What is urban nature and how do we perceive it?

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Abstract

This chapter discusses the complexities and apparent contradictions in defining 'nature' and 'urban nature' in the context of human-nature interactions. It explains why urban nature is so important to human health and well-being at this point in the twenty first century, focusing particularly on why considering nature perception is crucial if we are to plan, design and manage urban nature to prioritise people's aesthetic appreciation, health and well-being. Nature-perceptions are then framed in relation to diversity in nature: the role of varying biodiversity, perceived biodiversity and different aesthetics of nature (specifically flowering and colour, structure and care). The significance of varying socio-cultural and geographical contextual factors in nature perception is then highlighted (Fig 1). The chapter closes by addressing implications for policy and practice and future research directions in relation to urban nature perception. The author draws extensively from her own and related research.

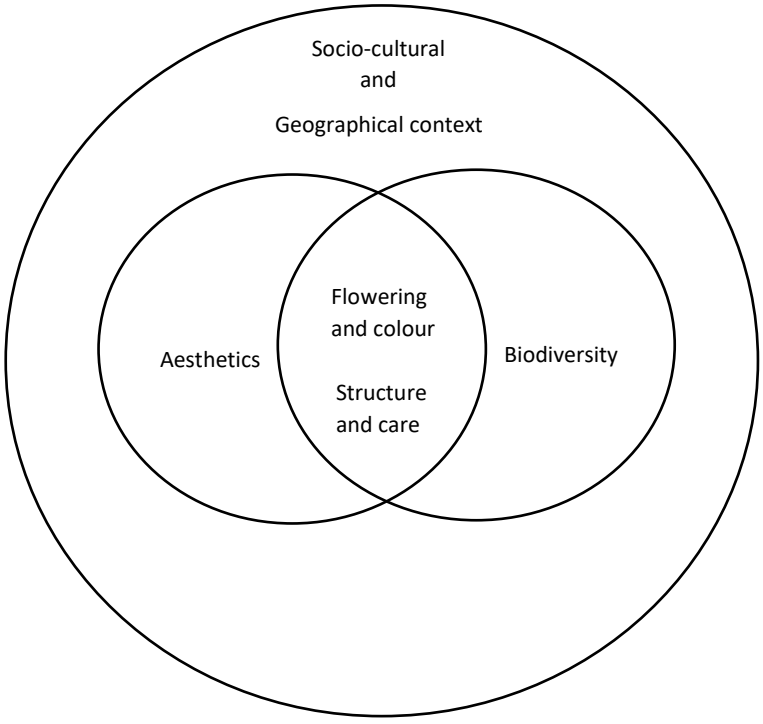


Fig.1 Urban nature perception: The roles of diversity in nature (Biodiversity and aesthetics), socio-cultural and geographical contextual factors in people's perceptions of urban nature.

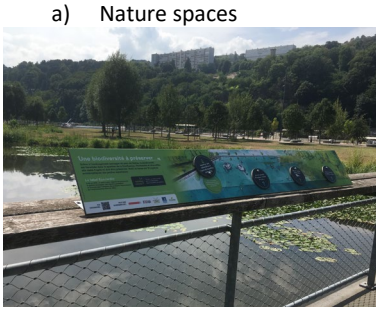
1. Defining urban nature

In recent years there has been an exponential increase in scientific interest in the relationship between people and nature, with a new British Ecological Society journal launched with the same name (People and Nature, December 2018) and a proliferation of studies providing evidence for the physiological, social and psychological benefits for people of contact with nature (for reviews see Clark et al. 2014; Hartig et al.2014; Frumkin et al.2017). Many of these studies do not seek to define 'nature' (for example Soga & Gaston, 2016; Cox et al. 2017a), perhaps needing to circumnavigate the extensive discourse on nature as a social construction (for further discussion see Cronon, 1996; Proctor, 1998) and questions about a human-nature binary, when other interpretations place humans 'in nature'. Nassauer (1995) emphasises nature as a 'cultural concept' distinct from the 'scientific concept of ecology', arguing that the definition of nature is clearly highly contested. Frumkin et al. (2017) suggest that diverse definitions of nature are appropriate according to the type of nature contact being studied, for example, people may engage with nature through an immersive wilderness experience, or may view it through a window, in a photograph, film or virtual reality simulation. Nature interaction may range from experience at the wide landscape scale (Purcell et al. 2001) to direct contact with a single species (Palliwoda et al. 2017). Bratman et al. (2012) provide a pragmatic and flexible definition of 'nature' describing it as "areas containing elements of living systems that contain plants and nonhuman animals across a range of scales and degrees of human management, from a small urban park through to relatively 'pristine wilderness'".

The term 'urban nature' itself may appear contradictory. Indeed, many studies emphasising the psychologically restorative benefits of contact with nature have compared participants' responses to natural and built environments as polar opposites (for example Herzog et al. 2003; Staats et al. 2016). Yet over half the world's population now lives in urban areas, rising to 70% by 2050 (United Nations, 2018) and most people's nature contact and experience occurs within the highly managed built environment context. Here nature experience is enabled by access to deliberately planned, designed and managed green infrastructure (GI) (Hoyle et al. 2019). These intra-urban, multifunctional networks of GI including parks, gardens, rivers and street trees, provide opportunities for people to engage with nature which is managed and remote from the relatively pristine wilderness. Newman and Dale (2013) describe 'urban nature' as 'mundane' and 'very different from our collective conception of "wild"' yet worthy of celebrating'. Three forms of urban 'mundane nature' are presented: first the 'remnant nature' of spaces which defies development due to topography and geomorphology, such as cliff faces and river banks, as well as 'buffer' zones, often along railway lines. Within 'remnant nature, we find 'accidental nature' such as the prolific *Buddleia* which spontaneously colonises derelict city centre brownfield sites. This type of nature is often depicted negatively by the media (Jorgensen & Keenen, 2012), recently being described as 'a symbol of national neglect' in the UK (Chiles, 2019) and may be short-lived as new development transforms urban brownfield sites. Secondly, mundane nature may be 'cultivated nature' in the form of living walls, green roofs and roof gardens, allotments and living sewage plants. Finally, Newman and Dale (2013) describe 'nature on display' which includes 'highly mediated spaces' such as formal parks and gardens, allowing

an interactive (and controlled) relationship between people and nature. Parallels can be drawn with the three 'management classes' as identified by the City of Lyon, France Green Space Division which distinguishes between a) 'nature spaces', where biodiversity is prioritised; b) 'living spaces', where human recreation is facilitated, such as along the wide reclaimed riverbanks; and c) high profile 'flowered spaces' where resources are targeted to create 'the wow factor' (Hoyle et al. 2017a) with colourful flowering herbaceous planting (Fig.2)

