CWM_broadleaf			0.39	0.22	0.61	0.36	0.08-0.41
CWM_evergreen			0.36	0.15	0.51	0.29	0.09-0.23
NDVI			0.88	0.15	1.03	0.15	0.02-0.3
Species richness	PR	Tree perception	0.27	0.11	0.38	0.29	0.04 - 0.19
Evenness trees			-0.67	-0.07	-0.74	0.09	-0.13 – -0.02
CWM_broadleaf			0.77	0.25	1.02	0.25	0.09 - 0.43
CWM_evergreen			0.70	0.04	0.74	0.05	0 - 0.09 (NS)
NDVI			0.42	0.27	0.69	0.39	0.11 - 0.45
Species richness	BDP	Tree perception	0.09	0.25	0.34	0.74	0.17-0.34
Evenness trees			-0.22	-0.16	-0.38	0.42	-0.26 – -0.06
CWM_broadleaf			0.03	0.58	0.61	0.95	0.36-0.82
CWM_evergreen			0.42	0.09	0.51	0.18	0.01-0.18
NDVI			0.48	0.55	1.03	0.53	0.35-0.77

Figure 5.2 – Schematic diagram of mediation analysis results. Path a represents the effect of broadleaf species in tree diversity perception, path b the effect of tree diversity perception in the perception of biodiversity, and together they represent the indirect (mediated) effect of broadleaf species in biodiversity perception through the perception of tree diversity. Path c represents the direct effect of broadleaf species on biodiversity perception when the indirect, mediated effect, is controlled and path c' represents the total (mediated and direct) effect of broadleaf species in biodiversity perception. The requirements for a mediation effect are satisfied: Path a, Path b, and Path c' are significant, and Path c is significantly smaller than Path c', demonstrating that the perception of high tree diversity almost completely mediates the effect broadleaf species on users' perception of biodiversity.



Our results showed that mental restoration was primarily determined by users' perceptions, meanings and values associated to the park, rather than by park's biophysical attributes themselves, including its biodiversity. The major determinant for restoration was the perception of biodiversity which itself was not directly influenced by any of the quantified metrics. Biodiversity perception was indirectly determined by the amount of broadleaved species through the mediation of the perception of tree species diversity.

5.4 Discussion

This is the first work integrating materialized park attributes (biodiversity and park facilities) with users' perceptions about those attributes and their profile of visitation. Our results showed that individual perceptions, or lived experiences, played a more important role in restorativeness than materialized attributes. Perception-related variables, including biodiversity perception, emotional connection with the space and complaints, were the most significant in the PR model. Moreover, the variation explained by them was more than double the variation explained by the remaining set of variables, related with biophysical measurements and patterns of visitation, as shown by the partial regression values.

Park quality, as assessed by the number and preservation state of amenities and facilities and the park's level of cleanliness, also contributed positively to perceived restorativeness, though to a much lesser extent. The presence of amenities and facilities meeting visitor's needs and desires

may contribute to a better appreciation and, thus, to restorativeness (Nordh and Østby 2013, Wilkie and Stavidou 2013). Evidence of litter or degraded furniture, on the contrary, impose undesired stimuli that attracts attention and thus prevents the feeling of being away, important for mental restoration according to the Attention Restoration Theory (Kaplan and Kaplan, 1989). Cleanliness is one of the most desired attributes in urban parks (Nordh and Østby 2013, Madureira et al. 2018) and the presence of litter was a major source of disturbance referred by users, along with the lack of adequate management and complaints about the misbehavior of other users, including littering.

People seek urban green spaces for many different reasons and their needs and preferences for parks' features vary accordingly (Peschardt et al. 2016). With multiple uses, meanings and needs at stake in a single space, conflict is likely to occur (Dinnie et al. 2013), especially if the space area and/or design do not offer an adequate separation of those multiple interests. Spatial niche segregation is a well-known phenomenon observed in biological communities sharing a common space with multiple resources (Pianka 2000). Larger parks, or with a design offering a perception of large dimension, have been related with higher restorative capacity (Nordh et al. 2009). A highly fragmented pattern with diverse types of land cover, as expressed by a high Patch Richness Density, may favor the close contact with less desired environments and impair the ability to feel immersed (*extent*) in a pleasant environment, adequate for the purpose of the visit (*compatibility*). These results support the importance of large patches dedicated to a single function, a design offering the possibility of seclusion and privacy, or the need to allocate specific functions to smaller parks, connected in a multifunctional network of greenspaces in contrast to networks of one-size-fits-all multifunctional greenspaces. A similar relation with Patch Density was found for the existence of street trees and neighborhood satisfaction, with residents being more satisfied with large and well-connected tree patches than with highly fragmented and isolated patches (Lee et al. 2008) with street greenery promoting walkability and visitation to greenspaces (Lu et al. 2018) and higher tree canopy being associated with better mental health (Astell-Burt and Feng, 2019). These findings reinforce the importance of greenways and green corridors as connectors of greenspaces to create such multifunctional network, while contributing to enhance restorativeness.

As for parks' biodiversity, the proportion of evergreen species emerged as a driver for perceived restorativeness. Evergreen species have been associated to a perception of higher visual and aesthetical quality (Eroglu et al. 2012, Du et al. 2016), and higher preference over deciduous

species (e.g. Camacho-Cervantes 2014, Kuper 2015) and landscape preferences have been associated with higher mental restoration likelihood (Pazhouhanfar and Kamal 2014, Lindal and Hartig 2015). The color green is known to elicit positive emotional responses as relaxation and calmness due to its association with nature (Hemphill 1996, Kaya and Epps 2004) and, in fact, virtual scenes with evergreen species were shown to have a higher restorative potential than defoliated scenes (Paddle and Gilliland 2016, Kuper 2020).

The perception of high levels of biodiversity and the emotional connection to the place showed to have a stronger influence in perceived restorativeness than land cover, taxonomical or functional diversity indexes. Biodiversity perception was indirectly determined by the diversity of tree leaf types with this effect being completely mediated by the perception of tree species diversity. As trees are usually the predominant and most prominent parks' feature it is easily conceivable that people associate biodiversity with tree species diversity and this with the diversity of leaf forms, specifically the percentage of broadleaved species. Broadleaved species have a large variety of easily distinguishable leaf shapes and tree habits, while those with needle and scale leaves, mostly very similar conifers, are difficult to distinguish without a more profound analysis of their morphology (Welch, 1991). Different leaf shapes and tree habits represent a variety of visual stimuli attracting attention and providing cues to make sense and give meaning to the stimulus object, essential in the perceptual process (Lindsay and Norman 1972). Preference for broadleaved species has been described (Lee 2001), especially in regions where they are the predominant (Schraml and Volz 2009) which is the case of the Mediterranean region where native vegetation is dominated by broadleaved evergreen shrubs and trees, but also in other regions as, e.g. Australia (Williams, 2002). Broadleaved species mostly have oval and spreading canopies which are also preferred over conical or pyramidal shapes common in conifers (Summit and Sommer, 1999; Lohr and Mims, 2006).

Partial mediations of the effect of species richness, NDVI and tree evenness in biodiversity perception were also found, and these mediation processes mean that people do perceive differences in biodiversity, essentially through visual cues. This fully supports the statement by de Vries and Snep (2019:167) that "*Perceived biodiversity is likely to depend strongly on the visibility of the different species, and on the extent to which they are perceived as being different*". Mediation analysis was used by several authors to study the mechanisms by which different environmental qualities, either existent or perceived, influence mental well-being outcomes (e.g. Nordh et al. 2009, Lindal and Hartig 2015, Marselle et al. 2016, Carrus et al.

2015, Hipp et al. 2016, Knez et al. 2018, Tabrizian et al. 2018, Wang et al. 2019). To our knowledge, however, none applied such analysis to the mechanisms influencing perception of biodiversity or restorativeness itself.

Emotions play an important role in how we perceive and categorize the surrounding environment (Brosch et al. 2010, 2013), and emotionally significant stimuli are better recognized and identified than neutral stimuli (Zeelenberg et al. 2006, Zadra et al. 2011). It is important to understand how emotions and perceptions mediate the interaction between tangible biophysical features and mental restoration. A regular and continuous interaction with a space is important to create meaning and a sense of belonging (place identity) which translates in an emotional connection to the place, so-called place attachment (Tuan 1975, Williams and Vaske, 2003, Smaldone 2007). The emotional connection with the place had a positive influence in perceived restorativeness, with regular users visiting the spaces at least once a week, and those visiting for longer periods, scoring higher perceived restorativeness. This indicates that psychological restoration takes time and does not “just happen” as soon as one enters a greenspace. Previous studies got similar results having shown that quick visits (< 15 min) in greenspaces do not stimulate physiological restoration (Tyrväinen et al. 2014). A positive influence of personal association with the place in restorative perceptions has been described (Korpela and Ylén 2009, Menatti et al. 2019), with place identity, a dimension of place attachment, also having mediating roles between naturalness and well-being (Knez et al. 2018) and between memory and mental restoration (Ratcliffe and Korpela 2016). In this work the emotional connection with the place did not exert any significant mediation role between biodiversity or its perception and restorativeness.

Promoting restorativeness in urban green spaces lies, therefore, on offering clean greenspaces with evergreen and/or broadleaf tree species, well-preserved amenities and facilities compatible with visitors' needs and desires, which invite and welcome people to visit the place. Considering tree functional traits and not only tree species, offers a higher potential for park managers to decide locally, combining visual traits with local preferences and ecological requirements. This approach may be particularly important in less developed countries with more recent urbanization processes and less acculturated urban populations, which may tend to import solutions not adapted to local realities. The importance of this approach in these countries is indicated by little evidence accumulated from low and middle-income countries (Shuvo et al. 2020) when compared with the growing research on greenspace-health relationships in high-

income countries in Europe, North America and Australia (Markevych et al. 2017). Citizen science may offer a useful tool to understand local preferences (Krasny et al. 2014), particularly in less resourceful communities where social surveys to advance scientific knowledge may not be easily feasible.

Our findings highlight the need of a close integration of ecological and social values in urban greenspaces planning and management and a next step would be to assess how different origins and cultural constructs influence preferences, meanings and values and thus the perception of biodiversity and restorativeness. The Biocultural Diversity (BCD) concept offers a valuable and much needed socio-ecological lens through which study urban greenspaces socioecological dynamics; it addresses the interrelatedness between people and nature, and is expressed by the diversity of ways people live, experience, perceive and value their natural environment. BCD can be easily recognized in cities (Elands et al. 2019) where human action has shaped urban nature through times, with Materialized BCD and Lived BCD describing two dimensions of that interaction. The first is related with tangible manifestations, represented by quantifiable discrete objects as ecological communities or cultural artefacts, and the other concerns the ways by which people relate to the biophysical environment through their experiences, emotions and perceptions. Our results fully agree with this concept, as they show that restorativeness and biodiversity perception, besides being closely interlinked, are both dependent not only of place characteristics (Materialized BCD) but also on the perceptions and evaluations about it (Lived BCD). By recognizing the mutual influences and interlinkages between natural and cultural realms and the need to integrate social dynamics in urban ecosystems management, it is our understanding that the BCD concept is useful to assist planning, designing and managing greenspaces that are not only ecologically sound but offer locally adapted solutions, with population well-being in mind.

5.6 Conclusion

According to our results both parks' biophysical characteristics and users' perceptions about them are important for perceived restorativeness. The presence of large land cover patches, evergreen tree species and an adequate number of well-maintained amenities were the features found to be more restorative. Yet, the personal experience of the space and its qualities, the emotional connection with it and, essentially, the perception of its biodiversity are key for this process. And, although existing biodiversity did not play any role in promoting perceived restorativeness at first sight, our results demonstrate the opposite. People do perceive existing

biodiversity through visual clues such as the diversity of leaf forms in broadleaf species, with this process being almost completely mediated by the perception of tree diversity. These findings have direct translation into planning and management practices by acknowledging the importance of biodiversity-related attributes of the greenspaces, namely of tree species, in promoting restorativeness of urban parks' users, and reinforce the importance of using standard ecological methods when assessing biodiversity in urban greenspaces and their influence on human well-being.

Aknowledgments

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MUCH LEARNING
DOES NOT TEACH
UNDERSTANDING.

Heraclitus

CHAPTER 6

General Discussion

WE DO NOT RISE TO THE LEVEL OF
OUR EXPECTATIONS.
WE FALL TO THE LEVEL
OF OUR TRAINING.

— *Anchilochus* —

This thesis is the result of a cross-disciplinary approach linking natural and social sciences which brings out results that are intrinsically needed to sustain biological and cultural diversity in a rapidly changing world. Here, we embraced the Biocultural Diversity concept as a common thread to explore the ecological and social function of green infrastructures in urban ecosystems. That choice proved to be relevant and fruitful as the profound interlinkage between biological and social realms became evident in all chapters and their findings.

6.1. Biocultural diversity as a complement and an alternative to Ecosystem Services discourse

The BCD framework structured a rather complex concept which, until then, was still in a conceptual level. By providing a structure with three broad, interconnected, layers/dimensions - Materialized, Lived and Stewardship of BCD - covering the manifestations of the interaction between biological and cultural diversity in urban settings, opened the door to the use of BCD as a complementary and alternative option to existing frameworks studying socio-ecological systems.

Several frameworks, from different theoretical backgrounds and with different scopes, scales of analysis and applicability have been used to study and analyze socio-ecological systems (Binder et al., 2013; Cumming, 2014), with the Ecosystem Services (ES) (de Groot, 1992), and the Socio-Ecological System (SES) frameworks (Ostrom, 2007; 2009), being two of relevance for this thesis context. The ES framework, likely the most widely used to assess the role of biodiversity in cities (Elmqvist et al., 2013), have a focus on ecosystem functioning, with nature providing services that support life and contribute to human well-being. SES, on the other hand, as a rather anthropocentric perspective with a focus on human actions affecting the ecological system (Binder et al., 2013; Cumming, 2014). From these two, only ES consider the intangible benefits humans derive from nature, with the so-called cultural ecosystem services (CES) (e.g. Haines-Young and Potschin 2009). Yet, and despite its relevance in translating the role and importance of ecosystem processes for human existence, health and thriving, the ES concept still faces some criticisms. Namely, when it assumes a one-directional flow of supplies from ecosystems to humans, and consider these just as a beneficiary of such services and a driver of negative changes, disregarding their role as co-producers of services (Comberty et al., 2015; Buizer et al., 2016). CES also face some operationalization difficulties (Plieninger, et al., 2013; La Rosa et al., 2016; Blicharska et al., 2017; Dickinson et al., 2017), as it are not the reflex of ecological processes, features or properties, but rather the result of complex information processing. CES

only come to existence when perceived and valued by their beneficiaries (Chan et al., 2012, 2016; Buchel and Frantzeskaki, 2015) with this value being determined by individual characteristics, cultural values and belief systems. CES cannot thus be assessed merely by expert's opinions or proxy-based indicators related with biophysical features.

An additional but very important shortfall of the ES framework concerns the lack of the recognition of stakeholder's role in decision making processes, essential for successful governance (Schewenius et al., 2014; Muñoz-Erickson et al., 2016). On the other hand, while the SES framework does not consider the social system solely as an end-user of ecosystems' functions and integrates both interaction and feedbacks between social and ecological systems, including governance systems, it is primarily focused on the use value of resources (Binder et al., 2013). It does not include the ways how people live and experience the natural world, nor the intangible values associated with it.

The BCD concept assumes that, in socio-ecological systems, biological and cultural diversity evolve jointly over time, in a continuously changing relationship. Diversity should, thus, be understood and recognized as a multidimensional and dynamic phenomenon and cultural dynamics included in urban green infrastructure policy- and decision-making processes. The BCD concept was previously suggested to be an alternative to ES concept for cities governance, as being a rather reflexive and transdisciplinary approach, which is essential to deal with the dynamics of multiple values and knowledges assigned to urban greenspaces (Buizer et al., 2016). The BCD framework presented in this thesis (Chapter 2) advances and consolidates this proposal, by structuring the concept with the introduction of Materialized, Lived and Stewardship as the three dimensions of BCD which address the ways people live with and experience the environment, how they get benefits, tangible and intangible, but also how they transform and co-create their environment by actively be engaged in the process. These are the dimensions to which pay attention when discussing, planning and managing urban green infrastructure under the BCD perspective and offer the foundation to operationalize such a complex concept with the proposed indicator-based tool.

