Fisher, Jessica C. (2020) *The benefits of biodiversity: Human-wildlife interactions in urban Guyana.* Doctor of Philosophy (PhD) thesis, University of Kent,.

The benefits of biodiversity: Human-wildlife interactions in urban Guyana

Jessica Claris Fisher

Durrell Institute of Conservation and Ecology
School of Anthropology and Conservation
University of Kent, Canterbury

Thesis submitted for the degree of Doctor of Philosophy in Biodiversity Management
August 2020
Word count: 59048

Benefits of Biodiversity:

Human-wildlife interactions in urban Guyana

Jessica Claris Fisher

Supervised by:

Professor Zoe G. Davies

Dr Jake E. Bicknell

Professor Jayalaxshmi Mistry

Mr Damian Fernandes

Acknowledgements

A huge number of people have supported me, many of whom are not mentioned here. I am foremost indebted to the supervisory dream-team of Zoe Davies, Jake Bicknell, Jay Mistry, Damian Fernandes and (unofficially) Kate Irvine, whose intelligence, caring attitude, and thoughtful contributions to my PhD, as well as my personal development, were invaluable and inspiring throughout. Thanks also to my examiners, Dave Roberts and Chris Ives, who were hugely supportive of my work.

During fieldwork in Guyana, dozens of amazing individuals helped me collect data, navigate bureaucracy, and adventure into the interior. Specifically, Meshach Pierre, Huichang Yang, and Arianne Harris supplemented four field seasons with lots of rum and chicken wings, and whom I hope to work with again. Additional thanks to Will Hayes, Annalise Bayney, Aiesha Williams and Odacy Davies, who were integral to everything running smoothly. Many thanks also to Oleta Williams, Kayla De Frietas, Lan Mei, Nicholas Peters, Mia Pierre, Nadia Hunte, Joshua Bonie, Sara Bharrat, Juliana Persaud, Denise Fraser, Rayon McGregor, Kristia Ramlagan, and to Keshav Joshi, a cheerful and eccentric friend who sadly died in Spring 2020.

In Canterbury, special thanks are due to the ever-fluctuating student and staff community of DICE. I am grateful to have shared the PhD journey with such a supportive community of people, especially Dee Rundle, Rachel Sykes, Claire Stewart, Gemma Harding, Gwili Gibbon, Kate Allberry, Keira Pratt-Boyden, Addy Lowe, Laura Burke, Tally Yoe, Helen Pheasey, (Isa)bela Berata, Ellie Rankin, Chris Dunmore and Tristan Pett. Extra thanks to Nick Deere, who shared crisps, Chinese takeaway and horror films in times of need.

In London, friends were exceptionally supportive since my initial PhD application through to the end of the thesis itself, including Sonia Baralic, Freddy Tennyson, Catherine Levi, Clara Pelly, Francesca Raimondi, Caterina Incisa, Caleigh Kimberley, Graeme Hibbs, Kieran Towers, Camilla Blasi Foglietti, Lizzie Conlon, Jade Delaney, and Ralph Blackburn, who looked after me both at home and in Canterbury, as well as during the COVID-19 pandemic. During my policy internship at Natural England, Cheryl Willis and Susie Gold provided both friendship and guidance.

Finally, thanks to my two brothers, Tom, Will, and my dad Don, who never really understood what I was actually doing but were there for me regardless. Special thanks to my mum, Wendy, who offered insights from her experience in social science, and who has always been, and continues to be, a constant inspiration for everything I do.

Author's declaration

J.C. Fisher wrote all of the chapters, with editorial suggestion made by PhD supervisors J.E. Bicknell, J. Mistry and Z.G. Davies. Chapters 2-5 include collaborations with researchers outside of the supervisory team, as outlined below.

Chapter 2 originated during discussions with D. Fernandes, K.N. Irvine, J.E. Bicknell, J. Mistry and Z.G. Davies. The sampling and questionnaire design were developed by J.C. Fisher with support from all co-authors. Data collection was led by J.C. Fisher, with local field assistance. All data analyses were conducted by J.C. Fisher, with independent and iterative qualitative coding also done by K.N. Irvine. J.C. Fisher wrote the chapter with collaborative input from K.N. Irvine, J.E. Bicknell, J. Mistry and Z.G. Davies.