a) Nature spaces



The rivers' confluence, where biodiversity is prioritised

b) Living spaces

The Rhone riverbanks reclaimed (from a car park) for public use

c) Flowered spaces

Place Bellecour, where flowering displays are prioritised

Fig.2 The City of Lyon, France Green Space Division Management Classes

2. Why is urban nature so important for human health and well-being?

The increasing proportion of the world's population living in urban areas means that global health problems are concentrated in cities. Although urban populations can enjoy higher quality of life than those in rural areas and living in cities has benefits such as access to employment, health inequalities are starker in urban areas (Dye, 2008), with less affluent disadvantaged groups suffering the greatest burden of ill health. Urban areas have also been associated with specific mental health challenges including depression and anxiety disorders (Peen et al. 2010; Lederbogen et al. 2011). In Europe, the economic cost of this mental ill-health has been estimated at €187.4 billion per year (Olesen et al. 2012) and in 2015 mental ill-health cost the UK economy alone an estimated £94bn (Organisation for Economic Co-operation and Development, 2018). The causal link between urban living and compromised mental health is complex and not well understood (Bratman et al. 2015), yet sedentary urban lifestyles with diminished nature contact, 'the extinction of experience' are likely a contributor (Soga & Gaston, 2016; Cox et al. 2017a). Results of a recent study involving 1023 urban residents in Bedfordshire, UK indicated that the most common form of 'nature experience' involved viewing nature through a window at work and at home, that is, not being physically present in nature (Cox et al. 2017b). In the USA the disconnection of urban residents from nature may be more extreme, with evidence that Americans spend >90% of their time inside buildings and vehicles (Klepeis, 2001, cited in Frumkin et al. 2017). In 2016 in the USA total daily 'media consumption' amongst adults was 10 h 39 min and increasing (Nielson, 2016) and more concerning, the daily screen time of children under 8 had reached 1 hr 55 min (Rideout 2013).

There is still a need for greater understanding of the pathways between nature and human health and well-being (Clark et al. 2014). Hartig et al. (2014) highlight evidence of four key

pathways by which nature might impact positively on people; one indirect pathway, through air quality, and three direct pathways involving being within nature: physical activity, social cohesion and stress reduction. There have been significant additions to the evidence base since 2014, yet the model still provides a useful framework.

2.1. Air quality

Urban vegetation such as street trees and shrubs may enhance ambient air quality and reduce the risk of respiratory problems through uptaking gaseous air pollutants such as ozone and nitrous oxides (Fowler, 2002). Nevertheless, some species are the source of problematic hydrocarbons and others produce allergens, making careful species selection important. A recent study (Laia & Konokostab, 2019) used tree census data for the 652,169 street trees in New York City, integrating this with data on air quality and neighborhood asthma hospitalisation and emergency department visit rates. Results indicated that although a greater concentration of trees contributed to higher local air quality, localised asthma hospitalisation rates were greater in areas where tree species with severe allergenicity were located. This pathway is described as 'indirect', because benefits or disbenefits are brought about by air quality characteristics, and no direct contact with nature is involved.

2.2. Physical activity

There are 11.5m people (25.7%) in the English population who are currently 'inactive', meaning they do less than 30 minutes of physical activity a week (Sport England, 2018). Physical inactivity in the population is thought to cost the healthcare system over £1 billion annually (Scarborough et al. 2011). Urban parks, woodlands and river corridors provide the opportunity for physical activity such as walking, cycling and running, with research in the UK and across Europe highlighting walking as the most popular form of active recreation in public parks, and the need to prioritise natural walking environments to support human health. A recent population-based cross-sectional study in England (White et al. 2016) revealed the total annual financial value of England's parks, woodlands and beaches to be £2.18 bn. Using data from the Monitor of Engagement with the Natural Environment (MENE) Survey (Natural England, 2015) the study assigned Quality of Life Adjusted Years (QALYs) to individuals in relation to their number of active visits to natural environments. A a single visit per week was estimated to generate 0.010677 QALY, with the social value of one QALY assumed to be £20,000. This study included physical activity in the countryside and in coastal areas as well as in urban parks and other green and blue spaces, yet as outlined above, the need for high quality GI to support physical activity within urban areas is particularly acute because urban populations are often remote from the countryside or coastal areas. Working specifically in urban parks, Fischer at al. 2018a focused on park uses of 3487 urban park users across five European cities (Malmo, (Sweden); Berlin (Germany); Edinburgh (UK); Bari (Italy); Ljubljana (Slovenia)). This extensive Europe-wide study indicated that park use varied across the cities, yet physical park uses dominated at the European level (60%) and in each of the five cities walking was the most frequently reported participant response at the European level (28% of overall sample, and 47% of physical uses).

2.3. Social cohesion

'Social cohesion' relates to 'shared norms and values, the existence of positive and friendly relationships and feelings of being accepted and belonging' (Hartig et al.,2014). Social relationships have been associated positively with both health and well-being (Nieminen et al., 2010) and natural environments (Maas et al 2009). In the study of recreational uses of parks in European cities cited above (Fischer et al. 2018a) the use of parks for social reasons including meeting friends and relatives was 25% across the five cities. This varied considerably across the cities, with the highest social use in Bari, Italy (36%) and lowest in Edinburgh, UK (10%). Different socio-cultural groups with different backgrounds and values have contrasting needs and expectations in terms of the specific characteristics of urban nature. These points are discussed in depth later.

2.4. Stress reduction

There is a significant body of evidence for the psychologically restorative value of spending time in natural environments, with much of this research (for example Herzog, 2003; Hoyle et al., 2017a) drawing on Attention Restoration Theory (ART) (Kaplan and Kaplan, 1989). This proposes that spending time in nature provides an antidote to urban living and working, where the pressures of directed attention on a focused task are fatiguing. Nature provides a 'soft fascination' and a sense of escape or 'being away' from work and mundane routines, allowing the transformation of negative thought processes to more positive ones (Bratman, 2015). Much research in this area has focused on comparing human reaction to natural and built environments (For example Staats et al. 2016; Bratman, 2015) yet a significant body of research has considered reactions to varying natural environments at different scales within urban areas (see Qiu et al. 2013; Van den Berg et al. 2014; Carrus et al. 2015; Hoyle et al. 2017a&b). Bratman et al. (2015) offer physiological evidence for the effects of 'soft fascination' and the pathway between nature experience and improved mental well-being. Research conducted in the USA indicated that a 90-minute walk in a greenspace including grassland, oak trees and shrubs resulted in a decrease in activity in the subgenual prefrontal cortex of the brain. Activity in this area is associated with sad or negative thoughts and is considered a risk factor for depression. Participants also self-reported experiencing fewer negative thoughts and emotions. Conversely, decreased nature experience has been associated with negative, self-directed thoughts leading to increased risk of developing mental illness. Other participants undertaking a 90-minute walk in a busy 3-4 lane urban thoroughfare experienced no improvement in physiological or psychological state. These contrasting reactions reinforce the importance of including spaces with natural features such as grassland and trees within dense urban centres where traffic and commercial activities otherwise dominate.