6.2. BCD indicators as a decision support tool

The indicator-based tool proposed in chapter 3 operationalizes the BCD concept in urban settings to enable its use in decision making. The tool offers a comprehensive set of indicators covering the manifestations of interactions between people and greenspaces in cities and provides an

effective and efficient way to study greenspaces through this perspective, as exemplified in the case-studies used as testbed.

In spite of the urgent need for indicator-based decision-support tools, and of the growing use and integration of the ES concept in UGS planning and management decisions, evidence base on the relation between BD qualities and ES as not yet been demonstrated and, probably due to that knowledge gap, there is no consensus on which ES indicators to use, what indicates what, and still less on metrics or references and benchmarks. The SES framework, as mentioned in the previous section, though being operationalized with indicators covering Resource and Governance Systems, Resource Units and Users, and the interactions between these four dimensions and their outcomes, lacks the assessment of intangible interrelations between the social and cultural realms. Though considering governance systems, it considers nature as a resource provider which is impacted by human activities and, other than its utility or economic value, does not take into consideration people's perceptions, meanings and values ascribed to the place and its biodiversity. The major advance of BCD indicators, relatively to other available indicator sets, e.g. of CES (La Rosa et al., 2016), is the inclusion of items concerning not only cultural background and governance systems, as SES does but are inexistent in ES, but also information concerning the ways people live, experience, perceive and value greenspaces and how they shape and are shaped by their interaction with nature.

The proposed indicators and the way they operate overcome the problem of using singular measures to represent the highly dynamic and heterogeneous relations between people and nature, as defended by e.g. Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) or the United Nations through its New Urban Agenda (NUA), and allow to address the need for locally relevant indicators to inform decision making.

Besides offering several metrics, with various levels of accuracy and detail, that can be used according with assessment's purpose and scope, the proposed tool provides the exact steps needed to obtain a result easy to understand, share and compare. The possibility of setting local references and benchmarks, that assess where the UGS stands in relation to the desired outcome, allows planners and decision-makers to approach cities sustainability issues in a contextualized manner, instead of the normative setting drawn by the United Nations New Urban Agenda (NUA). The lack of contextualization is one of major criticisms made to the agenda as, by relying on general and universal indicators and metrics, it set standards of what "should be" a sustainable

city, decontextualizing and devaluing the intrinsically local and social urban realities and complexities, raising governance and inclusiveness concerns (Caprotti et al., 2017). This tool, on the contrary, offer a foundation to deal with conflicts, negotiate trade-offs and set priorities through adequate governance processes.

6.3. “And justice for all”

Case-studies in Chapter 3 revealed self-exclusion processes both in low- and high-quality parks. Young educated adults of the neighbourhood were not proportionally represented in the visitors’ sample of a low-quality greenspace, while older, less educated neighbours were not represented in the studied high-quality park. Also, Chapter 4 showed an inequity of access to high-quality parks as assessed by their structural diversity, a combined score of number of biotopes, vegetation structure, facilities and services, and artificial elements. One of the main reasons for visiting low structural diversity parks was its location, meaning the closeness to their home. Park location was the only motivation that was more important in low structural diversity parks than in medium and high diversity parks. Visitors of high structural diversity parks referred a high number of different motivations, with location being one of the less important. According to results in Chapters 3 and 5 these high-quality parks are also those contributing more for mental restoration.

Parks with higher structural diversity, and providing higher levels of mental restoration, are found in wealthier neighbourhoods, and thus available to those living in the wealth neighbourhood or with physical and economic conditions to go there. Parks with low structural diversity are mostly located in neighbourhoods of lower socio-economic condition and perform worst in terms of cleanliness and amenities maintenance. As such, people with lower socio-economic status and without physical and/or economic capacity to travel to a better park, have to settle for the available low-quality greenspaces in their neighbourhood. This means that people living in less wealthier neighbourhoods have lower access to the benefits provided by a quality greenspace, as illustrated in chapter 3 case studies, and raise questions of environmental justice both of equity of access to high quality greenspaces and the benefits they provide.

The term ‘environmental justice’ (EV) was firstly coined to address the general belief that environmental hazards were unevenly distributed, with the most disadvantaged social groups being disproportionately impacted (Schlosberg, 2009). Over time EV evolved to also include the unequal access to environmental benefits, including the access to urban green spaces and their

benefits (Byrne and Wolch 2009). Not just a geographical access provided through an even and equitable spatial distribution of greenspaces but an access to intended and preferred uses, free of barriers, either physical, societal or personal (Elands et al. 2018). Barriers may include distance to the greenspace, proximity to high traffic roads, lack of adequate recreational infrastructure or low quality of the green space, cultural norms, safety and/or confidence issues. These barriers do not impact all people equally. Access goes, therefore, beyond spatial distribution and must integrate how green space attributes can function as ‘barriers or promoters’ taking people’s different identities and vulnerabilities into consideration (Davoudi and Brooks, 2016). From type of amenities and overall conservation status and cleanliness, to perceived and actual levels of safety, or vegetation attributes, greenspace qualities are important factors determining how welcomed and comfortable people feel in the space. Equitable access to greenspaces is thus related with space qualities and how these attract or deter people from visiting the space.

Due to its ancient origin and growth pattern, Lisbon has an uneven distribution of quality greenspaces, forcing its residents to either displace in search of a greenspace suiting their needs and desires or settle for whatever they have closer to their home (Luz et al 2019). For the last decade Lisbon municipality has invested in expanding the coverage and physical connection of its greenspaces network to create a green infrastructure across the entire city. As its own designation suggests, the “Municipal ecological network” strategy has been mostly focused on ecological connectivity and the need to cope with climate change adaptation, while promoting the availability of greenspaces in a short distance through an even spatial distribution (GOP 2015-2018, 2018-2021). Greenspaces have thus been designed essentially from an ecological perspective, not necessarily addressing barriers other than physical, nor the variability of functions derived from different social and cultural identities, needs and desires (Verheij and Corrêa Nunes, 2020).

Our results clearly indicate an inequity of access to quality greenspaces and the mental well-being benefits they provide. This implies the need of a shift in Lisbon’s strategy regarding its green infrastructure planning with the integration of active governance processes to tackle the diversity of socio-ecological functions involved. The BCD framework and indicators here proposed are important assets and may provide a major contribution to address these issues.

6.4. “One-size-fits-all” or “All different, all equal”?

Motivations for visiting greenspaces were found to be very diverse and variable between the four European cities studied in Chapter 4. Yet, though having different motivations to visit the parks, and contact with nature seldom being one of them, people mostly appreciated and enjoyed nature itself, along with park immaterial characteristics as ambiance, layout or its cleanliness. This was observed across the studied cities, with their own patterns of motivations and enjoyments, and independently of parks’ structural diversity. This means that, even if the park does not have high diversity of biotopes, vegetation structure and amenities and facilities, people enjoy its nature and immaterial characteristics, even though, a higher proportion of visitors mentioning to enjoy nature in more structurally diverse parks and a positive correlation being found between biotope richness and environmental-based enjoyments.

Motivations for visiting greenspaces have been largely addressed in the literature worldwide, much more than getting to know what people really enjoy while being there, and the variety of motivations lead some authors to argue “*that there may be no simple way to manage greenspaces to maximise their use across user cohorts as the motivations for visits are very different*” (Dallimer, 2014). This argument highlights the importance of distinguishing between motivation to visit, enjoyment experienced while visiting and benefits obtained from visiting the space. Managing greenspaces with users’ motivation in view, risk to be trapped in one-size-fits-all solutions, with a full range of mainstream facilities and amenities attempting to fulfil most users’ needs, or to transpose solutions proved successful in other locations. This approach risk to impose decontextualized solutions not adapted to local needs and desires, or to leave out fringes of society, usually those already in disadvantage. A park without facilities is not necessarily bad nor synonymous of poor quality, unfulfilling its visitors’ needs. A park may be purposely designed without facilities, as playgrounds or picnic areas, to give users the liberty to explore and create their own experience with the greenspace, finding new ways of interacting with the space (Pardal, 1997). Designed areas for children to play or for elders play cards, for a picnic or to exercise, conduct the experience of the space and induce spatial and age segregation. Diverse functions must be addressed in a spatial scale with multiple spaces providing variable and complementary functions in short distance, in a multifunctional network of greenspaces rather than a network of multifunctional spaces.

In contrast, managing greenspaces with users’ benefits in view, namely enjoyments, imply providing highly biodiverse spaces planned and managed to maximize well-being. According to

our results this can be achieved with clean, welcoming spaces, with well-preserved amenities, large patches of vegetation and a high proportion of evergreen and broadleaved tree species, which have also the advantage of being major contributors for ecosystem services (Manes et al., 2012; Gutsch et al., 2018; Roeland et al., 2019)

6.5. Appearances can be (but are not) deceptive. Biodiversity and restoration, reality and perception

This thesis (Chapter 5) by addressing biodiversity, involved the sampling of several biological taxa groups requiring different sampling approaches and methodologies, the collection of data on functional traits of numerous species, along with the characterization of parks' attributes and their visitors, in an effort to obtain a large and solid data set that could provide a holistic and integrative vision of the role of the different park's components, either measured or perceived, on visitors well-being.

At first sight, perceiving high levels of biodiversity seemed to be more important for mental restoration than high levels of biodiversity itself, assessed by any of the standard metrics used for estimating biological diversity. However, biodiversity perception showed to be indirectly determined by the diversity of leaf shapes, with the perception of high levels of biodiversity being associated with the predominance of evergreen species. These findings support the body of researchers arguing that lay-people may accurately perceive variations in biodiversity but could have been unnoticed if not by the use of functional traits metrics and mediational analysis. Besides the variety of biodiversity definitions used, the non-inclusion of functional traits may be one of the reasons for the disparity in results concerning the influence of biodiversity both on biodiversity perception and mental restoration. Though several studies addressed the relation between measured and perceived biodiversity (Botzat et al., 2016), and between these and mental restoration (Marselle et al., 2019), and visual cues being probably the first stimulus for perceiving the world (Lindsay and Norman, 1972), to our knowledge no study has ever considered the diversity of visual functional traits in the analysis of these interrelationships. Some studies linked tree shape and leaf type to tree preference, noticing that globular and spreading canopies were preferred and elicited more positive emotions than narrow canopies, as they were perceived as being more friendly, beautiful, warm, comforting, safe and stable than the less preferred conical and columnar-shaped trees (Gerstenberg and Hofmann, 2016). Other studies focused on the influence of preferences on restoration (Wilkie and Clouston, 2015), but none considered the role of functional diversity to biodiversity perception and mental restoration.

Also, studies on biodiversity perception are not consistent both in form (e.g., methodological approach) and content. While some use on-site inquiries, others use photos with these photo-based studies following two main approaches. Some use photo manipulation to show the same setting with more or less flowers, higher or lower vertical structure diversity and simulate variations in biodiversity level (e.g. Fischer et al., 2018), while others use images of greenspaces with different features, variable levels of greenness, naturalness, or other, as surrogates for varying levels of biodiversity (Botzat et al., 2016). As for the last method, the naturalness concept lies on how close the system is to its natural state. In cities, except for derelict lands, most greenspaces are designed, horticultural spaces, sometimes highly diverse, but far from the original natural state. Assume naturalness as a surrogate of biodiversity in the urban setting may represent a gross error.

The usefulness of using pictures for perceptions in studies of outdoor environments and if these photo-based assessments could be considered equivalent to on-site evaluations, has been subjected to a long debate with flaws being attributed to both methodologies (Gyllin et al. 2015). In a recent study in which lay-people and experts were asked to rate biodiversity of different sceneries, showed differences between on-site and photo-based ratings and if amongst lay-people those differences were not conclusive, for experts the differences were significant with on-site assessments being consistently different from the photo assessment and different from lay-people's on-site assessments (Gyllin and Grahn, 2015).

The lack of consistency also applies to the concept of biodiversity itself and the lack of a common language. The term biodiversity may assume different definitions even among professionals, according to expertise and focus of analysis (Gyllin and Grahn, 2015; Mayer, 2006). And though lay-people may refer interchangeably to biodiversity and nature (de Vries and Snep, 2019), and not exactly as professionals do, they possess an array of representations and meanings that presupposes a knowledge on nature attributes, function and benefits (Gyllin and Grahn, 2005; Buijs et al., 2008; Fischer and Young 2007, Vieira da Silva 2017). The biodiversity concept may even be related rather with a perception of feeling well in a place than with the richness or diversity of species there (Voigt and Wurster, 2015). Also, what is asked is not necessarily what is really understood by the respondent. These different understandings create a mismatch between what is asked and what respondents understand to be the question. Several studies have shown high frequencies of questions' misinterpretation and variability of interpretations amongst

respondents, raising doubts about the accuracy and variance of surveys results (Suessbrick et al., 2000; Schober et al., 2004).

Biodiversity perception studies are made by experts aiming lay people. Try to evaluate something with different meanings for interviewers and interviewees, and state that lay-people do not accurately perceive existing biodiversity, may simply mean that either the question, language, metric or analysis was not the adequate. This argues in favour, and reinforce, the importance of using a common language and standard ecological metrics to avoid ambiguities open to interpretation. Only then it will be possible to objectively clarify the mechanisms underlying biodiversity perception, the role of existing biodiversity and its perception in mental restoration to, then, be able to define criteria to evaluate greenspaces' planning and management. It also reinforces the need of a deeper integration of natural and social sciences for a real multidisciplinary research in urban ecology, and the need for ecologists to move from a paradigm of ecology *in* the city, to a paradigm of ecology *of* the city or, better still, to an ecology *for* the city (Pickett et al., 2016). Ecology *in* the city has focused mostly on studying biodiversity, community succession, species adaptation, exotic species spread or other ecological research issues, in terrestrial or aquatic habitats embedded in a non-hospitable urban matrix, or on the comparison between analogue urban and non-urban patches. Ecology *of* the city differs from ecology *in* the city by dealing with entire urban mosaics, of built and non-built patches, as social-ecological systems, and implies an increased complexity by incorporating biological, social and physical components in the study of urban ecosystems. The paradigm of ecology *for* the city evolved from the previous two to link socio-ecological science with civic processes. In this paradigm, ecologists are invited to engage with other specialists, namely social scientists, and urban dwellers, to integrate scientific knowledge in decision-making dialogs for more sustainable urban socio-ecosystems (Chapin et al. 2011, Krasny and Tidball 2012, Cadenasso and Pickett 2013).

The studies in this thesis were consonant with an ecology *of* the city paradigm but their findings support the usefulness of an ecology *for* the city conceptualization, with both the BCD framework and its operationalization offering an opportunity, and an important support tool, for ecologists to adopt an ecology *for* the city paradigm.

6.6. Future research needs and planning implications

The use of very different parks in their design, vegetation composition and population served, is an inherent limitation to ecological studies in cities, hardly possible to overcome. Nevertheless, we tried at most to overcome this limitation by selecting free access parks, larger than 4ha, with fully developed vegetation structure and the use of standard in a stratified sampling scheme. Though sampling the patch centroid being the commonly accepted method in ecological surveys, in urban parks designed by landscape architects to offer specific visual cues and experiences it would be interesting to assess the patch's edge where visitors circulate and to which have a closer contact, and relate this with perception of biodiversity and restorativeness.

We explored how biodiversity and its perception related with mental restoration but did not explore how motivations and enjoyments related both with biodiversity and well-being. It would be interesting to explore if biodiversity perception and mental restoration differed between visitors motivated by social reasons or park's facilities and amenities, for which parks' structural diversity seemed to be less influential, and those seeking parks for reasons related with nature, relaxation and well-being. Tough informative and possible to perform with existing data, this analysis would have benefited from the inclusion of a nature connectedness scale in the questionnaire, which was not the case due to the large number of questions already included. This approach could address how biodiversity perception and/or restoration are related with the level of nature connectedness.

A very important step forward would be to prove indicators applicability across spatial and temporal scales, with different goals and benchmarks. Conceptually it is possible but the proof of concept would be to study and apply them in different cities worldwide with locally defined references and benchmarks, addressing different questions for diverse green spaces typologies, such as a park in a highly multi-ethnic neighbourhood that wants to be more inclusive in its visitor profile, a urban forest which needs to link up with the ecological network while at the same time providing recreational facilities for people commuting to school and work, or a derelict land that can be transformed in an allotment gardening.

Another proof of concept for the use of BCD indicators in greenspace planning could be achieved, e.g., in a community-based planning experiment to redesign and restore a vacant lot, where community and decision-makers could follow the full process presented in the tool flowchart to reach a solution grounded in participatory and stewardship processes. Such

experiment, associated with assessments on nature connectedness, biodiversity perception and mental restoration prior, along and after the experiment would also allow to infer on the influence of active involvement in planning and stewardship actions.

Giving active voice to citizens and motivate them to participate in planning, managing and monitoring greenspaces, namely of its biodiversity, is key to improve greenspaces quality by addressing and supporting their needs, and, if this active involvement in stewardship actions has a positive influence on citizens' well-being as expected, this represents nothing but a win-win situation.

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Supplementary material

Annex 1 – Questionnaire used to assess motivations, uses and experiences

1. Secção sobre a relação do entrevistado com espaços verdes. Nesta secção gostaríamos de saber mais sobre a sua relação com este e com outros espaços verdes.

1.1. Porque veio a este parque?	1.2. Quanto tempo vai ficar? ☐ De passagem ☐ < 30 minutos ☐ 30-90 minutos ☐ 1,5-3 horas ☐ 3-5 horas ☐ > 5 horas
1.3. Veio: ☐ Sozinho ☐ Acompanhado. Por quem? ☐ Encontrar-se com:	1.4. Como veio? ☐ A pé/ corrida ☐ De bicicleta ☐ De carro ☐ De transportes públicos
1.5. Visita este parque frequentemente? ☐ Sim, frequência: ☐ Não, ocasionalmente ☐ Apenas durante (estação do ano):	1.6. Visita regularmente outros espaços verdes de Lisboa? Porquê?
1.7. Tem algum local em Lisboa que goste particularmente de visitar com frequência? O que o faz gostar desse local?	1.8. Este local é especial para si? Porquê?
1.9. O que gosta mais neste local?	1.10. O que acha que é o melhor deste local?
1.11. Há algo neste parque que o incomode?	1.12. Está preocupado com o futuro deste local? Porquê?

2.Diversidade biocultural de parques urbanos. Nesta secção estamos interessados em saber o que acha sobre a diversidade cultural e da natureza neste local e que tipo de benefícios pode trazer às pessoas. Gostaríamos de ter a sua própria opinião, não há respostas erradas, responda espontaneamente, sem hesitar e sem pensar demasiado.

2.1. Considera que este parque tem muita biodiversidade? ☐ Sim ☐ Não. Porquê?	2.2. De todas as espécies que aqui existem há alguma que gosta mais ou que gosta menos? Porquê?
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2.3. Para estes grupos, quantas espécies acha que existem neste local?

Grupos	Nenhumas	Muito poucas	Algumas	Muitas	Muitíssimas	Não interessado
Árvores e arbustos	1	2	3	4	5	0
Flores cultivadas	1	2	3	4	5	0
Flores silvestres	1	2	3	4	5	0
Aves	1	2	3	4	5	0
Borboletas	1	2	3	4	5	0
Fungos e líquenes	1	2	3	4	5	0

2.4. Acha que a existência de espécies animais e vegetais e a sua riqueza neste local contribuem para uma melhor qualidade de vida?

- ☐ Sim. Muito pouca/ alguma/ muita/ completamente/ contribui mesmo sem a diversidade de espécies
- ☐ Não. Para si/ para a cidade

2.5. Considera que este parque oferece oportunidade de encontro, tolerância e compreensão de grupos culturais diferentes?

- ☐ Sim. Muito pouca/ alguma/ muita/ completamente
- ☐ Não

2.6. Acha que grupos diferentes usam este espaço? (idosos, crianças, imigrantes, etc)

- ☐ Sim. Que tipo de grupos?
- ☐ Não, nunca considerei/ me apercebi

2.7. Neste parque especificamente como é que algumas destas características ou elementos contribuem para o seu entretenimento/prazer?

Características	Não	Muito pouco	Algo	Muito	Completamente
Localização	1	2	3	4	5
Bancos	1	2	3	4	5
Relvados limpos	1	2	3	4	5
Flores coloridas	1	2	3	4	5
Árvores grandes	1	2	3	4	5
Aves a cantar	1	2	3	4	5
Proximidade a corpos de água	1	2	3	4	5
Equipamentos para crianças	1	2	3	4	5
Cafés/ restaurantes	1	2	3	4	5
Equipamentos para exercício	1	2	3	4	5
Seguranças/ vigilantes/ funcionários câmara	1	2	3	4	5

2.8. Tem sugestões de mudanças ou melhorias para o parque?

2.9. Os espaços verdes podem oferecer muitos benefícios aos cidadãos. Poderia, olhando para estas quatro fotografias de diferentes espaços verdes em Lisboa, dizer quais os que contribuem mais para:

Serviço ou benefício	Local escolhido	Todos	Não sei	Não estou interessado em responder
Produção de alimentos				
Purificação do ar				
Regulação da temperatura				
Sequestro de carbono				
Controlo das cheias				
Polinização				
Habitat para espécies				
Convívio				
Inspiração				
Experiência espiritual				
Lazer				

2.10. Avalie numa escala de 1-5 até que ponto concorda com as afirmações abaixo.

Afirmação	Não concorda	Concorda pouco	Não concorda nem discorda	Concorda bastante	Concorda completamente
Estar neste parque permite-me fazer uma pausa na rotina do meu dia-a-dia	1	2	3	4	5
Neste lugar posso-me abstrair das coisas que requerem a minha atenção	1	2	3	4	5
É como se este lugar não tivesse limites/ fronteiras	1	2	3	4	5
Este local é fascinante	1	2	3	4	5
Há muito para explorar e descobrir neste lugar	1	2	3	4	5
Estar aqui vai ao encontro dos meus interesses pessoais	1	2	3	4	5
Neste lugar posso fazer coisas que gosto	1	2	3	4	5
Há uma ordem clara na disposição física deste lugar	1	2	3	4	5

3. Secção pessoal sobre o entrevistado. Gostaríamos de fazer algumas perguntas sobre si e a sua família. As informações são sigilosas e servem exclusivamente para este estudo. Pedimos que responda com cuidado e de modo completo porque as informações de base são muito importantes para a interpretação dos resultados.

3.1. Ano de nascimento: _____	3.2. Género: ☐ Feminino ☐ Masculino
3.3. País de nascimento: ☐ Portugal: _____ ☐ Outro, qual: _____ 3.4. Quando se mudou? _____	3.5. Vive permanentemente em Portugal? ☐ Sim ☐ Não 3.5.1. Qual o seu código postal/ bairro onde vive?
3.6. Qual a língua mais falada em sua casa? ☐ Português ☐ Russo/ucraniano ☐ Crioulo ☐ Chinês ☐ Inglês ☐ Outra, qual: _____	3.7. Com quem vive? ☐ Sozinho(a) ☐ Com os pais ☐ Companheiro(a) ☐ Companheiro(a) e criança(s)/idoso(s) ¹ ☐ Sozinho(a) com criança(s)/idoso(s) ¹ Ano de nascimento da(s) criança(s): _____
3.8. Qual o seu grau de ensino mais elevado? ☐ 4ª classe/ primária ☐ Ciclo preparatório/ 6º ano ☐ Antigo 5º ano/ 9º ano ☐ Complementar/ 11º ano ☐ Propedêutico/ 12º ano ☐ Curso superior 3.8.1. Área de estudos: _____ 3.8.2. Trabalho actual: _____	3.9. Qual o seu estatuto profissional actual? ☐ Trabalho a tempo inteiro ☐ Trabalho a tempo parcial ☐ Desempregado. Há quanto tempo? _____ ☐ Estudante a tempo inteiro ☐ Doméstica/ em licença de maternidade ☐ Reformado ☐ Outro

3.10. Tipo de casa: ☐ Própria ☐ Alugada ☐ Outro _____	3.11. Tipo de habitação: ☐ Apartamento ☐ Moradia ☐ Moradia geminada ☐ Pequeno edifício com poucos apartamentos																					
3.12. Tem, ou a sua família tem: ☐ Horta em Lisboa ☐ Habitação de férias na zona de Lisboa ☐ Habitação de férias noutra local em Portugal ☐ Nenhuma	3.13. Pratica actividades regularmente ao ar livre? ☐ Passeia um cão ☐ Cultiva uma horta (quintal/casa de férias/horta comunitária) ☐ Faz exercício ao ar livre (correr, caminhar, vela, caiaque, BTT...) ☐ Não																					
3.14. Pertence a uma ONGA (Organização Não-Governamental de Ambiente)? ☐ Sim ☐ Não	3.15. Sofre de alergias e/ou infecções respiratórias? ☐ Sim ☐ Não 3.15.1. Há alguma planta em particular que lhe cause alergia? ☐ Sim. Qual? ☐ Não ☐ Não sei																					
3.17. Como avalia, em termos de saúde e bem-estar:																						
<table style="margin: auto; border-collapse: collapse;"> <thead> <tr> <th style="border: none;"></th> <th style="border: none;">Nada</th> <th style="border: none;">Muito pouco</th> <th style="border: none;">Algo</th> <th style="border: none;">Muito</th> <th style="border: none;">Completamente</th> <th style="border: none;">Não sei</th> </tr> </thead> <tbody> <tr> <td style="border: 1px solid black; padding: 2px;">Sinto-me saudável</td> <td style="border: 1px solid black; text-align: center; width: 50px;">1</td> <td style="border: 1px solid black; text-align: center; width: 50px;">2</td> <td style="border: 1px solid black; text-align: center; width: 50px;">3</td> <td style="border: 1px solid black; text-align: center; width: 50px;">4</td> <td style="border: 1px solid black; text-align: center; width: 50px;">5</td> <td style="border: 1px solid black; text-align: center; width: 50px;">0</td> </tr> <tr> <td style="border: 1px solid black; padding: 2px;">Estou satisfeito(a) com a minha situação de vida actual</td> <td style="border: 1px solid black; text-align: center;">1</td> <td style="border: 1px solid black; text-align: center;">2</td> <td style="border: 1px solid black; text-align: center;">3</td> <td style="border: 1px solid black; text-align: center;">4</td> <td style="border: 1px solid black; text-align: center;">5</td> <td style="border: 1px solid black; text-align: center;">0</td> </tr> </tbody> </table>			Nada	Muito pouco	Algo	Muito	Completamente	Não sei	Sinto-me saudável	1	2	3	4	5	0	Estou satisfeito(a) com a minha situação de vida actual	1	2	3	4	5	0
	Nada	Muito pouco	Algo	Muito	Completamente	Não sei																
Sinto-me saudável	1	2	3	4	5	0																
Estou satisfeito(a) com a minha situação de vida actual	1	2	3	4	5	0																
3.18. Sente-se melhor ou pior quando visita espaços verdes? ☐ Sim. Porquê? ☐ Não. Porquê?																						
3.19. Gostaria de acrescentar algum comentário? 																						

Annex 2 – Pictures used to assess ecosystem services perception in annex 1 questionnaire

a.



b.



c.



d.

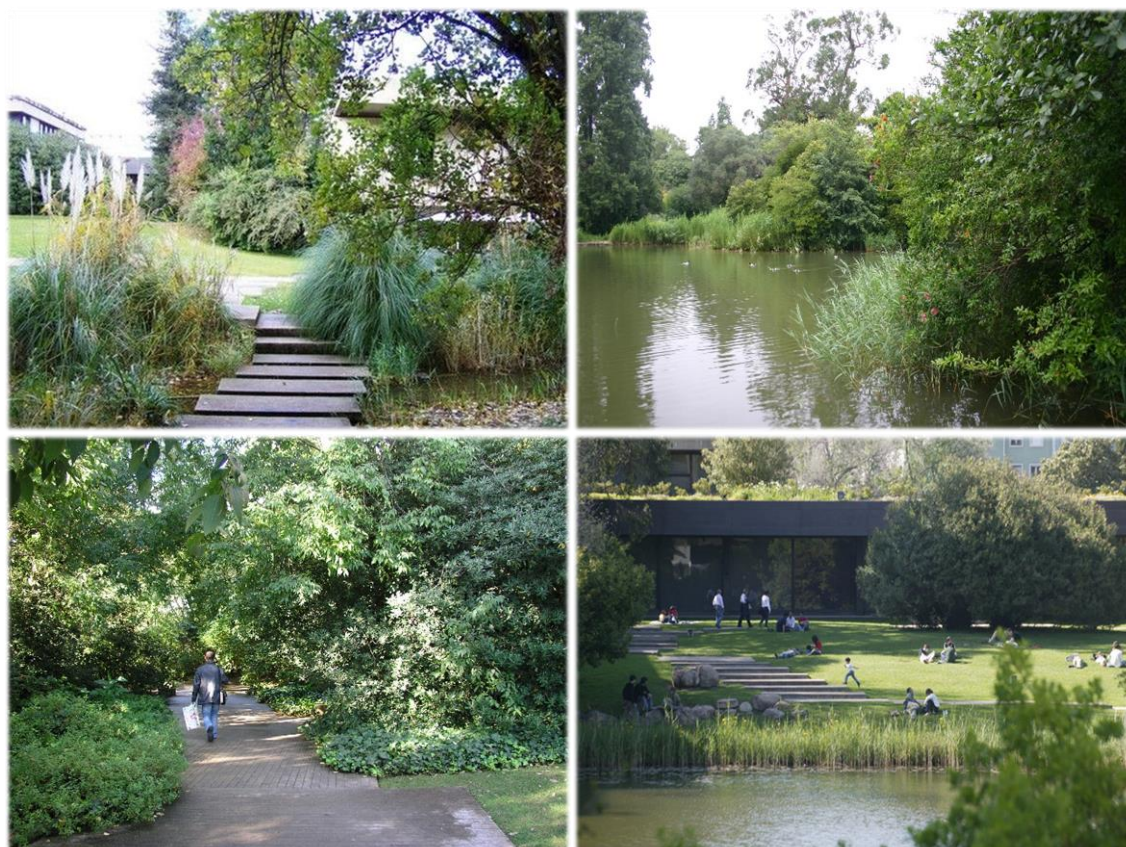


Annex 3 – Exemplary photos of Lisbon parks surveyed

a. Jardim da estrela (Jardim Guerra Junqueiro)



b. Jardins da Fundação Calouste Gulbenkian



c. Mata de Benfica (Parque Silva Porto)



d. Tapada das Necessidades



e. Mata de Alvalade (Parque José Gomes Ferreira)



f. Mata da Quinta das Conchas



g. Parque Urbano de Vale Fundão



h. Parque Urbano do Vale do Silêncio



i. Parque Recreativo do Calhau



j. Alameda Keil do Amaral



k. Miradouro de Montes Claros



l. Mata de São domingos de Benfica



Annex 4 – Survey tool used to assess overall parks’ condition

PARK ASSESSMENT

Name/ID of Greenspace

Assessor

Date

Start time:

time

Access										
	Code	1	1	1	2	2	2	2	3	3
AC1	How many entrance points (formal and informal) are there? (circle one)	n	1	2	3	4	5	6	7	8+
	Is there a timetable? Which?									
AC2	Is there a zebra or pedestrian crossing to assist access to the green space?	No	Yes	Number						
	Is there public transportation in walking distance?									
	Is there a parking lot?									
AC3	Does the open space provide a short cut/direct route between areas?									
AC4	Are there any walking trails?	None	Some	Adequate	A lot					
		0	1	2	3					
AC5	Are there any informal trails (cut-throughs, walking trails, desire lines, bike trails)	None	Some	Adequate	A lot					
		0	1	2	3					

Recreational Facilities									
	Number	Poor	Adequate	Good	Excellent	Shade	Sun	Paid	
RF1	Playground equipment (e.g. swings, slide, natural play equipment)								
RF2	Grass pitches (e.g. football, cricket, bowls)								
RF3	Courts (e.g. tennis, basketball including half court, netball, multicourt area)								
RF4	Skateboard ramp(s)								
RF5	Other (specify)								
RF6	Fitness equipments								
RF7	Pic-nic area (with or without grill)								
RF8	Amount of open space suitable for informal games, play and walking	None	Some	Adequate	A lot				
		0	1	2	3				
RF9	Quality of open space suitable for informal games, play and walking	None	Poor	Adequate	Good	Excellent			
		0	1	2	3	4			
RF10	Are there any informal playground/sport pitch?	No	Yes						