It is important to recognise that these three direct pathways are complex and interrelated (Hartig et al. 2014), for example physical activity in an urban green space may facilitate long term physical health benefits (White at al. 2016), yet the immediate stress relief (White et al 2017) and social benefits of exercising with friends (Sugiyama et al. 2008; Maas et al. 2009) might be the primary and secondary motivators. One example of this in practice is Parkrun. Founded in Bushy Park, UK, in 2004, there has since been an explosion of interest in Parkrun, a weekly, free-to enter timed run through varied green and blue spaces. This now operates in 20 countries throughout the world including Namibia, eSwatini and Malaysia. In 2018 323 new events were launched globally, and the 5 millionth runner registered. In December 2018, the founder, Paul Sinton-Hewitt acknowledged that 'Parkrun is "now

widely viewed as an innovative health intervention with an impact that reaches far beyond our parks and open spaces" (Parkrun, 2018).

3. Why is human perception of urban nature so significant? The nature dose.

There is a clear distinction between 'objective nature', physical features and processes including plants and animals, lakes, rivers and landscape features, and 'subjective nature', perceived and experienced by people (Hartig et al. 2014). Objective urban nature (or urban GI) has clearly definable vegetation type, biodiversity, structure, density and aesthetics. If this is to be planned, designed, managed and funded to prioritise people, diversity and equity, it is essential to understand the subjective nature experience of potential users in different socio-cultural and geographical contexts. What a person experiences or perceives during a period of nature contact or exposure has been referred to as the "dose" of nature. The nature "dose" or subjective nature experience can vary according to different natural stimuli (referred to below as "diversity in nature") and socio-cultural factors as discussed below. The interplay of different socio-cultural influences means that reactions or perceptions may vary dramatically between individuals experiencing (objectively) the same woodland or parkland walk (Frumkin et al. 2017). As an example, there is considerable evidence that nature experience and dose may be related to individuals' existing "nature-connectedness" (Lin et al. 2104).

For considerable time, researchers have recognised the role of our underlying values in shaping perceptions (Fishbein and Ajzen, 1975). Ives and Kendal (2014) highlight the relationship through discussion of the Cognitive Hierarchy (Fulton et al. 1996) (Fig. 3). Whereas attitudes (perceptions) are often fleeting, fickle or changeable, the deeply held underlying values which inform these perceptions are more stable, and less likely to fluctuate.

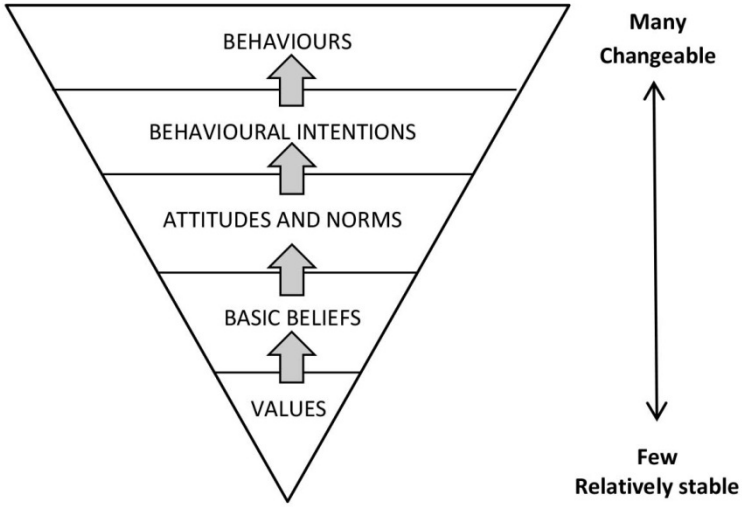


Figure 3: The cognitive hierarchy. Values are more stable and fewer in number than attitudes (perceptions) and behaviours. (Source Ives and Kendal, 2014).

The distinction can be made between different value-orientations: 'Biospheric', (nature-centred); 'Social Altruistic' (human-centred) and 'Egoistic' (self-centred). People with

different value-orientations might perceive and value urban nature in contrasting ways, linked to their value orientation. Significantly, the same urban park may be appreciated for different reasons by people with contrasting value orientations. Those with a biospheric value orientation might value it for its biodiversity, those with a social altruistic orientation might appreciate opportunities to socialise there, whereas people with an egoistical orientation might appreciate the recreational facilities they or their children use (Ives and Kendal, 2014). People may also hold multiple orientations. This emphasises the need to provide diverse environments and stimuli (either within one park or via complementary smaller green spaces) to support well-being across diverse communities with contrasting values and needs.

Awareness of the potentially negative mental well-being consequences the nature 'deficit' in urban areas described above has led to a recent increase in 'green prescribing', one form of social prescribing, or non-medical referral option. Green prescribing involves 'a prescription for a monitorable activity that involves spending time in natural environments for the benefit of human health and well-being' (Robinson & Breed, 2019). Activities might include: care farming (the use of farming practices for health, socialising and education); green exercise (e.g. nature walks, biking, climbing); therapeutic horticulture; biodiversity conservation; wilderness arts and crafts. Advocates of green prescribing have been criticised for reductionist approaches which underestimate the social challenges faced by some patients, yet in the UK, NHS England are now driving to support social prescribing through new Primary Care Networks (PCNs). Since April 2019 PCNs (envisaged as collaborations between different GP practices) have had the mandate to deliver social prescribing, offering different care models for different population groups, such as frail older people, adults with complex needs and children. (British Medical Association, 2019). Positive support for social and green prescribing should be celebrated. As well as focusing on the health and well-being needs of specific groups, there is evidence that green prescribing can produce co-benefits such as enhanced biodiversity in urban areas (Robinson & Breed, 2019).

4. Perceptions of urban nature: diversity in nature

Until recently there was a relative scarcity of research focusing on human response to different natural environments (Clark et al 2014). Attention restoration studies (Herzog et al. 2003; Staats et al., 2016) and early studies of aesthetic preference (Berlyne, 1971; Ulrich, 1986) treated natural spaces as homogeneous, comparing these to built urban scenes. An awareness of the growing 'extinction of experience' in urban areas has prompted an urgency amongst policymakers to create high quality urban nature (GI) to prioritise both human well-being and biodiversity conservation. This has been a stimulus for research at the people-biodiversity interface (Botzat et al. 2016), including an increasing body of research focusing on response to varying natural environments (for examples see Martens et al. 2011, Van den Berg et al. 2014; Qiu et al. 2013; Carrus et al. 2015; Hoyle et al. 2017a,b; Southon et al. 2017; Hoyle et al. 2018; Hoyle et al. 2019). "Diversity in nature" acknowledges that varying (objective) characteristics of urban nature such as biodiversity, and aesthetic qualities such as flowering and colour, structure and tidiness influence subjective experiences of nature, or the nature "dose".

4.1. Diversity in nature: Biodiversity perception and preference at different scales

A significant body of research now highlights the specific role of biodiversity and biodiversity perception in delivering health and well-being benefits to urban populations. A recent review of 200 studies focusing on 'urban biodiversity perception and valuation', between 1972 and 2014 indicated that before 1990, only 4 research papers were published on the theme, whereas 19 were published in 2012, 32 in 2013 and 37 in 2014 (Botzat at al. 2016). The number has continued to grow.

These studies have addressed biodiversity perception at different scales from the broad habitat /ecosystem (Carrus et al. 2015), through species communities (Fuller et al. 2007; Dallimer et al. 2012; Qiu et al. 2013; Fischer et al. 2018 b), where a notable proportion of the research has considered perception of (urban) meadows (Lindeman-Matthies and Bose; 2007; Graves et al. 2017; Southon et al. 2017; Hoyle et al., 2018; Southon et al. 2018).