Amenities									
	None	Some	Many	None	Poor	Adequate	Good	Excellent	
AM1	Seating/benches	0	1	2	0	1	2	3	4
AM2	Litter bins	0	1	2	0	1	2	3	4
AM3	Dog mess plastic bags dispensers	0	1	2	0	1	2	3	4
AM4	Is there lighting within the green space	0	1	2	0	1	2	3	4
AM5	Toilets	0	1	2	0	1	2	3	4
AM6	Water fountains	0	1	2	0	1	2	3	4
AM7	Kiosk/cafeteria/other businesses	0	1	2	0	1	2	3	4
AM8	Information boards (map, events, safety, info, etc)	0	1	2	0	1	2	3	4

Natural features and maintenance									
	None	Poor	Adequate	Good	Excellent				
NA1	Grass (well maintained AND/OR aesthetically pleasing)	0	1	2	3	4			
NA2	Trees / shrubs / plants (well maintained AND/OR aesthetically pleasing)	0	1	2	3	4			
NA3	Flower beds / wild flowers	0	1	2	3	4			
NA4	Water / water features (e.g., ponds, streams)	0	1	2	3	4			
NA5	View points (quality of sight)	0	1	2	3	4			
NA6	Structures for wildlife (nest boxes, feeders, dove-cotes)	0	1	2	3	4			

Incivilities / safety		Rating				
		None	Hardly noticeable	Notice- able	Very noticeable	Reverse scoring
IN1	General litter	3	2	1	0	
IN2	Evidence of alcohol use? (empty bottles/cans)	3	2	1	0	
IN3	Evidence of drug taking (e.g. needles, syringes)	3	2	1	0	
IN4	Graffiti	3	2	1	0	
IN5	Broken glass	3	2	1	0	
IN6	Vandalism	3	2	1	0	
IN7	Dog mess	3	2	1	0	
IN8	Noise	3	2	1	0	
IN9	Presence of gardeners, staff, security elements	3	2	1	0	

Biocultural elements		Number			Rating				
		None	Some	Many	None	Poor	Adequate	Good	Excellent
BC1	Are there any biological salient features or with cultural, aesthetic value?	0	1	2	0	1	2	3	4
BC2	Are there any artefacts made from or representing nature? (benches, paintings)	0	1	2	0	1	2	3	4
BC3	Are there other signs of permanent interaction with nature?	0	1	2	0	1	2	3	4
BC4	Type of biocultural elements								

Cultural elements		Number			Rating				
		None	Some	Many	None	Poor	Adequate	Good	Excellent
CE1	Architectonic elements	0	1	2	0	1	2	3	4
CE2	Statues	0	1	2	0	1	2	3	4
CE3	Fountains	0	1	2	0	1	2	3	4
CE4	Other	0	1	2	0	1	2	3	4

Usage		Rating			
Is the green space generally suitable for:		Not at all	Somewhat	Suitable	Very suitable
US1	Sport (organised or not)	0	1	2	3
US2	Informal games (football, frisby etc)	0	1	2	3
US3	Walking	0	1	2	3
US4	Childs play	0	1	2	3
US5	Conservation/biodiversity	0	1	2	3

Annex 5 – BCD indicators description

Materialized BCD indicators

Greenspaces, even those with the same typology (e.g. public parks, urban forests, wetlands), are not universal units. Each has its own biophysical attributes established through time by culturally defined management options (Luck, 2009), that determine greenspace structure and functioning, and the way people use and interact with it. The **UGS biophysical attributes** theme refer to ecosystem's components and functions, the foundation for ecological quality, adaptation capacity and ecological resilience, but also for people-nature interaction, and include **Spatial heterogeneity**, **Vegetation structure**, **Biological diversity**, **Functional diversity**, **Tree health** and **Regeneration status** indicators. **Spatial heterogeneity**, or the existence of spatial units with different characteristics or functions (Shugart, 1998), which can be assessed by the “Number and diversity of biotopes” and/or its “configuration in the landscape”, is key for ecological functioning and resilience as, by providing a variety of niches and habitats, promotes the coexistence of greater diversity of taxa (Lovett et al., 2005). The diversity of landscape elements support multifunctionality and affords people the opportunity of multiple uses, being also associated with aesthetic and landscape preferences (Dronova, 2017). The same type of relationships is found with **Vegetation structure**, which can be assessed by its “vertical structure”, “tree density”, “height” and/or “canopy cover”, all presenting direct relationships with biodiversity (Beninde et al., 2015) but also with attractiveness, preferences and psychological restoration (Bjerke et al., 2006; Chiang et al., 2017; Jiang et al., 2015). “Ground cover” is an integrant part of vegetation structure and besides being important for e.g. soil erosion and runoff protection (Kim, 2016), plays an important role in people's preferences and attractiveness (Rega-Brodsky et al., 2018).

Biological diversity in urban greenspaces provides direct and indirect benefits to urban dwellers (Oliver et al., 2015). In many cases, urban nature represents one of the few opportunities for people being in direct contact with the natural environment, with correspondent benefits in physical health, cognitive performance and psychological well-being (Keniger et al., 2013). Biodiversity can be assessed using various metrics, such as “Richness” and “Diversity of species” (Colwell, 2009) or through surrogates as the “Normalized Difference Vegetation Index (NDVI)”, an index derived from multi-spectral remotely sensed data with close correlation with species richness and diversity (Bailey, et al. 2004; Gould et al., 2000). Biodiversity can also be assessed by the existence of “Keystone species”, which play essential

roles in maintaining community structure and integrity and are key for ecosystem functioning (Mills et al., 1993), or of “Species with conservation status”, an important element for biodiversity conservation. Although cities are highly modified landscapes, they can be home of many endangered species (Ives et al., 2016) that raise conservation planning and management concerns but also offer educational and awareness opportunities (McKinney, 2002). The large number of vascular plants in cities encompasses both native and non-native species and, in many cases, the decline of native species caused by urban sprawling is compensated with the introduction of non-native species, often though as with greater aesthetic value or more resilient to urban conditions. Exotic species contribute, as the native ones, to ecosystem services (ES) provision (Schlaepfer, 2018), with the ornamental species being particularly important for human appreciation (Wilson et al., 2016). Yet, exotic species may present negative impacts, which analysis is out of the scope of this work, but that must be considered when planning and managing urban greenspaces (Gaertner et al., 2016). “Nativeness” as a biodiversity metric accounts for this need to balance the roles of native and non-native species in maintaining ecosystem structure, functioning and resilience (Kowarik, 2011). More than the number and diversity of species, functional diversity determines the functioning and resilience of an ecosystem (Diaz and Cabido, 2001; Peterson et al., 1998). **Functional diversity**, which can be assessed by “Richness”, “Structure” or “Dispersion” metrics, also plays an important role on human appreciation and engagement with nature, with higher diversity of visual traits affording multiple ways to explore and appreciate biodiversity (Andersson and McPhearson, 2018; Goodness et al., 2016). **Tree health and regeneration status** are important to assure system continuity (Fuller and Quine, 2015; Greenberg et al., 2011), especially in urban forests but also in horticultural greenspaces, with the existence of young specimens being critical to maintain habitat structure and quality and assure the future replacement of old trees (Le Roux, et al., 2014). On the other hand, dead and fallen trees, when security issues have been considered, can contribute for higher biological diversity (Stokland et al., 2012).

Welcomeness as a theme of materialized BCD focus on tangible and visible features providing an accessible, inclusive and comfortable environment, and an adequate layout for whatever purpose people pursue when visiting the space (Dunnett et al., 2002; Holland et al., 2007; Mehta, 2014). It includes **Physical accessibility, Infrastructure and amenities, Cleanliness/Neglect** and **Security** as indicators of welcomeness. People must feel welcomed and not excluded when visiting a greenspace. An inclusive greenspace welcomes people of all ages, socio-economic status and walks of life, without any kind of barriers: physical, cultural

or emotional (Elands *et al.*, 2018). Equity in **Physical accessibility** to greenspaces involves providing an access without natural or artificial physical barriers or transportation difficulties (van Herzele and Wiedmann, 2003). Metrics for this indicator are “Accessibility by public transportation” in walking distance, the existence of “Pedestrian crossings” assisting the crossing of high traffic roads when present, and the suitability of “Access for people with special needs” or reduced mobility. Access to greenspaces concerns not only the ability to reach the space but also to use it in a meaningful way. **Facilities and amenities** of the place, along with their “Quality and maintenance”, are key for a useful and meaningful layout for many users, encouraging regular visiting (Mehta, 2014). The quality of maintenance of the space also concerns **Cleanliness and maintenance**, with “Cleanliness” being one of the most valued characteristics of greenspaces, with the absence of litter offering a sense of comfort and relaxation, while the presence of “Damaged property or incivilities” being often associated with a perception of lack of safety (McCormack *et al.*, 2010; Mehta, 2014). **Safety** is often cited as the first concern in public spaces and though its perception (to be addressed in the lived layer) being highly influenced by a few factors, the presence of “Lighting” and “Municipality/security staff” is associated with an immediate sense of safety (Holland *et al.*, 2007; McCormack *et al.*, 2010). A real picture of safety issues can be obtained with the number of “reported incidences to local authorities”.

The ***Signs of social memory carriers and cultural symbols*** theme refers to manifestations of close and consistent human-nature interactions, embodied in the space. These signs, from the complex architecture, design and composition of ornamental species of a park, to a desire path in a derelict land or a carved tree in a forest, reflect different periods, socio-cultural contexts and ideologies of nature-making, structure human movement in space and bring past meanings and experiences into the present, contributing to build place’s character and unique identity to which people relate (Andersson and Barthel, 2016; Byrne and Wolch, 2009; Green, 2009). Indicators informing this layer are **Biological salient features**, **Cultural artefacts**, **Biocultural artefacts**, **Signs of prior use** and **Relicts or Remnants**.

Biological salient features represent elements with historical, cultural, aesthetic or educational value such as large, symbolic or heritage trees that create and perpetuate cultural value for keystone species, umbrella species and long-living organisms (Andersson and Barthel, 2016). **Cultural artefacts**, like architectonic elements or urban art, provide information about societies’ history, how it used to live and express. In a greenspace, artefacts can offer meaning

and identity, create a sense of belonging and help preserving cultural heritage (Andersson and Barthel, 2016; Tweed and Sutherland, 2007). **Biocultural artefacts**, created from and/or representing nature, as e.g. cane fences in allotment gardens, stone walls as field divisions or carved trees, represent and perpetuate dynamic relationships between people and nature (Salick et al., 2014). Consistent patterns of users' engagement with a space create novel uses and functions and leave spatially explicit traces of their interaction with the space here designated as **Signs of prior use** (Campbell et al., 2016). These signs of space appropriation, like informal pitches or desire paths, inscribe the memory of repeated human action in the landscape and stimulate the perpetuation of those novel uses and functions. **Relicts or remnants** of natural ecosystems in the city preserve a species composition closer to the original natural landscape, hosting many native and endangered species (Kowarik and von der Lippe, 2018). They also retain the original ecosystem functioning that cannot be fully replaced by the novel man-made habitats (Kowarik, 2011) and have a high conservation and educational value (O'Farrel et al., 2012). Remnants of natural vegetation also contribute to visual diversity in the urban landscape design homogeneity, and by bringing the historical land-use into contact it offers sense of identity and belonging (Florgård, 2009).

Each UGS is embedded in a given socio-ecological context and neither biological nor cultural diversity in a greenspace can be dissociated from its surrounding matrix (Ersoy, 2016; Werner, 2011) and a theme on **Neighbourhood biophysical characterization** with indicators on **Permeability** and **Complementarity** was included. **Permeability** stands for the degree to which the matrix facilitates or impedes the movement of organisms, not only animal and plant species, which movement and dispersal between areas of habitat is essential for ecosystem functioning and resilience, but also movements of people in their displacements. Ecological permeability depends essentially on the percentage of vegetated areas in the urban matrix, its species composition and structure (Ersoy, 2016), while permeability for human movements dependent not only on the environment, with street greenery promoting walking behaviours (Lu et al., 2018), but also on how people experience it (Zuniga-Teran et al., 2017), available paths and forms and how these are perceived (Southworth, 2005), particularly in terms of safety. Dense, compact and continuous, fine-grained urban fabric are more inviting to displacements on foot or bike, with the physical characteristics of the built environment, e.g. poorly maintained buildings or evidence of incivilities, strongly influencing the perception of safety and the willingness to walk or bike (Foster et al., 2011; Mehta, 2008; Southworth, 2005). Proposed

metrics are thus “Green/grey proportion” and “Typology of green” in the matrix, “Granularity” and “Density of urban fabric” and its “Typology” and “Conservation status”.

Complementarity stands for the need of a variety of land-uses performing complementary social and ecological functions in the spatial greenspace network, assessed by the presence of “Attractive elements”, “Complementary functions” and “Park provision”. Urban human-made habitats are not likely to perform the entire range of ecological functions of natural ecosystems, but each can contribute to the overall ecosystem functioning (Kowarik, 2011) by means of land-use or habitat complementation (Colding, 2007; Lovell and Johnston, 2009). The same complementation principle applies for greenspaces’ social functions as different users have different needs and no single space is likely to meet all desired facilities or activities, in a single one-size-fits-all typology. The existence of other greenspaces in the neighbourhood with distinct facilities or layouts, may offer alternative and/or more interesting functions for some users, creating a multifunctional network of greenspaces (Hansen and Pauleit, 2014; Lovell and Taylor, 2013). A wider variety of greenspaces in a close vicinity meet diverse complementary needs, environmental equity goals and, by diverging users, it also decreases pressure towards a greenspace (Sister et al., 2007), assessed by “Park provision”. On the other hand, the existence of attractive elements in the vicinity, as museums, architectonic or touristic attractions, may also act as invitation to visit nearby greenspaces, increasing the pressure on it.

Indicators of Lived BCD

The **User group diversity** theme directly assesses users’ cultural diversity in terms of their origin, socio-demographic and economic status, and visible patterns of allegiance to any kind of subculture. Indicators for this theme are **Socio-demographic and other differentiation** assessed by “Nationality“, “Parents and grandparents birth place“, “Age“, “Gender“, “Education level“ and “Occupational status“, **Ethnicity or Urban subcultures** and **Residence**. Users’ residence provides information on socio-economic background and on the effort spent to reach the greenspace, a potential proxy for given value (Gilles-Corti et al., 2005).

People experience a greenspace, use and value its biodiversity and perceive its benefits in different ways, influenced both by their socio-cultural background and identity (Loukaitou-Sideris, 1995; Morton et al., 2017) and by the perception of welcomeness and sense of belonging (Seaman, 2010). Actual access and use of a UGS can be determined more by experiential barriers associated with the level of perceived integration, than by the UGS

resources or physical qualities (Seaman, 2010), with perceived accessibility primarily reflecting personal perceptions, or social barriers and interpretations regarding the accessibility of places (Paloniemi et al. 2017). An inclusive greenspace should thus reflect the neighbourhood, as people tend to use the spaces at shorter distance (McCormack et al., 2010). The underrepresentation of some groups may reveal the existence of some non-physical barrier leading to self-exclusion (Seaman, 2010) and the theme ***Neighbourhood cultural characteristics***, try to capture the existence of such barriers by determining if the cultural diversity of the neighbourhood is fully represented in greenspace users and diversity of uses. Culture and economy are mutually influential and **local economy** development intertwine with social processes that shape place meaning as good or bad (McCann, 2002). Local economy may be assessed with “Household prices” and diversity of “Businesses and services”. A diversity of businesses and services, besides being representative of neighbourhood’s economic status, provide a sense of usefulness and promote walking behaviours (Mehta, 2008). On the contrary, the perception of lack of safety, of which **crime rate** provides a real picture, prevents this willingness to walk in the streets (Mehta, 2008). Urban greenspaces offer opportunity for physical activity and relaxation in a cleaner, cooler and quieter environment, with significant positive effects in mental and physical health, as manifested in lower incidence of “diabetes”, “respiratory” and “cardiovascular diseases”, and lower mortality, and morbidity contributing for a neighbourhood better **health status** (Braubach et al., 2017).