Carrus et al. (2015) identified a positive relationship between biodiversity at the broad habitat scale and urban residents' subjective well-being in four medium-large sized Italian cities (Bari, Rome, Florence and Padua). 'Broad support for biodiversity' has since been confirmed across five multicultural European cities: Bari (Italy); Berlin (Germany); Edinburgh (UK); Ljubljana (Slovenia); Malmo (Sweden) in an extensive study of diverse respondents (*N*=3716) in different greenspace types (parks, wastelands, streetscapes and forests) (Fischer et al. 2018b). The research showed that in the case of parks, wastelands and streetscapes, people largely preferred higher plant species richness and agreed that this quality facilitated a more 'liveable city' (Fischer et al. 2018b). This study was one of the first to consider perceptions and preferences in relation to biodiversity characteristics of wastelands showing that the mundane 'remnant nature' such as *Buddleia* growing on brownfield sites is valued by the public.

In contrast Qiu et al. 2013) revealed that recreational preferences were negatively correlated with biodiversity values. Here four different habitat zones were identified: an ornamental park; transition area between a residential area and nature woodland; moist multi-layered woodland and a dry single-layered woodland on a ridge. The ornamental park, graded as the least biodiverse habitat by the researchers' biodiversity assessment, was preferred to the other more complex habitats. Apparent divergence in findings from those of Carrus at al. (2015) and Fischer et al. (2018b) might be explained by the biodiversity grading system employed by Qiu et al. (2013) which recognised native rather than overall plant species diversity. The parkland with its large percentage of exotic biodiversity was the most preferred, yet because it contained a high percentage of 'alien' or exotic species it rated low for biodiversity. These findings, i.e. aesthetic preference for areas of parkland dominated by non-native species are in line with UK research by the author (Hoyle et al. 2017b). This study revealed broad support (75.3% participants) for non-native planting in designed urban greenspaces, with climate change identified as a key driver of acceptance.

Fewer studies have addressed human biodiversity perception or valuation at the individual species level. An exception, (Palliwoda et al., 2017), highlighted as the first study of direct human-biodiversity interaction in relation to other activities, indicated that 17% visitor

activities on park grasslands in Berlin were biodiversity interactions, with 17% wild or cultivated plants from local species pools targeted. Specific species were important to participants for consumption (60%), decoration (21%) and biodiversity experience (17%). Kendal et al. (2012) illustrated that people's biodiversity preferences are relevant at the level of specific non-visual plant traits such as nativeness and drought-tolerance, as well as flower size, leaf width and foliage colour, yet it can be argued that these are aesthetic qualities of individual species, rather than biodiversity per se.

4.1.1. Biodiversity: Can people recognise it?

The scale at which positive biodiversity-human well-being relationships operates and if and at what scale biodiversity recognition occurs is important because if urban nature (GI) is to be designed and managed to prioritise people, it is important to understand how and at what scale improvements in actual biodiversity can be made which are evident and observed by people, to optimise the human health and well-being benefits (Hoyle et al 2018). If people can recognise biodiversity, is this at the broad habitat or species scale? A further question also arises, i.e. Do people need to recognise biodiversity for it to be effective and meaningful in terms of enhancing their well-being? The positive relationship between biodiversity and well-being may be subconscious, likely mediated by reactions to the aesthetics of urban nature, for example visual plant traits linked to biological functionality such as large colourful flowers, which attract pollinators. To date there has been conflicting evidence about people's biodiversity-recognition skills, yet the evidence suggests that recognition by the lay-person is better at the broad visual scale and less-honed at the species level, and that recognition skills vary according to education and income (Hope et al. 2003) as well as ecocentricity/nature orientation (Dallimer et al., 2012; Southon et al. 2018).

Several studies have indicated that lay-people can identify broad habitat types. In a previously cited study (Qiu et al. 2013), participants recognised broad levels of biodiversity in urban green spaces, and in the author's research on public perception of non-native planting, respondents recognised the three broad levels of nativeness (strongly native, intermediate and strongly non-native) (Hoyle et al, 2017b). At the more detailed community species level, findings have varied. In the case of introduced urban meadows, Southon et al. (2018) found that actual and perceived plant species richness were positively correlated, yet the accuracy of biodiversity estimates was greater for more nature-connected members of the public. Research conducted in Sheffield focusing on identification of plant, butterfly and bird species generated contrasting results. Fuller et al. (2007) found that greenspace users could recognise species richness, the extent to which they did so depending on the taxonomic group considered. Recognition was best in the case of plants, moderate in the case of birds and poor in the case of butterflies. In contrast, Dallimer at al. (2012) attributed the lack of a relationship between biodiversity and well-being, but positive relationship between perceived biodiversity and well-being, to people's poor biodiversity-recognition skills. It may be that the two research studies sampled different demographics, with contrasting biodiversity-recognition skills. In the first study, where biodiversity-recognition skills were relatively good, the 15 greenspaces studied were

in a wedge extending 13km from the centre of Sheffield in a westerly direction. This encompasses the more affluent residential areas of Sheffield, where arguably biodiversity-recognition is likely to have been higher due to higher educational levels, or a higher level of family income providing exposure to more diverse planting in private gardens (Hope et al., 2003, Hoyle et al., 2019). The second study sampled a wider area of Sheffield, possibly including a more socio-demographically diverse sample of participants, with biodiversity-recognition skills more typical of the city. Yet biodiversity recognition is not a prerequisite to accessing the benefits of nature. The stronger relationship between perceived biodiversity and well-being than actual biodiversity and well-being in this research showed that perception of diversity based on visual cues as discussed below was a stronger driver of positive emotions than biological diversity per se.

The extent to which people perceive and respond to biodiversity per se, or to visual cues which they interpret as biodiversity is debateable. The growing body of research focusing on public perception of urban meadows highlights this issue (Lindeman-Matthies & Bose 2007; Southon et al. 2017; Southon et al 2018; Graves et al 2017; Hoyle et al 2018). Two studies in different contexts (Lindeman-Matthies and Bose, 2007; Southon et al. 2017) indicate preference for diverse meadows containing more plant species (as well as some structural diversity). The first study (Lindeman-Matthies and Bose, 2007) involved visitors (*N*=152) to a botanical garden in Switzerland, creating their own idealised meadow from 25 out of 779 wild plants of 54 species. The second study, (Southon et al, 2017) involved in-situ surveys of users (*N*=300) of urban sites (and control sites) in Bedfordshire, UK. In this study, perennial meadows of three levels of structural diversity were crossed with three levels of species (and floristic) diversity and established at five sites (Fig.4).

In the first study, the authors acknowledge that 'participants favoured plants with large or colourful flowers'. In the second study, meadows of medium height and high species (and floristic) diversity were most preferred by site users. Subsequent research by the authors revealed flowering and colour to be key to participants' estimates of meadow biodiversity (Southon et al. 2018). In each of these studies, were people responding to species diversity or aesthetic flower (colour) diversity?

Fig. 4: The nine different meadow mixes defined by three levels of structural diversity (short, medium and tall) and three levels of species and floral diversity (no flowers, some flowers, many flowers) (Source Hoyle et al. 2017c)

Research in the contrasting context of the Southern Appalachian forest trails (Graves et al. 2017) confirmed the dominance of flower colour over species diversity in driving people's aesthetic preferences in this context. Results showed that aesthetic preference was unrelated to species richness but increased with more abundant flowers, greater species evenness and greater colour diversity. Further UK research (Hoyle et al. 2018) related to that of the previously cited studies (Southon et al. 2017; 2018) tested whether species or flower colour diversity was the main driver of human (and invertebrate) response to urban meadows (Fig.5). Restorative effect was unrelated to either plant species or flower colour diversity. Aesthetic appreciation of attractiveness and interest was related to flower colour diversity, but not to plant species diversity. Results also indicated poor plant and invertebrate biodiversity recognition skills across laypeople and 'experts' involved in environmental professions, with participants using flower colour diversity as a cue to estimating plant species diversity. Clearly, people can gain aesthetic and well-being benefits from nature without recognising biodiversity, but this raises the question as to whether people actually care about biodiversity, and whether it should be prioritised in urban contexts. Pragmatically, land managers can prioritise colour diversity over species diversity

and vice versa, depending on the specific urban context, as discussed in the case of ‘nature spaces’, ‘living spaces and ‘flowering spaces’ in Lyon. France.

Fig. 5. Annual meadows in Luton, UK. Participants used flower colour diversity as a cue to estimating plant species diversity.

4.2. Diversity in nature: Varying Aesthetics - perception and preference

A significant body of research has gauged human reaction to the visual aesthetic qualities of urban nature (for reviews again see Hartig et al. 2014; Frumkin et’ al. 2017). Early studies relied on straightforward preference ratings and used photographic or film stimuli to depict urban or rural nature at the landscape scale (for example Shafer & Brush, 1976; Ulrich, 1986; Herzog et al. 2003). At the other extreme, research has occurred at the microscale, focusing on perception of individual plant traits (for example Kendal et al., 2012). Some research has focused one vegetation community or type, such as woodlands, (Jorgensen et al. 2007; Martens et al. 2011; Van den Berg et al. 2014), street trees (Todorova et al. 2004), or herbaceous planting, (Strumse, 1996) or specifically urban meadows (Lindemann – Matthies & Bose, 2007; Southon et al. 2017,2018; Graves et al 2017; Hoyle et al 2018). The growing awareness of ‘the extinction of experience’ (Soga and Gaston, 2016) of urban nature has heightened awareness amongst researchers that the environment is experienced rather than looked at (Ittleson, 1973) with an increase in research generated through in-situ surveys of people within urban nature experiencing it first-hand (see for example Fischer et al. 2018a&b; Hoyle et al 2018).

In many preference studies perceived attractiveness has been taken to represent preference, with the proposition that well-being arises from a positive aesthetic response to

the natural environment. This relationship is discussed here, where the focus is on the two key aesthetic drivers of human reaction to urban nature; *flowering and colour* and *structure and care*.

4.2.1. Varying aesthetics - Flowering and Colour

"That's just stunning! As soon as you gave me the picture I thought, 'Wow, that is amazing!'..I just love it, I'd love to see it real and be there. It just really attracts me in so many ways, the colours, the textures, the naturalness, but it's obviously carefully created..and it, to me that looks like a real artist has made that.."

Fig. 6. Annual wildflowers at RHS Wisley, Surrey, UK.

"Colour has a big impact on me. This particular one, because although you are getting an overall impact of something rather beautiful, you can focus in on individual colours, especially the blues..which is a bit of a rarity in gardening, true blues anyway. Which one is it, the corn cockle?"

Research focusing on public perception of designed planting (Hoyle, 2015) illustrates the role of colour diversity as a driver of positive reaction to meadows. These participant interviewees are responding to an image of the same annual wildflower meadow at RHS Wisley (Fig. 6). There is now considerable evidence for the power of flowers to generate strong emotional reponses. Research conducted in contexts abstracted from urban nature showed that flowers could elicit a true or 'duchenne' smile (Haviland-Jones et al. 2005). Positive reactions to flowers and colour are reported in the discussion on recognising meadow biodiversity above (Lindemann – Matthies & Bose, 2007; Southon et al 2018; Graves et al 2017; Hoyle et al 2018). Further research in Japan (Todorova et al. 2004) found that participants selected low, ordered, brightly-coloured flowers over taller or subtly coloured flowers and non-flowering ground covers such as bare soil, grass or hedge underneath street trees. Research by the author (Hoyle et al. 2017a) indicated that people found flower cover of 27% or more to be significantly more attractive than a lower percentage flower cover. We explored the relationship between perceived attractiveness and restorativeness in semi-structured interviews (*N*=34) Interviewees were presented with two images of one of the study sites (Fig. 7), first showing the azalea planting in full flower (in May) and then showing the planting in lush green tones (after flowering in August).

Fig. 7: Azalea planting at 'The Punchbowl', Valley Gardens, UK. This was considered most attractive in May (the 'wow factor') but potentially most relaxing to walk through in August, after flowering had finished.

When asked which area of planting they would find the most attractive, and then the most relaxing to walk through, most chose the first image as the most attractive. For them, attractive urban nature was colourful, vibrant and demanded their attention. In contrast, most chose the second (green) image as potentially the most relaxing to walk through, as it was a 'background' for positive or problematic thoughts. This reaction encapsulates that perception.

"I think then, it can be, it can be too stimulating, so then it's not that relaxing, really..because, to be honest, it's an assault on the senses..it's so bright (in May). I think you go there for the 'Wow factor', but you don't go there to relax. Here, I think if you wanted to have a relax and just wanted to sit, maybe listen to the birds of just generally stare into space, this is probably more relaxing (in August). This is really, this is quite an assault on the senses when you see it..It's almost unreal, as though someone's painted it but used the wrong colours.."

We applied the Circumplex Model of Affect (after Russell, 1980, Posner et al. 2005) to explain participants' reactions (Fig.8). Both vibrant and green azalea planting elicited positive yet contrasting affective responses in our participants. The bright, colourful stimulus provoked the 'wow factor' – an activated excited response, whereas the lush green induced deactivated, relaxation and a calm state of mind. This model, together with our participant responses, provides a useful tool and guide for planting designers aspiring to create a particular emotional response in resident or visiting publics.