The ***Space usage*** theme, that groups **Visitation rate, Frequency and duration, Uses and motivations** and **Social activities**, indicates if UGSs are supporting different uses, and points out potential conflicts with increasing use diversity (Raymond et al., 2016). Visiting regularly a greenspace for prolonged periods allows a consistent interaction with nature with relevant benefits in health and well-being (Lovell et al., 2014) while fostering feelings of connectedness and emotional bond to the space (Smaldone, 2007). Even not engaging in direct interaction, people enjoy the presence of others and to observe their activities, and a regular use of a greenspace favors social encounters, promotes the sense of community and attachment to place (Cattell et al., 2008; Peters, 2010). The diversity of activities and their actors may reveal the extent of usefulness and inclusiveness of the space with the presence of other people also contributing to increase the perception of safety and attractiveness of the greenspace (Mehta, 2014). One way of encouraging the visiting and use of greenspaces is the promotion of socio-cultural events offering extra attractions (Ellicott, 2016). Those social activities, when promoted by non-official entities, reflect a higher engagement and appropriation of the space

by creating meaningful experiences (Mehta, 2014). A greenspace, which is regularly visited by a high number of people with a variety of uses and motivations denotes appropriateness for use but may also generate conflicts over the space, to be addressed in a specific theme.

Interactions with someone or something are the foundation to develop a positive or negative emotional connection towards the object of interaction (Tuan, 1975). The theme **Interactions**, with indicators on **Human-human interaction** and **Human-nature interaction**, accounts for the ways people interact in and with nature as important to develop cohesion and place attachment. Casual interaction with other people, either active in “Users’ interaction” or coincidental e.g. in “shared activities”, affords opportunities to face and acknowledge distinct realities, ways of living and attitudes, fostering tolerance and integration. In a regular basis, social interactions are the base for social cohesiveness by creating bonds and promoting the sense of community (Cattel et al., 2008; Peters, 2010). The same is valid for interaction with nature, with emotional experiences with the natural world inducing empathy for the environment and the desire to protect and conserve nature (Soga and Gaston, 2016). “Active use of natural elements”, besides representing a direct interaction between culture and biodiversity, contributes to avoid the extinction of experience, or the ongoing separation between people and nature, increasingly observed in urban settings (Soga and Gaston, 2016). Interactions with nature are not always friendly and positive but can assume the shape of “Environmentally harmful behaviours” denoting a lack of connection and respect towards nature (Soga and Gaston, 2016). Passive interactions with nature can also occur through “digital” processes as e.g. geocaching, which number can indicate the preference for a certain space (Rosário et al., 2019).

People perceive and enjoy nature in many ways, conditioned by the meaning and value they ascribe to a greenspace and what it has to offer. A theme dealing with **Meanings, values and perceptions** is of uttermost importance when dealing with BCD (Sterling et al., 2017) and perception of **Safety, Inclusiveness, UGS qualities, Biodiversity and Ecosystem services, Sense of place, Wellbeing** and **Conflict** are the indicators proposed for this theme. Perceived **safety, inclusiveness** and integration are some of the most important factors for people to feel welcome and comfortable in the space and its perceived **qualities**, the convenience for visit and the satisfaction with the place, are often more important than its availability (McCormack et al., 2010; Mehta, 2014).

Biodiversity perception, even if not reflecting the real number of species, play an important role in the perception of benefits derived from contacting the greenspace (Dallimer et al., 2012; Schebella et al., 2019) and laypeople often use the term ‘diversity’ to reflect a subjective quality of the site that express their feeling of well-being rather than an objective measure of existing species (Voigt and Wurster, 2014). The perception of benefits derived from visiting the greenspace can also be assessed through the “perception of ecosystem services” with this indicator providing information also on users’ demands and preferences, and on conflicting interests to be considered in defining management strategies and trade-offs (Fischer et al., 2018; Martín-López et al., 2012). Valuing biodiversity and its services is key to develop connection feelings towards nature and induce protection and conservation behaviours (Soga and Gaston, 2016). Some people may appreciate the space solely for its aesthetic properties, or the useful amenities and infrastructures it provides, while others can develop a more emotional or affective relationship that translates a sense of belonging and attachment to place, but all derive benefits from visiting the place. Assessing how users perceive **wellbeing** and **sense of place** feelings can be an indicator on how well the greenspace is performing in providing those experiences and benefits. Place attachment and sense of belonging also play crucial roles in social inclusion and sustainable communities by inspiring people to protect and participate in collective decision concerning the places that are meaningful for them (Horlings, 2015; Manzo and Perkins, 2006).

Yet, users have different needs and experience the place in diverse manners that can collide with the interests and well-being of others, causing **conflicts**, self-exclusion or space-time segregation. Conflict can also arise with nature itself or with managing institutions, by constraining certain behaviours or activities or by taking managing options that are not welcomed (Dinnie et al., 2013; McMillen et al., 2018; von Döhren and Haase, 2015).

Places’ history is engraved in people’s memories and represent an informal repository of information perpetuated in time through knowledge transfer (Andersson and Barthel, 2016), here addressed in the theme *Memory carriers of place* with **Place memory**, **Reputation**, **Digital external memory**, **Local ecological knowledge (LEK)** and **LEK transfer and exchange** indicators. Experiences and stories create a **place memory**, important in assigning value to the place, and keep record of past events and changes on the biophysical or social structure of the place (Cilliers at al., 2015). Those memories and their dissemination are major contributors to places’ **reputation**. Spaces acquire reputations, built upon real facts or based on rumors and legends that persist in time and affect place’s identity and the way people use or not

the UGS. Negative reputations can be very difficult to overcome, even with positive actions, and are potential deterrents for people of using those spaces (Holland et al., 2007). Digital media provide an easy and extensive access to information and “content analysis of news sites or city information”, and the “classification in local reviews platforms” are potential metrics to assess greenspace’s reputation. **Digital records**, in sites, blogs and similar, are major tools to disseminate knowledge and share experiences, while keeping a memory of place that lasts in time for future generations. One of the key areas of interdependence between biological and cultural diversity is **local ecological knowledge** (LEK) and its **transfer and exchange**. Besides keeping a memory repository for future use, LEK provide additional information about ecological processes and meaningful places and can represent a very useful tool for planners and managers, if opportunity is granted to users to fully participate in decision processes (Yli-Pelkonen and Kohl, 2005). “Events involving active interaction with nature” are opportunities for LEK transfer and exchange in a greenspace and when “promoted by non-official entities”, may show a higher involvement and appropriation of the space by the stakeholders (Mehta, 2014).

Indicators of Stewardship of BCD

Land tenure and **Property-right regime** (Bac, 1998) are the first conditioning factors in determining how people may access and use greenspaces and the existence of fees or **Conditions to access** represent control rights that may impose restrains to some groups use rights by restricting free access to the space (Sikor et al., 2017). **Specific rules and norms**, either “formal” issued by legal institutions responsible for the space management or “informal” and acknowledged by space users, may promote or deter certain uses and activities, shaping the way people interact with the space. **Governance** is a system of decision-making processes in which actors other than legal institutions can take part, but the way these actors, either formal or informally, can have an active voice in the decision process, depend on the way they relate with each other and with legal institutions, on their position and role in the actors’ network. **Stakeholders** represent the “entities, both official and non-official, or users” actively involved in planning, management and maintenance of the greenspace, while **Opportunities and barriers** stands for the “capacity of stakeholders to have real voice in decision-making”. Stakeholders, opportunities and barriers are in key position to define locally relevant and adequate planning and management goals and objectives, with solutions found through participatory methods being more prone to be implemented and well-accepted by the involved communities (Buijs et al., 2018; Gavin et al., 2018; Sterling et al. 2017).

The ***Civic practices*** theme stands for the active engagement with the space through environmental stewardship, by protecting, conserving, managing, monitoring, advocating and/or educating about environmental issues (Krasny and Tidball, 2012) and includes **Stakeholders' activities**, **Citizen science**, **Civic ecologic/environmental practices** and **Engagement** as indicators. The type of **activities** developed by **stakeholders** are representative of their relation and involvement with space's life. Biodiversity observations made by lay people, offer a major contribution to ecological knowledge production, and when integrated in organized programs represent a major tool to raise public awareness on conservation topics. Engagement in **citizen science** or in **civic ecologic practices** denote a direct interaction with nature that translates in pro-conservation attitudes and behaviour (Cosquer et al., 2012). Taking care of a space creates a connection, a sense of belonging and ownership, that may motivate active participation in decision-making processes concerning planning and/or management of the place (Chapin and Knapp, 2016; Manzo and Perkins, 2006). This way, **engagement** may also manifest by communicating suggestions or complaints regarding the greenspace.

Tough the major purpose of some greenspaces is to provide clean, welcoming places with multiple choice of activities and relaxation opportunities, and its management deeply influenced by the socio-cultural context, greenspace managers have the responsibility to incorporate the best practices to conserve, protect and promote biodiversity and ecosystem services provisioning (Aronson et al., 2017). This concern with a quality **Management** can be assessed by “ecological practices”, the “Membership” of associations for exchange of good practices or the compliance to some “Certification” scheme or standard (CABE Space, 2004; Ellicott et al., 2015). These management options may collide with users' interests and effective governance systems are needed to effectively balance users' needs and perceptions with sound ecological management required (Aronson et al., 2017).

Urban greenspaces are highly dynamic systems. Changes in its biophysical structure and/or surroundings, influence the way people use, perceive and experience the space and indicators should be able to reflect this. Most indicators here proposed can be assessed at different times to detect those changes and expose trends and shifts, particularly important in urban socio-ecological systems, namely on what concerns gentrification processes or governance shifts (Muñoz-Erickson et al., 2016; Pinkster, 2016).

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Annex 6 – BCD indicators candidate metrics

Indicators of Materialized BCD

MATERIALIZED						
Theme	Indicator	Candidate metrics	Units	Methods and data source	Link with BCD	References
UGS biophysical attributes	Spatial heterogeneity	Biotope richness	Number	Field inventory; GIS; aerial photos	Ecological quality, perceived diversity ; multifunctionality; environmental/landscape preferences and attractiveness; place making; human-nature interaction; ecological resilience	Dronova, 2017; Lovett et al., 2005; Tews et al., 2004;
		Biotope diversity	Diversity indexes (e.g. Shannon)	Field inventory; GIS		
		Landscape pattern	Landscape configuration indexes (e.g. LSI - Landscape Shape Index)	Field inventory; GIS		
	Vegetation structure	Tree density	n/ha	Field Inventory, modelling, LiDAR; i-Tree	Surrogate for biological diversity; landscape preferences; place making; affordances of uses; ecological resilience; aesthetical value	Bjerke et al., 2006; Jiang et al., 2015; Chiang et al., 2017
		Vertical vegetation structure	Median; Interquartile range (IQR); Proportion of large trees, small trees, shrubs and herbaceous plants)	Field Inventory, modelling, LiDAR; i-Tree		Lamb and Purcell, 1990; Beninde et al., 2015
		Canopy cover	Min, max, mean, median percentage, Interquartile range (IQR)	Field inventory; LiDAR; aerial photographs; Remote sensing; LCCS		Shanahan et al, 2015
		Ground cover (litter, vegetation, rock, soil/sand, water)	Median; Interquartile range (IQR); Proportion of litter, soil/sand, rock...	Field inventory; LiDAR; aerial photographs; LCCS.		Nearing et al., 2005; Rega-Brodsky et al., 2018
		Tree height	Meters	Field inventory; LiDAR		
	Biological diversity	NDVI	Unitless	Remote sensing	Diversity; shaping nature; ecological quality (ecosystem functioning); resilience; affordances; aesthetical value	Gould, 2000; Bailey, 2004
		Species richness	Number	Field inventories/ citizen science City inventories databases		Colwell, 2009
		Species diversity	Diversity index (e.g. Shannon)	Field inventories		Schwartz et al, 2002; Ives et al., 2016 Mills et al., 1993; Siddig et al., 2016 Kowarik and von der Lippe, 2018
		Species with conservation status	Number	Red Lists dtbases		
		Ecological key species	Number	City inventories databases		
		Nativeness	Proportion native:exotic species	Field inventories		
	Functional diversity	Functional richness	Number	Field inventories and functional traits databases	Diversity; shaping nature; ecological quality; resilience; affordances; landscape preferences; aesthetical value	Peterson et al., 1998; Diaz and Cabido, 2001; Hooper et al., 2002; de Bello et al., 2010; Biggs et al., 2012; Goodness et al., 2016; Tribot et al., 2018
		Functional structure	CWM (Community Weighted Mean)			
		Functional dispersion	Diversity index			

Materialized BCD (cont.)

	Tree health and regeneration	Tree health - Trees with signs of disease (e.g. holes, broken, unusual leaf shapes or colors, damaged bark)	Number; Percentage	Field observation	Ecological quality; ecological resilience; landscape preferences; aesthetical value	Fuller and Quine, 2015
		Regeneration potential capacity - Seedlings, saplings or young specimens, natural or planted, of native or exotic non-invasive species	Abundance	Field observation	Ecological quality; ecological resilience; educational value	Greenberg et al., 2011; Le Roux et al., 2016
		Invasion potential -Seedlings, saplings or young specimens of invasive species	Abundance	Field observation		Hejda and de Bello, 2013
Welcomeness	Physical accessibility	Accessibility by public transportation in walking distance (5-10 min)	Number of stations/stops	Public transportation sites and apps; Municipality GIS	Equity of access; inclusiveness	Holland et al., 2007; Mehta, 2014; Liang and Zhang, 2018
			Frequency per hour			
		Pedestrian crossings assisting high traffic roads/railway crossing	Number	On-site observation; Aerial photographs		
		Accessibility for people with special needs	Score	On-site observation		
	Infrastructure and Amenities	Amenities	Number	On-site observation	Use/amenity value; inclusiveness; purpose for visit; affordances	Holland et al., 2007; Mehta, 2014
		Facilities	Number	On-site observation		
		Quality/maintenance of facilities and amenities	Qualitative scale	On-site observation		
	Cleanliness/Neglect	Litter visibility	Score	On-site observation	welcomeness; social cohesion	Bertram and Rehdanz, 2015
		Damaged property/incivilities	Score	On-site observation		
	Security	Security/municipality staff	Number per observation hour	On-site observation	Welcomeness; social cohesion; sense of refuge; place making	Dunnett et al., 2002
		Number of reported incidences	Number	Local data (local police, parish council)		
		Lighting	Number	On-site observation		
			Qualitative scale			

Materialized BCD (cont.)

Signs of memory carriers and cultural symbols	Biological salient features	Biological elements with historical, cultural, aesthetic or educational value.	Number	Municipality GIS; Local data; field inventories	Memory carriers; sense of belonging; place making; aesthetical value	Garibaldi and Turner, 2006; Andersson and Barthel, 2016
	Cultural artefacts	Constructed elements with historical, cultural, aesthetic, or educational value.	Number		Memory carriers; sense of belonging; place making aesthetical value	Tweed and Sutherland, 2007; Andersson and Barthel, 2016
	Biocultural artefacts	Constructed elements created from and/ or representing biodiversity/natural elements	Number	Municipality GIS; local data; field inventories	BCD creation; aesthetical value; appropriation value; making place	Andersson and Barthel, 2016
	Signs of prior use	Signs of interaction with the space, other than incivilities	Number	Filed observations	BCD creation; appropriation value; making place	Campbell et al., 2016
	Relicts or remnants	Presence of relicts of former use or meaning of the green space	Percentage of cover	field observations, field inventories, historical maps, historical aerial photographs, historical records	Memory carriers; sense of belonging; place making; educational value; conservation value	Florgard, 2009; Kowarik and von der Lippe, 2018
Neighborhood characteristics	Permeability	Green/grey proportion	Percentage of green cover	GIS; aerial photos; Urban Atlas	Ecological connectivity and habitat fragmentation; landscape heterogeneity; habitat complementation; ecological resilience; walkability; environmental justice; equity	LaPoint et al., 2015; Ersoy, 2016; Lu et al., 2018
		Typology of green in the grey matrix	Dominant typology	GIS; aerial photos; Municipality data		Colding, 2007; Dobbs et al., 2014 Lovell et al., 2009; Threlfall and Kendall, 2017
		Granularity of urban fabric	Mean block size	GIS; aerial photos; Street view		Levy, 1999; Southworth, 2005
			Qualitative scale			
		Density of urban fabric	Weigthed percentage	GIS; Urban Atlas		Sung and Lee, 2015
		Typology of urban fabric	Dominant typology	GIS; aerial photos; Municipality data		Sung and Lee, 2015
	Conservation status of urban fabric	Score	On-site observation; Local data; municipality archives; Street view	Foster et al., 2011		
	Complementarity	Attractive elements (monuments; museums; services)	Number		environmental justice; equity; place making; multifunctionality	
		Complementar uses/facilities/amenities	Number	GIS; local data; observation		Colding, 2007; Dobbs et al., 2014 Lovell et al., 2009; Kowarik, 2011; Hansen and Pauleit, 2014
	Park provision	Greenspace area per inhabitant	ha/1000 inhabitants	GIS; local census	environmental justice; equity	Sister et al., 2007

Indicators of Lived BCD

LIVED						
Theme	Indicator	Candidate metrics	Units	Methods and data source	Link with BCD	References
User group diversity (social identities)	Socio-demographic and other differentiation	Nationality	Number	On-site, online questionnaires	intercultural and intracultural diversity; inclusiveness; social cohesion	Seaman et al., 2010; Morton et al., 2017
		Parents and grandparents birth place	Number			
		Age	Years			
		Gender	Ratio			
		Education level	Years			
		Occupational status	Number			
	Ethnicity/urban subcultures	Ethnic groups/urban subcultures using the space	Percentage of users	On-site observation	intercultural and intracultural diversity; inclusiveness; social cohesion	Seaman et al., 2010; Morton et al., 2017
Neighborhood socio-cultural attributes (in selected buffer)	Residence	Distance to home/work	Meters	On-site, online questionnaires; GIS	Effort; attractiveness; aesthetical value	Morton et al., 2017; Gilles-Corti et al., 2005
	Socio-demographic characterization	Nationality	Ratio	Census data	Intercultural and intracultural diversity. Inclusiveness; social cohesion; self-exclusion	Seaman et al., 2010; Morton et al., 2017
		Parents and grand parents birth place	Ratio			
		Age	Ratio of age classes			
		Gender	Ratio			
		Education level	Ratio of education level classes			
		Occupational status	Occupational status classes			
	Local economy	Household prices	Ratio neighbourhood/ city median	local census data	well-being, social cohesion, environmental justice	McCann, 2002; Pinkster, 2016
		Businesses/services/economic sectors	Number	Statistical data		
			Diversity	Statistical data		
	Crime rate	Reported complaints at local police	Number/1000 inhabitants	Statistical data	Social cohesion	Bogar and Beier, 2015
	Health status	Longevity	Index	Statistical data	Environmental justice	Braubach et al., 2017
		Hospital stays	Number/1000 inhabitants			
		Incidence of cardiovascular diseases	Number/1000 inhabitants			
		Incidence of respiratory diseases	Number/1000 inhabitants			
		Incidence of diabetes	Number/1000 inhabitants			

Indicators of Lived BCD (cont.)

Space usage	Visitation rate	Visitation rate	Number of visitors/observation period	On-site observation; local data	social interaction; social inclusion/cohesion	Dunnett et al., 2002; Smaldone, 2007; Raymond et al., 2016
		Groups, pairs and singles	Percentage	On-site observation		
	Frequency and duration	Frequency of visit	Number of times/week-month	On-site, online questionnaires	place attachment; use value	Dunnett et al., 2002; Smaldone, 2007; Raymond et al., 2016
		Duration of visit	Minutes	On-site, online questionnaires		
	Uses and motivations to use	Uses	Number (/observation period)	On-site observation	intracultural diversity; inclusiveness; use value	Dunnett et al., 2002; Mehta, 2014; Raymond et al., 2016
			Diversity	On-site observation		
		Motivation/purpose of visit	Descriptive	On-site, online questionnaires		
	Social activities	Activities/events aiming the general public	Number (/observation period)	Public events calendars	Appropriation value; passive interaction with nature; social interaction	Dunnett et al., 2002; Greenhalg and Parsons, 2006; Shaffray, 2018
			Diversity	Public events calendars		
		Activities aiming the general public promoted by non-official entities	Percentage (of the above)	Public events calendars		
			Diversity	Public events calendars		
Interactions	Human-human interaction	Users interaction (e.g. greeting, talking)	Percentage of users	On-site observation	Active social interaction; social cohesion; living together	Cattel et al., 2008; Peters, 2010
		Interaction with users of different subcultural group (e.g. greeting, talking)	Percentage of users	On-site observation		
		Shared activities (e.g. jogging, fitness)	Percentage of users	On-site observation		
	Human-nature interaction	Active engagement/ use of biodiversity elements (e.g. feeding or watching birds)	Percentage of users	On-site observation	BCD in action, living with BD	Nisbet et al., 2002; Keniger et al., 2013; Soga et al., 2015
		Environmentally harmful behaviors or practices (e.g. unauthorized vegetation cuttings, release of invasive species)	Percentage of users	On-site observation		
		Digital interactions (Geocaches, pokemons,)	Number	Internet search	Passive interaction with nature	Rosário et al., 2019

Indicators of Lived BCD (cont.)

Meanings, perceptions and values of users	Safety	Reference to concern with lack of safety or freedom	Number of references (/ number of interviewees)	On-site, online questionnaires	Welcomeness; social cohesion; sense of refuge; place making	Dunnet et al., 2002; Mehta, 2014
	Inclusiveness	Reference to the presence of different user groups and uses	Number of references (/ number of interviewees)	On-site, online questionnaires	Welcomeness; social cohesion; living together	
	Perceived UGS qualities	Enjoyed UGS features (nature, atmosphere, maintenance, amenities,...)	Number of references (/ number of interviewees)	On-site, online questionnaires	Use, aesthetic, narrative value and perception value; welcomeness, sense of place	Dunnet et al., 2002; Mehta, 2014; Kothencz and Blaschke, 2017; Zhang et al., 2017
		Disliked UGS features (nature, atmosphere, maintenance, amenities,...)	Number of references (/ number of interviewees)	On-site, online questionnaires		
	Biodiversity and ecosystem services	Biodiversity perception	Weighted average score	On-site, online questionnaires	Living with BD; perception value	Dallimer et al., 2012; Voigt and Wurster, 2014; Schebella et al., 2019 Martín-López et al., 2012; Chan et al., 2012; Scholte et al., 2015
		Ecosystem services perception	Weighted average score			
	Sense of place	Place identity/ dependence instrument	Weighted average score	On-site, online questionnaires	Appropriation value; place attachment	Manzo and Perkins, 2006; Hunziker et al., 2007; Horlings, 2015
		Reference to place attachment (this is like a second home, this is a special place)	Percentage of users	On-site, online questionnaires		
	Wellbeing	Perceived Restorativeness Scale (PRS)	Weighted average score	On-site, online questionnaires	Perception value; Spiritual and psychological value	Kaplan, 1995; Hunziker et al., 2007; Bratman et al., 2012
		Reference to emotional, psychological, spiritual wellbeing related feelings (emotional, psychological, spiritual)	Percentage of users	On-site, online questionnaires		
Memory carriers of place	Conflict	Conflict with other users, management or legal institutions	Number of references	On-site, online questionnaires	Living together; Living with BD	Dinnie et al., 2013; von Döhren and Haase, 2015
	Place memory	Reference to past place's biophysical characteristics	Percentage of users	On-site, online questionnaires	Memory carriers; place attachment; sense of belonging; narrative value	Cilliers et al., 2015; Andersson and Barthel, 2016
	Reputation	Content analysis of news/sites/city information	Content analysis	Internet search	Place identity; narrative value; attractiveness; self-exclusion	Loukaitou-Sideris, 1995; Holland et al., 2007; Andersson and Barthel, 2016
		Classification in websites	Average classification	Internet search		
			Percentage of 1-2 stars classification	Internet search		

Indicators of Lived BCD (cont.)

Memory carriers of place	Digital external memory	Records in social media (e.g. pictures and videos, sites and blogs)	Number	Internet search	Appropriation value; BCD creation	Andersson and Barthel, 2016
	local ecological knowledge	Number of users referring knowledge about species present in GS and/or their uses/habits	Number of users (/ number of interviewees)	On-site, online questionnaires	BCD in action, living with BD; memory carriers	Yli-Pelkonen and Kohl, 2005; Andersson and Barthel, 2016
	Local ecological knowledge transfer and exchange	Events/experiences in UGS involving active interaction with nature and/or its knowlegde	Number	Local data; Public events calendars	Memory carriers; active interaction with nature	Yli-Pelkonen and Kohl, 2005; Andersson and Barthel, 2016
			Diversity	Local data; Public events calendars		
		Events/experiences in UGS involving active interaction with nature or its knowlegde promoted by non-official entities	Percentage (of the above)	Local data; Public events calendars		Yli-Pelkonen and Kohl, 2005; Andersson and Barthel, 2016; McMillen et al., 2016
			Diversity	Local data; Public events calendars		

Indicators of Stewardship of BCD

STEWARDSHIP OF BCD						
Theme	Indicator	Candidate metrics	Units	Methods and data sources	Link with BCD	References
Property-right regime	Conditions to access	Access fee	Qualitative	Local data	Environmental justice; equity	Andersson and Barthel, 2016; Sikor et al., 2017
		Conditions to access	Qualitative	Local data		
	Specific rules and norms	Site-specific formal rules/norms (e.g. keep off the grass)	Qualitative	Local authorities; survey; interviews; participatory methods	Memory carriers, cultural diversity, living together; political relations	Andersson and Barthel, 2016; Buijs et al., 2018
		Informal rules/norms (e.g. acceptance of unleashed dogs)	Qualitative	On-site observation; survey; interviews; participatory methods		
Governance	Stakeholders	Entities/users (other than space owner and manager) involved in UGS planning, management and maintenance	Number Diversity	local census data; social network analysis; institutional analysis; interviews; participatory methods	Living together; managing common resources; political relations	Biggs et al., 2012; McMillen et al., 2016; Buijs et al., 2018; Gavin et al., 2018
	Opportunities and barriers	Stakeholders capacity to have real participation and active voice in decision-making	Score	local census data; social network analysis; institutional analysis; interviews; participatory methods	Living together; managing common resources; political relations	Biggs et al., 2012 ; Buijs et al., 2018; Gavin et al., 2018
Civic practices	Stakeholders' activities	Activities developed by stakeholders (planning, management, conservation, monitoring, education)	Number Diversity	local census data; social network analysis; institutional analysis; interviews; participatory methods	Living together; managing common resources; political relations	Biggs et al., 2012; McMillen et al., 2016; Buijs et al., 2018; Gavin et al., 2018
	Citizen science	Citizen science records in the UGS	Number	Public databases	Living with BD; engagement	Cooper et al., 2007; Cosquer et al., 2012
	Civic ecologic/environmental practices	Involvement in ecologic/environmentally friendly practices (e.g. watering plants, repairing, volunteering)	Percentage of users	Observations; survey; interviews; participatory methods	Living with BD; engagement; BCD creation	Krasny and Tidball, 2012; McMillen et al., 2016
	Engagement	Suggestion/complaints regarding UGS management, maintenance and/or planning, in official records, sites, complaints books	Number	Local data; survey; interviews; participatory methods	Living with BD, appropriation value; place making; engagement with	Krasny and Tidball, 2012; McMillen et al., 2016
Management	Ecological practices	Use of management practices concerning ecological sustainability e.g. water use, active biodiversity protection and conservation	Qualitative	Local authorities; institutional and document analysis; interviews; participatory methods	Living with BD; promoting BD; BCD creation	Lindholst et al., 2015; Aronson et al., 2017
		Membership / Certification (e.g. World Urban Parks, Certified Park Professional, Green Flag,FSC)	Qualitative			CABE Space, 2004; Ellicott, 2016

Annex 7 – BCD indicators used in Chapter 3 case-study with metrics, data sources, scaling system and rating criteria

Layer	Theme	Indicator	Metric	Units	Data source	Classes/Scales	Rating criteria
MATERIALIZED	UGS biophysical attributes	Vegetation structure	Canopy cover	Mean percentage of cover	https://land.copernicus.eu/pan-european/high-resolution-layers/forests/tree-cover-density	Rescale min-max to 1-5	For climate change and heat island effect mitigation 1 - sparse - lower mitigation to 5 - close - higher mitigation
		Spatial heterogeneity	Landscape pattern	Landscape Shape Index (LSI)	Field inventory; aerial photos; GIS	LSI ≥ 1 , with 1 being the less complex landscape	1 - Low landscape complexity - Lower ecological and social value to 5 - High landscape complexity - Higher ecological and social value
		Biological diversity	NDVI	Unitless	Remote sensing; GIS	-1 (water) to +1 (luxurious vegetation); higher NDVI - higher vegetation vigour, higher biodiversity	1 - Lower productivity; lower BD to 5 - Higher productivity; Higher BD
	welcomeness	Cleanliness and maintenance	Cleanliness	Score	On-site observation	1- No signs of litter/ dog poop; 3 - Signs of litter/dog poop; 5 - Visible litter/dog poop; overloaded trash bins	1 - Visible litter - Very unclear, inviting and unwelcoming; 5 - No signs of litter - very clean, inviting and welcoming
		Infrastructure and Amenities	Amenities	Number and variety of amenities	On-site observation	1 - None; 2 - low number of basic amenities (benches); 3 - some amenities (litter bins, water fountains, toilet); 5 - high number of diverse amenities (kiosk, cafeteria, library)	1 - poor provision of amenities - less inviting and welcoming; 5 - very good provision of amenities - more inviting and welcoming
			Quality/maintenance of amenities	Qualitative scale	On-site observation	1 - Very degraded; 3 - Regular maintenance (old but in good condition to be used); 5 - New or very well maintained	1 - Very low quality, less inviting and welcoming; 5 - Very high quality, more inviting and welcoming
		Security	Security/municipality staff	NA	On-site observation	1 - No park workers, security staff or other; 3 - regular but not constant presence of park workers, security staff or others; 5 - Full-time presence of several park workers and/or security staff	1 - Potential lower security perception and welcomeness; 5 - Potential higher security perception and welcomeness
	Signs of memory carriers and cultural symbols	Biological salient features	Biological elements with historical, cultural, aesthetic or educational value.	NA	On-site observation http://www2.icnf.pt http://www.monumentos.gov.pt	1 - Absence of salient biological elements; 3 - Some (>1-2) salient elements; 5 - Many (>4-5 salient elements)	1- lower memory carriers/potential less attractiveness; 5 - higher memory carriers/potential higher attractiveness
		Cultural artefacts	Constructed elements with historical, cultural, aesthetic, or educational value.	NA	On-site observation http://www.monumentos.gov.pt	1 - Absence of cultural elements; 3 - Some (>1-2) elements; 5 - Many (>4-5) elements	1- lower memory carriers/potential less attractiveness; 5 - higher memory carriers/potential higher attractiveness
	Neighborhood characteristics	Complementarity	Complementar uses/facilities/amenities	NA - descriptive analysis	http://lxi.cm-lisboa.pt/lxi/	1 - Absence of recreational GS with complementar features/facilities in 300m distance to 5 - High provision of complementar features/facilities in 300mt distance	1-poor provision of complementar features; 5 - very good provision of complementar features

BCD indicators used in Chapter 3 case-study (cont)