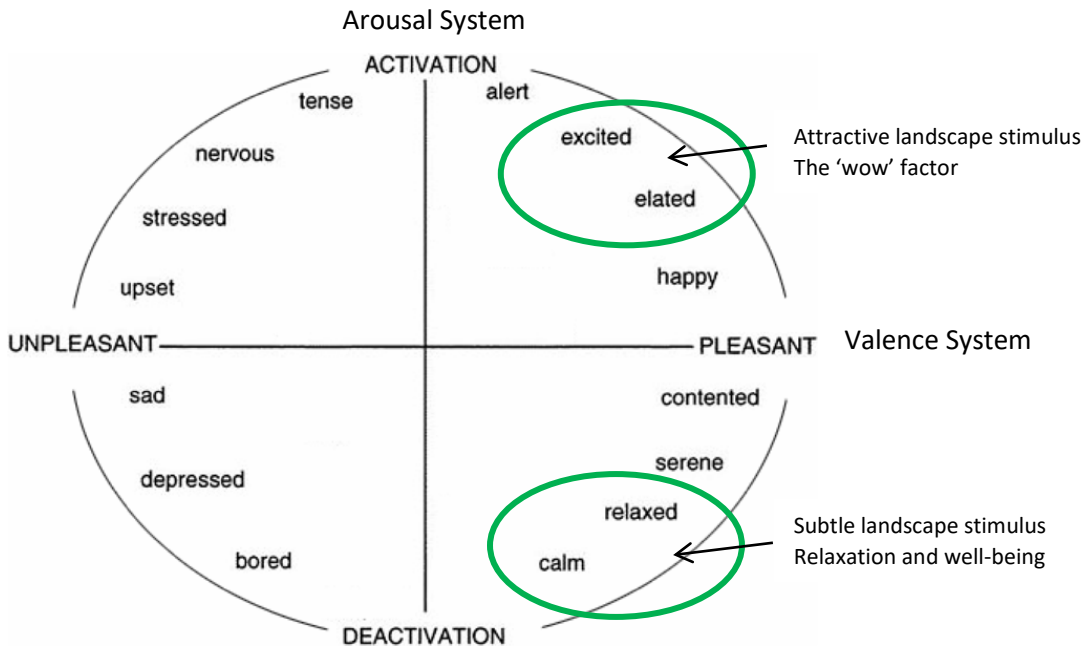


Fig. 8. The Circumplex Model of Affect (after Russell, 1980, Posner 2005) adapted by Hoyle et al. 2017a to show the impact of varying urban nature aesthetics on human emotional response

4.2.2. Varying aesthetics - Structure and care

Vegetation or planting structure refers to the way in which individual plants are arranged spatially to create an assemblage, or community. In the UK the most naturalistic woodland, shrub and herbaceous planting structure is exemplified by multi-layered woodland, shrubby woodland edge and herbaceous communities of mixed tall grasses and forb species (Hoyle et al. 2019). In urban nature contexts these relatively 'wild' structures represent 'mundane nature', either 'accidental' or 'remnant', identified by Newman and Dale (2013). A structural gradient occurs between highly naturalistic structures (the 'nature spaces' of Lyon – see previous discussion) and the highly designed 'nature on display' identified in formal parks and gardens (Lyon's 'flowered spaces'). In an urban nature context where people experience nature by walking through it in parks, greenspaces and incidental spaces structure is very important, because it has a direct bearing on the height, density and on visual permeability of the vegetation in relation to the human scale. Varying structural naturalness has been shown to impact significantly on people's urban nature experiences.

Some previous research has revealed negative or ambivalent attitudes to wilder urban planting structure (Jorgensen et al.2007; Martens et al. 2011). Ambivalent attitudes to an ecological woodland style were revealed in Warrington New Town, UK (Jorgensen et al. 2007). Residents both valued woodlands as their favourite places, but feared walking through them would risk exposure to physical or sexual assault. Other research (Martens et al. 2011) generated a stronger increase in positive affect and decrease in negative affect amongst participants walking through 'tended' as opposed to 'wild' urban forests. Nassauer

(1995) stated that people expected to see a 'look of human intention' in settled urban environments, signs of human agency or 'care'. An otherwise ecologically rich and structurally wild landscape could be sanitised for urban consumption through 'cues to care' such as mown verges and bright flowers in prominent locations.

A considerable body of recent research has demonstrated some contrasting results. Previously cited research by the author (Hoyle et al. 2017a) focused on public reaction to three levels of structural naturalness in woodland, shrub and herbaceous designed urban planting (Fig. 9). Results across all vegetation communities indicated that participants (*N*=1411) considered planting with a moderately and most natural structure significantly more restorative to walk through than that with a least natural structure, although a moderately natural structure was considered the most restorative.

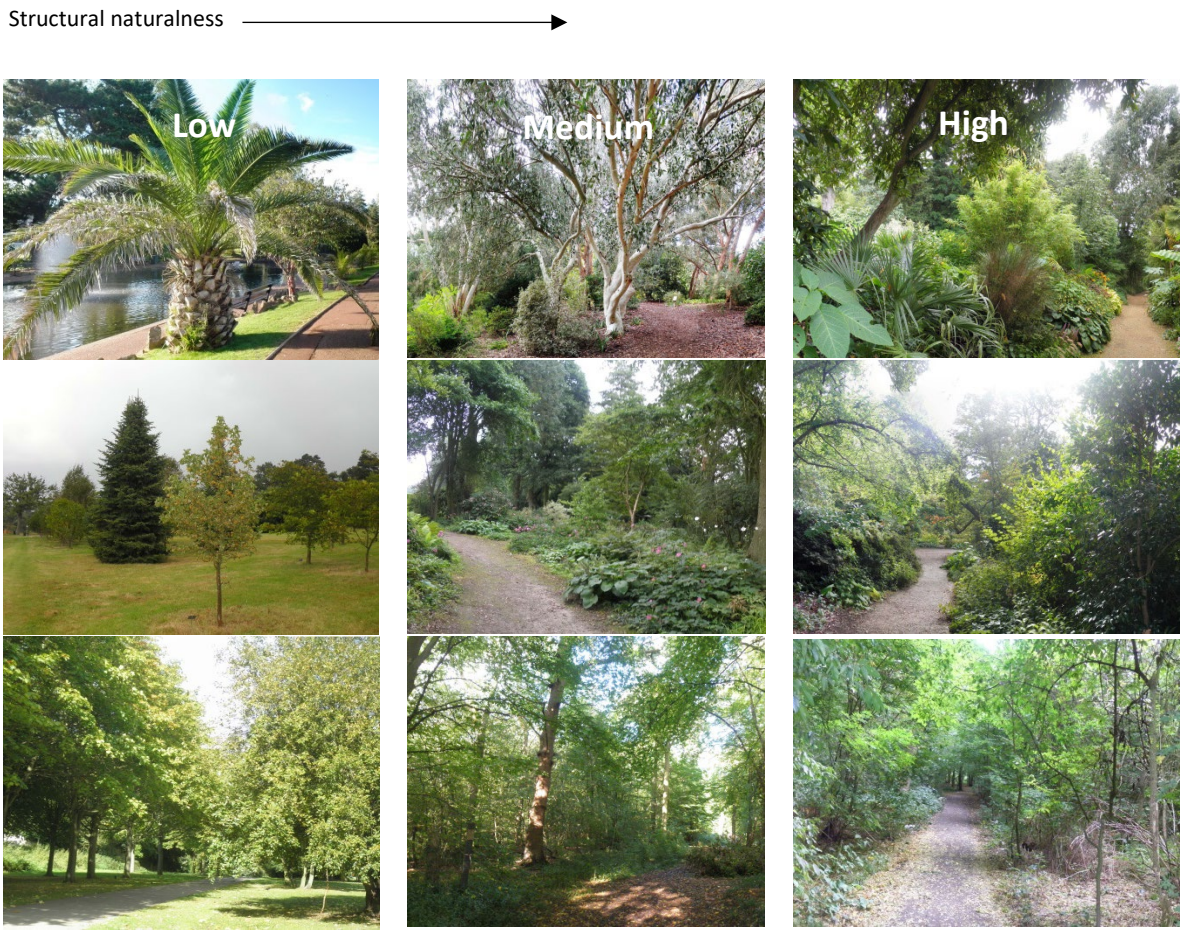


Fig. 9: Woodland case study sites showing the gradient of structural naturalness, showing the three levels: 'low'; 'medium' and 'high'. Planting at the 'medium' level of structural naturalness was considered the most restorative to walk through.

Other research in the UK and beyond has confirmed an increasing preparedness to tolerate and appreciate a structurally messier urban aesthetic. Previously cited research (Southon et al. 2017) on perceptions of urban meadows involved a photo elicitation exercise which showed that participants generally preferred meadows to formal bedding and herbaceous borders. Participants were receptive to naturalistic vegetation within different green spaces,

although the specific locational context was important. At one site, meadows were introduced to a narrow strip of amenity mown grass with trees, at the front of housing. Some vocal individuals objected to the messier aesthetic, leading to pressure on a local councillor and the withdrawal of the site from the experiment. Local land managers later expressed awareness of an increasing acceptance of less tidy planting in urban areas, but believed locational context must be considered carefully in relation to neighbourhood planting schemes. They related increasing public acceptance of messier urban planting to possible heightened awareness of the pollinator value of wilder meadow areas, as well as a perception that less-frequent mowing might reduce costs for local authority parks departments (Hoyle et al. 2017c.). Significantly, these land managers supported the need for 'cues to care' in this context, (Nassauer, 1995) in the form of mown edges and paths through informal planting, to indicate intended stewardship of the space (Fig.10). Findings from the extensive European research in Malmo, Berlin, Edinburgh, Bari, Ljubljana indicated that participants valued wasteland vegetation and wild vegetation in streetscapes. This provides wider evidence of support for wilder, more naturalistic urban nature, and the policy inclusion of valued informal spaces in planning high quality multifunctional GI networks (Fischer et al. 2018b).

Fig.10 'Cues to care' Grassland verge management in Stevenage, Hertfordshire. Diverse perennial meadows are allowed to grow and flower in a roundabout setting, but a section of the sward is mown adjacent to the footway.

Synthesis of these different findings indicates a complex pattern. Although the physical objective structural qualities of urban nature influence human perception, in the case of structure, tidiness and care, it seems contextual factors have a significant bearing on human perception.

5. Socio-cultural and geographical contextual factors

The concept of Biophilia (Wilson 1984) suggests that humans have a deep evolutionary bond with nature. Evolutionary theories of landscape preference (Heerwagen and Orians, 1995) propose that humans are almost 'hard-wired' to prefer certain landscape aesthetics such as large flowers, indicating a resource-rich environment, or savannah landscapes providing prospect for hunting. Yet, there is now real understanding that socio-cultural and geographical factors have a huge role to play. Perceptions, preferences and experiences of the same objective urban nature characteristics vary between cultures, places and individuals. The term 'socio-cultural' is used here and incorporates aspects of socio-

demographic diversity such as gender, education and professional background, and ethnicity, yet it also emphasises the strong influence of culture on these factors. The importance of nature-connectedness is considered.

5.1. *Gender*

Several recent studies have shown gender differences in responses to urban nature. In the previously cited study by the author, female participants found walking through urban woodlands, shrub and herbaceous environments significantly more restorative than men who walked through the same environments (Hoyle et al., 2017a). Female participants also perceived significantly higher levels of naturalness than did men (Hoyle et al. 2019). Findings from multicultural European cities concur, as women valued all park scenes and medium and high forest plant species richness more highly than did men (Fischer et al. 2018b). This is interesting, because earlier research reported higher levels of fear amongst women in woodland (Jorgensen et al. 2007) and woodland edge (Jorgensen et al. 2002) environments. As highlighted by Fischer et al. (2018b) these responses might relate to specific scale or context, or traditional role models. In support of this view, several female research participants interviewed by the author (Hoyle, 2015) expressed an appreciation of dense, multi-layered woodland, which one described as 'calming':

"Well, I think this one is still the most attractive..because I like the lush planting, I like the close planting, I like..I just like the way different shapes have been put together but it's very lush, so that's really nice.. "

"I think I would go for this one because its more natural, so you are going through a very natural area here, which I think if I was walking through, I would find quite calming and, yes I would like that."

5.2. *Education*

Although the author's research (Hoyle et al. 2017a) revealed no relationship between economic status (employment) and perceptions of designed planting, more highly educated participants recorded lower levels of perceived biodiversity across woodland, shrub and herbaceous sites, after controlling for variability in planting and locational context. More educated participants also recorded lower scores for perceived naturalness, those with a doctorate recording the lowest of all (Hoyle et al., 2019). This is possibly because more educated participants were more familiar with a broader range of plant diversity through exposure to these within their own private gardens, known as the "luxury effect" (Hope et al. 2003).Nevertheless, although less educated people may perceive biodiversity less accurately, there is no evidence that they benefit more from contact with nature in urban spaces more than those who are more educated or affluent. Indeed, Southon et al. (2018) demonstrated the opposite; site users with higher deprivation scores reported greater connection to nature than those with lower deprivation levels. Less educated or affluent residents are also less likely to have access to private gardens, so the need to maintain high quality public green spaces to support their well-being is paramount.

5.3. *Professional Background*

Professional background, specifically involvement in the landscape or environmental professions has been shown to have considerable bearing on landscape perception and preference. Typically, professionals (Ozguner, Kendle & Bisgrove, 2007) or students (Zheng, Zhang & Chen, 2011) in fields such as conservation and environmental science have been shown to prefer more naturalistic planting styles to tidier, ordered planting, or to find these more restorative (Hoyle et al., 2017a). The view expressed by this interviewee (Hoyle, 2015), sums this up explicitly:

"I am not a person that's into gardens, and gardening, and organised planting. I like to be out in the countryside. I go out in the countryside, a lot further from the centre of Stevenage, and I like to see land in its natural habitat, or as close to its natural habitat as you can get. In my experience, plants do not occur in great blocks of mixed colours, they occur all over the place…they don't occur in blobs, regularly, they occur on a random pattern, and it's the random pattern that appeals to me more than the organised pattern."

This is consistent with findings from the Europe-wide study (Fischer et al. 2018b) where environmental experts valued wild wasteland sites at all levels of plant species diversity more highly that did non-experts. Interestingly, in the UK annual meadows study (Hoyle et al 2018), environmental experts rated vibrant, colourful (predominantly non-native) annual meadows as less attractive and interesting than did non-experts. Although naturalistic in structure, these were probably perceived (accurately) as highly designed. Environmental experts are also likely to be more 'nature connected' than non-experts, maybe because the time they spend in nature enhances their connection, or maybe because nature connected people choose environmental professions. The relationship is likely to be self-reinforcing, where both pathways apply. When planning designing and managing green spaces professionals therefore need to reflect on the divergence of their own perceptions from those of wider urban publics.