Layer	Theme	Indicator	Metric	Units	Data source	Classes/Scales	Rating criteria
LIVED	User group diversity (social)	Socio-demographic and other differentiation	Age	Years	On-site interviews	18-25Yrs; 25-64 yrs; >64 yrs	Not applicable
			Education level	Years	On-site interviews	Elementary (9yrs); Secondary (12yrs); University (>12 yrs)	
	Neighborhood socio-cultural attributes	Socio-demographic and economic characterization	Age	Percentage of age classes	http://mapas.ine.pt/download/index2011.phtml	1 – No difference between users' and neighbourhood age/education strata to 5 – Very large difference between users' and neighbourhood age/education strata (absolute difference between strata percentage rescaled 1 to 5)	1 – Neighbourhood not reflected in users - Potential high self-exclusion processes to 5 - Neighbourhood reflected in users - No self-exclusion processes
			Education level	Percentage of education levels	http://mapas.ine.pt/download/index2011.phtml		
		Local economy	Household prices	Ratio neighbourhood / city median in 500mt buffer	https://geohab.ine.pt/index.html?locale=Pt-pt	1 - Much below to 5 - Much above city median	1 - lower economic capacity to 5 - higher economic capacity
	Space usage	Frequency and duration	Duration of visit	Minutes	On-site interviews	1 -Passing by to 5 - >180 minutes	1 - Mainly short period users - potential low attractiveness to 5 - Mostly long periods users - potential higher attractiveness
			Frequency of visit	Number of times/week-month	On-site interviews	Weighted average 1 - occasionally, 3 - weekly to 5 - Daily	1 - Lower to 5 - Higher need/willingness to visit space
	Interactions	Human-human interaction	Users interaction (e.g. greeting, talking)	Percentage of users	On-site observation	1 - Low percentage of interactions to 5 - High percentage of interactions	1 - Low social interaction to 5 - High social interaction
	Meanings, perceptions and values of users	Satisfaction with space	Disliked UGS features (nature, atmosphere, maintenance, amenities)	Number of complaints per visitor	On-site interviews	1 - low percentage of dislikes to 5 - High percentage of dislikes (rescaled 1 to 5)	1 - High percentage of complaints - lower satisfaction 5 - Very low percentage of complaints - higher satisfaction with place
		Sense of place	Reference to place attachment (is this a special place?)	Percentage of positive answers	On-site interviews	1 - Low percentage of users referring place attachment to 5 - High percentage of users referring place attachment (rescaled 1 to 5 and referred to maximum)	1 - Lower emotional bond to the place 5 - Higher emotional bond to the place
		Wellbeing	Perceived Restorativeness Scale (PRS)	Weighted average score	On-site interviews	1 - Low PRS score to 5 - High PRS score	1 - Lower capacity to provide psychological wellbeing to 5 - Higher capacity to provide psychological wellbeing

Annex 8 – Data and scores of Chapter 3 case-study

	Estrela			Gulbenkian			Mata Benfica			Tapada Necessidades			Mata Alvalade			Quinta Conchas		
Metric	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score
Canopy cover	29,5	3	3	26,2	3	3	30,3	3	3	15	2	2	27,3	3	3	40,2	4	4
Landscape pattern (LSI)	9,1	5	5	8	5	5	3,4	1	1	8,7	5	5	3,8	2	2	3,6	2	2
NDVI	0,78	5	5	0,77	5	5	0,68	4	4	0,65	3	3	0,78	5	5	0,72	4	4
Cleanliness	No litter or dog poop	1	5	No litter or dog poop	1	5	No litter or dog poop	1	5	Litter hardly noticeable Dog poop noticeable	3	3	Litter hardly noticeable. Dog poop noticeable	3	3	Visible litter and dog poop	4	2
Amenities	Toilet, 3 sets of tables, 200 benches and 125 bins Two cafeterias, one library	5	5	toilettes inside the buildings; high number of benches; some tables; adequate number of litter bins; 1 water fountain; 4 cafeterias	5	5	One toilet; cafeteria; large pic-nic area; Adequate number of benches and water fountains	4	4	Some benches, tables and litter bins; no water fountain; no toilet;	2	2	Many benches but mostly in the 3 picnic areas; No toilet; One water fountain; Cafeteria;	3	3	Some benches and litter bins; No toilet, water fountain or cafeteria but all available at short distance	2	2
Quality of amenities	Very well maintained	5	5	Very well maintained	5	5	Regular	3	3	Degraded	1	1	Regular to good	4	4	Regular	3	3
Security/municipality staff	Several gardeners in permanence (n=6)	5	5	Security and staff in permanence	5	5	Usual presence of gardeners	4	4	Permanent staff at the entrance. No gardeners	3	3	Kiosk staff in the afternoon. No gardeners	3	3	No security or gardeners	1	1
Complementary uses/facilities/amenities	English cemetery a quieter alternative but very secluded and very short opening schedule. No complementary amenities or facilities	2	2	Jardim Amália Rodrigues - less crowded, open view over the city and the river. No complementary amenities or facilities	4	4	Neighbourhood park w/o slopes; Allotment gardens. No complementary amenities or facilities	3	3	None	1	1	Parque Bela Vista - largest park in Lisbon; Vineyard park;	5	5	Quinta das Conchas w/ cafeteria, playground, lawns, ponds	5	5
Users' Age	18-24 - 7,8%; 25-64 - 62,8%; >65 - 29,4%	NA	NA	18-24 - 9,8%; 25-64 - 74,5%; >65 - 15,7%	NA	NA	18-24 - 9,8%; 25-64 - 49%; >65 - 41,2%	NA	NA	18-24 - 11,8%; 25-64 - 70,6%; >65 - 17,6%	NA	NA	18-24 - 5,9%; 25-64 - 76,5%; >65 - 17,6%	NA	NA	18-24 - 13,7%; 25-64 - 58,8%; >65 - 27,5%	NA	NA
Users' Education level	Elementary - 35,3%; Secondary - 21,6%; University - 43,1%	NA	NA	Elementary - 17,6%; Secondary - 17,6%; University - 64,7% 35 users living/working <1km 20/20/60%	NA	NA	Elementary - 42%; Secondary - 30%; University - 28%	NA	NA	Elementary - 19,6%; Secondary - 19,6%; University - 60,8%	NA	NA	Elementary - 36%; Secondary - 22%; University - 42%	NA	NA	Elementary - 26%; Secondary - 30%; University - 44%	NA	NA
Neighbourhood Age	15-25 - 11,9%; 25-64 - 64,4%; >64 - 23,6%	2	4	15-25 - 10,3%; 25-64 - 62,7%; >64 - 27%	4	2	15-25 - 9,8%; 25-64 - 60,4%; >64 - 29,7%	3	3	15-25 - 10,7%; 25-64 - 60,2%; >64 - 29%	3	3	15-25 - 11,4%; 25-64 - 60,6%; >64 - 28%	5	1	15-25 - 11%; 25-64 - 62,7%; >64 - 26,4%	1	5
Neighbourhood Education level	Elementary - 51,5%; Secondary - 15,1%; University - 27,8%	2	4	Elementary - 48,7%; Secondary - 15,6%; University - 29,7%	4	2	Elementary - 54,3%; Secondary - 17,2%; University - 22,1%	3	3	Elementary - 46,9%; Secondary - 17%; University - 30,2%	3	3	Elementary - 47,8%; Secondary - 16,7%; University - 30,7%	2	4	Elementary - 48,8%; Secondary - 16,4%; University - 28,6%	3	3

	Es trela			Gulbenkian			Mata Benfica			Tapada Necessidades			Mata Alvalade			Quinta Conchas		
Metric	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score
Household prices	3 ° trim 2018 3905€/m2 City median 2883 Ratio = 1,35	5	5	3 ° trim 2018 3807€/m2 City median 2883 Ratio = 1,32	5	5	3 ° trim 2018 2465/m2 City median 2883 Ratio = 0,86	3	3	3 ° trim 2018 2808€/m2 City median 2883 Ratio = 0,97	3	3	3 ° trim 2018 2933€/m2 City median 2882 Ratio = 1,02	3	3	3 ° trim 2018 2726€/m2 City median 2883 Ratio = 0,95	3	3
Duration of visit	Passing by - 4 <30 min - 9 30-90 min - 26 90-180 min - 5 >180 min - 7 Weighted average 3,04	4	4	Passing by - 9 <30 min - 3 30-90 min - 23 90-180 min - 13 >180 min - 2 Weighted average 2,92	3	3	Passing by - 6 <30 min - 12 30-90 min - 26 90-180 min - 6 >180 min - 1 Weighted average 2,69	1	1	Passing by - 4 <30 min - 12 30-90 min - 20 90-180 min - 7 >180 min - 8 Weighted average 3,06	4	4	Passing by - 3 <30 min - 7 30-90 min - 29 90-180 min - 10 >180 min - 2 Weighted average 3,02	3	3	Passing by - 2 <30 min - 5 30-90 min - 35 90-180 min - 8 >180 min - 1 Weighted average 3,02	3	3
Frequency of visit	Occasionally 25,5% (13/51) Weekly 58,8% (30/51) Daily 15,7% (8/51)	WA 2,8	3	Occasionally 48% (24/50) Weekly 34% (17/50) Daily 18% (9/50)	WA 2,4	2	Occasionally 37,2% (19/51) Weekly 41,2% (21/51) Daily 21,6% (11/51)	WA 2,7	3	Occasionally 58% (29/50) Weekly 32% (16/50)	WA 2	1	Occasionally 51% (26/51) Weekly 31,4% (16/51) Daily 17,6% (9/51)	WA 2,3	2	Occasionally 25,5% (13/51) Weekly 41,2% (21/51) Daily 33,3% (17/51)	WA 3,2	4
Users interaction (e.g. greeting, talking)	% interaction = 1,73 (44/2549)	1	1	% interaction = 0,92 (13/1407)	1	1	% interaction = 2,12 (15/709)	1	1	% interaction = 10,11 (20/193)	4	4	% interaction = 4,24 (10/236)	2	2	% interaction = 2,94 (6/204)	2	2
Dis liked UGS features	Dis liked features = 29 (51users) mean= 0,57	3	3	Dis liked features = 16 (51users) mean= 0,31	1	5	Dis liked features = 40 (51users) mean= 0,78	4	2	Dis liked features = 46(51users) mean= 0,92	5	1	Dis liked features = 49 (51users) mean= 0,96	5	1	Dis liked features = 46 (51users) mean= 0,9	5	1
Reference to place attachment (is this a special place?)	73,9% (34/46 interviewed users)	5	5	67,4% (31/46 interviewed users)	3	3	65,3% (32/49 interviewed users)	3	3	72,5% (29/40 interviewed users)	5	5	61,9% (26/42 interviewed users)	2	2	69,4% (34/49 interviewed users)	4	4
Perceived Res to rativeness Scale (PRS)	Mean PRS = 4,05	3	3	Mean PRS = 4,2	4	4	Mean PRS = 3,86	2	2	Mean PRS = 4,02	3	3	Mean PRS = 3,99	2	2	Mean PRS = 3,99	2	2

	Vale Fundao			Vale Silêncio			Calhau			Keil Amara			Montes Claros			S. Dom. Benfica		
Metric	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score
Canopy cover	4,3	1	1	31,7	4	4	38,5	4	4	29,5	3	3	37,2	4	4	46,6	5	5
Landscape pattern (LSI)	5,7	3	3	7,5	4	4	2,7	1	1	5,7	3	3	5,6	3	3	6,6	3	3
NDVI	0,49	1	1	0,71	4	4	0,71	4	4	0,64	3	3	0,7	4	4	0,75	4	4
Cleanliness	Visible litter and dog poop	4	2	Hardly noticeable litter and dog poop	2	4	Hardly noticeable litter and dog poop	2	4	No litter visible; Dog poop hardly noticeable	2	4	No visible litter or dog poop	1	5	Hardly noticeable litter and dog poop	2	4
Amenities	two pic-nic tables, one water fountain, some benches, litter bins in very short number	2	2	Many benches; two water fountains; toilet in the kiosk; one pic-nic area	4	4	Adequate number of benches mainly in the pic-nic area; two water fountains; one toilet	3	3	Many benches, two toilets, two pic-nic areas, two water fountains	4	4	Many benches and litter bins, one toilet	3	3	Low number of benches and litter bins; one water fountain, one toilet, two pic-nic areas	2	2
Quality of amenities	Regular to poor	2	2	Regular	3	3	Regular. Toilet very poor condition	2	2	Regular	3	3	Toilet good, benches poor	3	3	Poor	2	2
Security/municipality staff	No security or gardeners	1	1	Kiosk staff. Gardeners once a while	3	3	No security or gardeners	1	1	Gardeners and municipal police once a while	2	2	One security on permanence	5	5	No security or gardeners	1	1
Complementary uses/facilities/amenities	Allotment gardens. No complementary amenities or facilities	2	2	Pedagogic farm; Parque Urbano dos Olivais	3	3	None. No complementary amenities or facilities	1	1	Montes Claros - less crowded. architectonic and water elements. No complementary amenities or facilities	3	3	Keil Amara w/ pic-nic area, fitness equipments, basket courts adequate trails for running	5	5	None. No complementary amenities or facilities	1	1
Age	18-24 - 3,9%; 25-64 - 51%; >65 - 45,1%	NA	NA	18-24 - 7,8%; 25-64 - 58,8%; >65 - 33,3%	NA	NA	18-24 - 8%; 25-64 - 60%; >65 - 32%	NA	NA	18-24 - 5,9%; 25-64 - 70,6%; >65 - 23,5%	NA	NA	18-24 - 3,9%; 25-64 - 68,6%; >65 - 27,5%	NA		18-24 - 14%; 25-64 - 66%; >65 - 20%	NA	NA
Education level	Elementary - 86,3 %; Secondary - 7,8 %; University - 5,9 %	NA	NA	Elementary - 45,1%; Secondary - 17,6%; University - 37,3 %	NA	NA	Elementary - 38%; Secondary - 28%; University - 34 %	NA	NA	Elementary - 216%; Secondary - 23,5%; University - 54,9 %	NA	NA	Elementary - 39,2%; Secondary - 27,4%; University - 33,3 %	NA		Elementary - 36%; Secondary - 22%; University - 42 %	NA	NA
Age	15-25 - 10,7%; 25-64 - 59,4%; >64 - 29,9 %	5	1	15-25 - 10,9 % 25-64 - 59,9 % >64 - 29,1 %	1	5	15-25 - 11,5 % 25-64 - 63 % >64 - 25,5 %	2	4	15-25 - 7,7 % 25-64 - 52,4 % >64 - 40 %	5	1	15-25 - 11,4 % 25-64 - 65,1 % >64 - 23,4 %	2	4	15-25 - 10,3 % 25-64 - 57,6 % >64 - 32,2 %	4	2
Education level	Elementary - 47,3 % Secondary - 17,9 % University - 28,1 %	4	2	Elementary - 41,3 % Secondary - 15,8 % University - 36,4 %	1	5	Elementary - 53,6 % Secondary - 15 % University - 25,1 %	2	4	Elementary - 67,4 % Secondary - 14,8 % University - 12,2 %	5	1	Elementary - 42,3 % Secondary - 16,3 % University - 36,6 %	2	4	Elementary - 57 % Secondary - 15,1 % University - 21,6 %	3	3

	Vale Fundao			Vale Silêncio			Calhau			Keil Amaral			Montes Claros			S. Dom. Benfica		
Metric	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score	Data	Class Scale	Score
Household prices	3° trim 2018 1543 €/m2 City median 2883 Ratio = 0,54	1	1	3° trim 2018 1913€/m2 City median 2883 Ratio = 0,66	2	2	No data - parish 3° trim 2018 2838€/m2 City median 2883 Ratio = 0,98	3	3	No data - MClaros 3° trim 2018 2196€/m2 City median 2883 Ratio = 0,76	2	2	3° trim 2018 2196€/m2 City median 2883 Ratio = 0,76	2	2	3° trim 2018 2554€/m2 City median 2883 Ratio = 0,89	3	3
Duration of visit	Passing by - 6 <30 min - 12 30-90 min - 24 90-180 min - 5 >180 min - 2 Weighted average 2,69	1	1	Passing by - 5 <30 min - 5 30-90 min - 27 90-180 min - 13 >180 min - 1 Weighted average 3	3	3	Passing by - 1 <30 min - 6 30-90 min - 35 90-180 min - 6 >180 min - 2 Weighted average 3,04	4	4	Passing by - 0 <30 min - 4 30-90 min - 32 90-180 min - 13 >180 min - 2 Weighted average 3,25	5	5	Passing by - 1 <30 min - 4 30-90 min - 31 90-180 min - 13 >180 min - 2 Weighted average 3,22	5	5	Passing by - 3 <30 min - 6 30-90 min - 21 90-180 min - 16 >180 min - 4 Weighted average 3,24	5	5
Frequency of visit	Occasionally 21,6% (11/51) Weekly 27,5% (14/51) Daily 50,1% (26/51)	WA 3,6	5	Occasionally 27,4% (14/51) Weekly 45,1% (23/51)	WA 3	4	Occasionally 30% (15/50) Weekly 34% (17/50) Daily 36% (18/50)	WA 3,1	4	Occasionally 25,5% (13/51) Weekly 64,7% (33/51)	WA 2,7	3	Occasionally 47,1% (24/51) Weekly 47,1% (24/51)	WA 2,2	2	Occasionally 28% (14/50) Weekly 54% (27/50) Daily 18% (9/50)	WA 2,8	3
Users interaction (e.g. greeting, talking)	% interaction = 15,26 (47/308)	5	5	% interaction = 5,6 (36/643)	2	2	% interaction = 2,33 (5/215)	1	1	% interaction = 7,97 (22/276)	3	3	% interaction = 13,39 (15/112)	4	4	% interaction = 10,11 (27/267)	4	4
Dislike d UGS features	Dislike d features = 50 (51users) mean= 0,98	5	1	Dislike d features = 42 (51users) mean= 0,82	4	2	Dislike d features = 32 (50 users) mean= 0,64	3	3	Dislike d features = 25 (51users) mean = 0,49	2	4	Dislike d features = 22 (51users) mean = 0,43	2	4	Dislike d features = 36 (50 users) mean= 0,72	3	3
Reference to place attachment (is this a special place?)	56,9% (29/51 interviewed users)	1	1	69,6% (32/46 interviewed users)	4	4	65,2% (30/46 interviewed users)	3	3	70,6% (36/51 interviewed users)	4	4	58,7% (27/46 interviewed users)	1	1	67,4% (33/49 interviewed users)	3	3
Perceived Res to rativeness Scale (PRS)	Mean PRS = 3,76	1	1	Mean PRS = 4,06	3	3	Mean PRS = 4,25	4	4	Mean PRS = 4,25	4	4	Mean PRS = 4,38	5	5	Mean PRS = 4,09	3	3

Annex 9 - Materialised BCD of 33 studied parks. Values for gradient, vegetation structure, facilities & services, artificial elements, population density and socio-economic status is explained in the Table 1 (Materials and Methods). Type of park is presented in the Figure 4.4.