5.4. *Nature-connectedness*

'Nature connectedness', feeling tied to nature, or belonging in nature, has been shown to promote well-being (Lumber et al. 2017; Zelinski et al. 2012). This is also referred to as 'nature relatedness' (Nisbet et al. 2011), 'nature orientation' (Lin et al. 2014), 'ecocentricity' (Southon et al. 2017) or holding 'biophilic' values (Ives and Kendal, 2014). Nature-connectedness is a fundamental underlying value, shaping individual or group attitudes, behaviours and norms (see the Cognitive Hierarchy, above). People may have strong ties to nature for different reasons, with positive experiences of nature in childhood being a key factor, as these research participants express (Hoyle, 2015):

"I like that partly because that's a bluebell wood ..for me, bluebell woods is my mum, and when I was a kid, and the smell of bluebells is my mum…and so you will never get me picking anything else that I would like to do more than walk through a bluebell wood"

"I can remember when I was a kid erm I mean in those days children were allowed to roam off..Knebworth and everything. We used to come over here, sort of six, seven, eight years old…it would have been early sixties..and the wood was literally completely overgrown. It was like this the whole way through"

In this research, more nature connected individuals benefitted more psychologically than others during their walks through woodland, shrub and herbaceous planting. They also gave planting higher naturalness scores than less nature connected participants (Hoyle et al. 2019) and considered the planting more aesthetically attractive, after controlling for the objective planting characteristics (Hoyle, 2015). Nature-connected individuals are attuned to noticing nature (Franz & Mayer, 2014) and in our study may have been more receptive to the experience of walking through an area of planting. Because nature-connectedness has an emotional dimension (Mayer & Franz, 2004), more nature-connected individuals may have been more positively responsive to the physical and psychological experience of walking through an area of planting (Hoyle et al 2019). There are again parallels. Southon et al. (2017) found that more nature-connected participants who visited the countryside more regularly were more positive about the introduction of perennial meadows to urban sites. In the recent Europe-wide study (Fischer et al. 2018b), participants' biodiversity perception was related to their nature orientation and frequency of greenspace visits.

5.5. *Migration background*

People with a migration background often perceive and experience urban nature differently to native populations (Buis et al. 2009; Rishbeth and Finney, 2006; Jay and Schraml, 2009; Kloek et al., 2010; Hoyle, 2015; Fischer et al. 2018b; Hoyle et al. 2018). This is important for planners, designers and managers of urban GI to recognise when prioritising human well-being in the context of a multicultural city (Fischer et al. 2018b). Whereas native European or North American populations may hold a wilderness view of nature, people with a migration background may perceive it more functionally, associating it with rural landscapes and food production (de Boer and Schulting, 2002), evident in the case of people with Turkish migration backgrounds in Germany (Jay and Schramyl, 2009) and in the Netherlands (Buijs et al. 2009). Working in Sheffield with people with Asian and African refugee backgrounds, Rishbeth and Finney (2006) found that contact with particular animals, plants, activities and social use of outdoor nature spaces might trigger for migrants feelings of nostalgia for their country of origin. Importantly nature is not always positive for people with a migrant background. In this study, feelings of fear were found to be related to nature itself, insects in nature, other people and racial attacks. Preferences for tidier, managed places amongst people with a Mediterranean or Islamic migrant background have also linked to the portrayal of nature as manicured and ordered, as a 'cultivated oasis' (Schouten, 2005). The author found a significant association between ethnicity and perceptions of tidiness and care when researching perceptions of woodland, shrub and herbaceous planting (Hoyle, 2015). Perception of 'restorative effect and care' was also associated with ethnicity in gauging public response to annual meadows in Luton, UK (Hoyle et al., 2018), yet in both these cases the small number of research participants in some ethnic groups limited further quantitative interpretation. Nevertheless, in the first study qualitative interviews provided further insight. One participant with an Indian migrant background showed an awareness of how her cultural background and upbringing in India influenced her perceptions of urban nature:

"I'm the sort of anal idiot who gets crotchety if things aren't tidy..Poirot and I have a lot in common…that's why I liked Agatha Christie when I first came across her…we like our things symmetric....I don't find it relaxing if things are messy..all over the place...Actually it would be an interesting cultural thing..because I've always maintained that ..I've been to many many poor Indian homes. I've only ever been to one that I would call untidy. In India we don't have separate words for untidy and dirty. It's the same thing.…and my sisters think I am, and I quote 'a slob', but most of my friends think I'm unbelieveably tidy!"

This participant had a personal migration background, i.e., she was a first-generation migrant. Evidence from recent research across five multicultural European cities (Fischer et al. 2018b) shows differences in nature perceptions between first generation migrants and their children and grandchildren. For first generation migrants, perceptions of whether the green areas depicted in the study contributed to creating a liveable city differed significantly from those without a migrant background, yet there were no significant differences between perceptions of their children and grandchildren and the non-migrant populations.

6. Urban nature perceptions: What do we know? Implications for policy, practice and further research.

We now know that most people respond positively to colourful, flowering planting in urban spaces, finding this attractive and stimulating, yet 'green' spaces are also highly valued for their 'background' calming, restorative qualities. People appreciate diversity in nature, yet are not particularly skilled at identifying biodiversity at finer resolution than the broad habitat scale. This does not limit their potential to connect with nature and enjoy its benefits. There is also growing evidence of increasing acceptance of a messier urban aesthetic across Europe, with the remnant nature of wastelands and less formal spaces now valued and informal meadows enjoyed within urban spaces. In some locational contexts such as in front of homes and on verges next to footpaths, 'cues to care' such as close mown edges offer compromise solutions to land managers forced to prioritise in times of austerity economics.

The variety of experiences and responses to natural spaces means that the relationships between the general and particular require further exploration and careful balancing in terms of UGS provision and management. Further research must focus on the diverse perceptions and preferences of different socio-cultural groups in different geographical contexts. Much of the existing literature has addressed urban nature perceptions and preferences in temperate, often western regions, whereas other regions are undergoing the most rapid rates of urbanisation (Botzat et al. 2106). More understanding is needed of the relationship between people and nature in contexts where people do not hold a developed western wilderness view of nature. Because people with greater nature-connectedness are more likely to spend time in green spaces (Lin et al. 2014) existing studies have often consulted self-selecting nature-connected participants recreating in urban nature. Insights from people who do not spend time in nature would be valuable, focusing on perceived barriers to accessing the benefits of nature and investigating whether there are alternative pathways to health and well-being in cities which do not involve urban nature contact.

Understanding the way people perceive urban nature is important. The connections and disconnections between aesthetic appreciation of landscapes and their biodiversity needs to

be recognised, so natural spaces can be planned, designed and managed with both in mind. If social prescribing and green prescribing of nature-based therapeutic interventions becomes mainstream in countries such as the UK, such understandings will be key for health care professionals too.

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