Park	City	Gradient	Type of park	Age of park	Size (ha)	Number of biotopes	Vegetation structure	Facilities & services	Artificial elements	Population density (km2)	Socio-economic status
Alppipuisto	Helsinki	1	4	165	14.5	4	3	2	3	2378	2
Kaivopuisto	Helsinki	1	4	185	16.0	2	3	3	2	4971	5
Pengerpuisto	Helsinki	1	2	95	1.5	1	2	2	1	27498	3
Hesperian puisto	Helsinki	1	2	185	7.1	2	2	2	1	7074	4
Kauppala	Helsinki	2	3	35	6.5	6	3	1	1	6113	3
Pajalahti	Helsinki	2	1	35	4.1	2	2	1	0	5396	4
Meurman	Helsinki	2	2	65	0.8	3	2	2	0	4815	4
Annala	Helsinki	2	2	180	1.1	4	2	1	1	5482	3
Lampi	Helsinki	3	3	45	2.1	5	3	2	1	7685	1
Ala-Malmi	Helsinki	3	2	25	1.4	3	2	1	2	4060	1
Kirsikka	Helsinki	3	1	35	3.6	3	1	1	0	1904	3
Mustakivi	Helsinki	3	1	15	3.9	1	1	1	1	12562	1
Jardim Estrela	Lisbon	1	4	175	4.6	2	2	3	3	19756	4
Gulbenkian	Lisbon	1	4	55	7.5	4	3	2	3	13712	4
Mata Benfica	Lisbon	1	2	105	4.1	1	2	2	2	18778	3
Tapada Necessidades	Lisbon	1	3	275	10.0	3	3	1	3	20410	4
Mata Alvalade	Lisbon	2	2	65	11.0	2	1	2	1	8363	3
Quinta das Conchas	Lisbon	2	3	115	10.0	1	3	1	1	7109	3
Vale Fundão	Lisbon	2	1	45	9.0	1	1	1	1	9742	1
Vale Silêncio	Lisbon	2	2	65	8.0	2	2	2	1	17009	3
Calhau	Lisbon	3	2	75	11.0	2	2	1	1	11733	1
Keil do Amaral	Lisbon	3	3	75	10.0	2	3	2	1	1942	4
Montes Claros	Lisbon	3	2	75	1.6	3	1	1	3	11482	4
S. Dom. Benfica	Lisbon	3	2	75	10.0	1	2	2	1	6015	2
Plumbuita	Bucharest	2	3	38	80.0	4	3	2	2	23233	1
Herăstrău	Bucharest	2	4	79	187.0	6	3	3	3	14079	5
Brâncuși	Bucharest	3	1	15	1.0	1	1	2	1	8930	1
Cișmigiu	Bucharest	1	4	168	14.6	3	2	3	3	12323	5
Grădina Icoanei	Bucharest	1	2	142	2.4	2	2	2	1	15423	5
Motodrom	Bucharest	3	1	35	3.8	2	1	1	1	9313	1
Park am Gleisdreieck	Berlin	1	4	4	31.5	2	2	3	2	13942	2
Treptower	Berlin	2	4	168	88.0	5	3	3	3	1531	3
Volkspark Friedrichshain	Berlin	1	4	135	49.0	3	2	3	3	13942	3

Annex 10 - Lived BCD in parks. Total number of respondents, and number of respondents under the nine different themes of motivations (a), enjoyments (b) and disturbances (c).

a.		Human-based motivations				Environment- based motivations			Other reasons	
Park name	Number respondents (n)	Social relations	Mobility-based activity	Stationary-based recreation	Relax & well-being	Park characteristics	Nature related	Facilities & services	Location	Weather
Alppipuisto	50	22	3	11	3	0	2	3	7	21
Kaivopuisto	51	18	14	8	2	1	1	6	7	7
Pengerpuisto	50	21	5	25	3	1	1	1	3	15
Hesperian puisto	52	19	10	16	4	0	0	12	3	16
Kauppala	50	6	14	16	4	1	0	2	11	26
Pajalahti	50	9	8	13	2	0	3	0	18	11
Meurman	50	26	1	19	1	0	0	17	5	5
Annala	50	8	13	11	1	0	4	0	16	6
Lampi	50	25	6	7	5	3	2	0	18	7
Ala-Malmi	53	23	1	12	3	4	0	1	13	10
Kirsikka	42	3	11	3	1	1	0	1	24	3
Mustakivi	50	7	13	10	0	0	2	2	21	6
Jardim Estrela	51	7	37	0	13	10	5	0	2	1
Gulbenkian	51	7	16	4	27	5	3	0	3	0
Mata Benfica	51	7	36	2	10	9	8	2	11	1
Tapada Necessidades	51	4	31	1	13	9	9	0	14	1
Mata Alvalade	51	5	31	2	18	3	2	0	11	0
Quinta das Conchas	51	10	25	1	14	6	2	5	13	0
Vale Fundão	51	4	35	0	14	3	1	1	15	0
Vale Silêncio	51	12	1	12	17	12	6	8	11	3
Calhau	50	5	18	4	21	5	17	1	12	2
Keil do Amaral	51	18	12	5	14	7	6	0	19	2
Montes Claros	51	10	17	6	10	5	4	4	8	1
S. Dom. Benfica	50	9	17	14	21	10	5	1	12	2
Plumbuita	20	9	21	0	7	0	0	0	0	0
Herăstrău	20	5	15	1	12	0	0	0	0	0
Brâncuși	20	10	3	0	8	0	0	0	2	0
Cișmigiu	20	5	12	1	8	0	0	1	0	0
Grădina Icoanei	20	8	11	0	9	0	0	0	0	0
Motodrom	20	12	14	0	2	0	0	0	0	0
Park am Gleisdreieck	45	19	26	10	6	0	0	1	1	2
Treptower	50	16	17	18	16	2	1	1	2	4
Volkspark Friedrichshain	50	18	33	8	7	0	1	1	1	5

b.		Human-based enjoyments				Environment-based enjoyments			Other reasons	
Park name	Number of respondents (n)	Social relations	Mobility-based activity	Stationary-based recreation	Relax & well-being	Park characteristics	Nature related	Facilities & services	Location	Weather
Alppipuisto	50	12	0	1	1	29	33	5	3	19
Kaivopuisto	51	11	1	2	1	31	33	3	0	9
Pengerpuisto	50	19	4	6	0	18	17	7	6	17
Hesperian puisto	52	13	4	2	3	16	40	6	6	17
Kauppala	50	3	1	3	0	42	35	4	3	15
Pajalahti	50	6	3	1	0	34	41	3	2	6
Meurman	50	25	1	10	1	21	10	29	0	7
Annala	50	2	1	0	1	27	48	4	1	7
Lampi	50	9	1	4	3	19	17	28	2	5
Ala-Malmi	53	8	0	3	1	38	29	18	0	9
Kirsikka	42	3	0	1	1	32	38	7	0	1
Mustakivi	50	13	2	3	0	33	19	8	1	8
Jardim Estrela	51	4	2	0	10	27	36	14	0	1
Gulbenkian	51	0	1	0	19	23	51	4	0	1
Mata Benfica	51	5	6	1	10	36	32	9	2	3
Tapada Necessidades	51	1	0	0	13	25	35	27	1	3
Mata Alvalade	51	6	1	0	5	17	28	14	1	3
Quinta das Conchas	51	3	3	0	18	34	30	12	0	4
Vale Fundão	51	2	5	0	15	35	29	8	4	5
Vale Silêncio	51	1	0	0	14	29	41	23	2	2
Calhau	50	1	0	0	11	15	38	6	2	5
Keil do Amaral	51	0	1	0	20	29	29	1	0	4
Montes Claros	51	1	0	0	13	26	30	16	0	6
S. Dom. Benfica	50	5	1	1	14	35	41	8	1	4
Plumbuita	20	0	0	0	0	16	15	4	0	0
Herăstrău	20	1	0	0	0	14	10	4	0	0
Brâncuși	20	5	0	0	0	9	5	2	0	0
Cișmigiu	20	3	0	0	0	7	12	2	0	0
Grădina Icoanei	20	0	0	0	0	12	3	4	1	0
Motodrom	20	4	0	0	0	9	3	2	2	0
Park am Gleisdreieck	45	16	4	0	2	42	15	13	2	1
Treptower	50	4	0	0	1	39	50	10	1	0
Volkspark Friedrichshain	50	8	4	0	5	46	24	13	9	3

c.		Disturbed by				
Park name	Number of respondents (n)	People	Park characteristics	Nature related	Events	Nothing
Alppipuisto	50	20	19	3	3	17
Kaivopuisto	51	12	15	19	6	17
Pengerpuisto	50	25	24	0	2	18
Hesperian puisto	52	15	12	20	0	18
Kauppala	50	4	22	2	0	31
Pajalahti	50	11	22	14	0	22
Meurman	50	14	5	0	1	37
Annala	50	5	28	3	0	26
Lampi	50	34	20	0	0	21
Ala-Malmi	53	26	23	0	0	20
Kirsikka	42	7	20	1	0	20
Mustakivi	50	30	6	0	0	26
Jardim Estrela	51	17	7	0	1	30
Gulbenkian	51	8	12	1	1	32
Mata Benfica	51	13	18	0	0	25
Tapada Necessidades	51	11	24	0	0	26
Mata Alvalade	51	19	31	0	0	20
Quinta das Conchas	51	29	12	0	1	22
Vale Fundão	51	20	25	0	0	21
Vale Silêncio	51	3	11	2	0	37
Calhau	50	15	24	1	0	23
Keil do Amaral	51	9	36	1	0	18
Montes Claros	51	23	23	2	1	19
S. Dom. Benfica	50	5	17	5	1	26
Plumbuita	20	1	6	0	0	11
Herăstrău	20	1	7	2	0	11
Brâncuși	20	2	5	1	0	12
Cișmigiu	20	11	3	1	0	6
Grădina Icoanei	20	0	11	0	0	8
Motodrom	20	2	9	0	0	10
Park am Gleisdreieck	45	2	13	0	0	30
Treptower	50	5	26	0	3	26
Volkspark Friedrichshain	50	5	23	0	0	26

Annex 11 – List of variables used in Chapter 5 statistical analysis with p-value for GLM univariate analysis. Blank cells correspond to variables with p-value >0.25 and those that were not used either because they had outliers, were correlated >0.60 or were not adequate to the analysis (e.g. amenities for biodiversity perception).

List of variables used in the univariate analysis to build the Generalized Linear Models			p-value univariate analysis	
Variable	Description	Units	Perceived Restorateness (PR)	Biodiversity Perception (BPD)
Biotic				
H_TBB	Shannon diversity index of trees, butterflies and birds	NA		
H_Trees	Shannon diversity index of trees	NA	0.024	
H_Butterflies	Shannon diversity index of butterflies	NA	<0.001	
H_Birds	Shannon diversity index of birds	NA	0.041	<0.001
E_TBB	Evenness of trees, butterflies and birds	NA		0.004
E_Trees	Evenness of tree species	NA	<0.001	
E_Butterflies	Evenness of butterfly species	NA	0.167	
E_Birds	Evenness of bird species	NA	0.176	<0.001
Species richness	Total tree, butterfly and bird species	Number	0.003	0.190
N_Tree	Tree species richness	Number	0.238	0.020
N_Butterfly	Butterfly species richness	Number	<0.001	
N_Bird	Bird species richness	Number		0.004
LSIcov	Landscape Shape Index of land cover types	NA		
PRDcov	Patch Richness Density of land cover types	NA	0.019	0.248
SHDIcov	Shannon Diversity Index of land cover types	NA		0.028
MSIEIcov	Modified Simpson's Evenness Index of land cover types	NA	0.137	
LSIsp	Landscape Shape Index of dominant species	NA		
PRDsp	Patch Richness Density of dominant species	NA	0.0123	<0.001
SHDIsp	Shannon Diversity Index of dominant species	NA	0.001	0.041
MSIEIsp	Modified Simpson's Evenness Index of dominant species	NA		0.004
FDis_leafphen	Dissimilarity of leaf phenologies	NA	<0.001	0.019
FDis_leaftype	Dissimilarity of leaf types	NA	0.001	0.007
FDis_flowseason	Dissimilarity of flowering seasons	NA		<0.001
FDis_fruitphen	Dissimilarity of fruit phenologies	NA	<0.001	
FDis_flowshow	Dissimilarity of flower showiness	NA	0.200	0.001
FDis_fruitshow	Dissimilarity of fruit showiness	NA	0.212	<0.001
CWM_evergreen	Community Weighted Mean of evergreen species	NA	<0.001	0.014
CWM_broadleaf	Community Weighted Mean of broadleaf species	NA	0.001	
CWM_flowshowy	Community Weighted Mean of showy flowers	NA		0.051
CWM_fruitshowy	Community Weighted Mean of showy fruits	NA	0.118	
NDVI Summer	Normalized Difference Vegetation Index in summer	NA	0.026	<0.001
Socio-demographic				
Age	Age	Years		
Education	Education	Years		<0.001
Visiting profile, park attributes and users perceptions				
Frequency of visit	Classes: Occasional (less than 1x/week); Regular (> 1x/week)	0-1	0.031	
Duration of visit	Classes: Passing by; < 30 min; 30-90 min; 90-180 min; > 180 min	Score 1-5	0.015	0.036
Park quality	Availability and quality of facilities, amenities and space cleanliness	Number	0.005	
Biological salient features	Biological elements with historical, cultural, aesthetic value	Number		
Cultural artefacts	Built elements of cultural interest	Number		
Safety	Abundance of gardeners or security staff, and adequate lighting	Number		
Disturbing	Disturbing features referred by park users	Number	<0.001	
Special	Connection to place (is this place special?)	Yes-No	<0.001	0.053
PR	Perceived Restorateness	Score 1-5		
Biodiversity perception	Perception of high levels of biodiversity	Yes-No	<0.001	<0.001
Tree diversity perception	Perception of diversity of tree species	Score 1-5	<0.001	<0.001
Butterfly diversity perception	Perception of diversity of butterfly species	Score 1-5		
Bird diversity perception	Perception of diversity of bird species	Score 1-5	0.002	

“I am still learning.”

-Michelangelo, age 87