Chapters 3 and 4 originated during discussions with D. Fernandes, K.N. Irvine, J.E. Bicknell, J. Mistry, and Z.G. Davies. The sampling and questionnaire design were developed by J.C. Fisher with support from all co-authors. Data collection was conducted by J.C. Fisher with local field assistance. Bird point counts were conducted by W.M. Hayes, with assistance from J.C. Fisher and M.A. Pierre. All data analyses were conducted by J.C. Fisher, with independent and iterative qualitative coding also done by K.N. Irvine. J.C. Fisher wrote both chapters with collaborative input from K.N. Irvine, J.E. Bicknell, J. Mistry and Z.G. Davies.

Chapter 5 originated during discussions with D. Fernandes, J.E. Bicknell, J. Mistry and Z.G. Davies. Co-authors M.A. Pierre, H. Yang, A. Harris and N. Hunte contributed to workshop design and facilitation. Data analyses were conducted by J.C. Fisher, with independent and iterative qualitative coding also done by M.A. Pierre and J. Mistry. J.C. Fisher wrote the chapter with collaborative input from J.E. Bicknell, J. Mistry, M.A. Pierre, H. Yang, A. Harris, N. Hunte and Z.G. Davies.

Abstract

Worldwide, human populations are growing, the climate is changing, and natural habitat is being converted to alternative land-uses. In particular, urbanisation has both positive and negative implications for society and biodiversity conservation. Within cities, there is increasing evidence that green (e.g. parks, gardens) and blue spaces (e.g. rivers, coast) can benefit human subjective wellbeing by restoring attentional fatigue and reducing stress, while also providing resources to support biodiversity. However, it remains unclear how biodiversity, and other specific features of urban green and blue spaces, enhance or detract from wellbeing. These details are crucial to informing land-use management and policy decisions in towns and cities. Much of the existing evidence originates from the global North, despite biodiversity loss, population growth, and urbanisation rates accelerating in the global South. Drawing on theories and methods from multiple disciplines, this thesis empirically explores relationships between green and blue spaces and human wellbeing in Georgetown, the capital city of Guyana. This biodiversity-rich country in northern South America has the highest rate of suicide worldwide and is poised to transform due to the discovery of vast quantities of off-shore oil. First, I expose a dose-response relationship between patterns of visitor use to urban green and blue spaces and experiential wellbeing, finding that age, safety concerns, and nature-relatedness dictate patterns of use. Second, I show that green and coastal blue spaces are important for bird diversity and human wellbeing respectively, although the two do not relate. Third, I assess how human perceptions of bird diversity, naturalness, sounds, and safety affect wellbeing, influenced by how restorative these spaces are perceived to be. Finally, I use participatory video to triangulate earlier findings, discovering that biodiversity provides a multisensory experience, with place attachment, personal insecurity, and cultural beliefs contributing to wellbeing in green and coastal blue space. This interdisciplinary thesis makes important empirical contributions to the field of biodiversity-wellbeing research, representing the first evidence gathered from neotropical South America. Overall, my results provide a valuable evidence-base to inform the development of interventions (e.g. targeted public health and educational campaigns) in biodiversity-rich cities like Georgetown. From a wider perspective, these findings could be harnessed by policy-makers striving to meet international targets on sustainability while maximising human quality of life at a national scale.

Keywords: biodiversity; blue space; conservation; green space; global South; Guyana; human-wildlife interactions; mental health; wellbeing; urban planning.

Table of contents

List of tables

List of supplementary tables

List of figures

List of supplementary figures

Chapter 1. Introduction

1.1 Biodiversity in a changing world

Today, approximately 7.7 billion people exist on Earth, a figure expected to reach ~11 billion by 2100 (United Nations 2019). Human demand for food, energy and shelter is driving global land-use change at an unprecedented rate, 60% of which has been caused by agricultural conversion, resource extraction, infrastructural development and urbanisation over the last 35 years (Song et al., 2018). Indirect drivers of land-use change are responsible for the remaining 40%, such as increases in atmospheric carbon dioxide, surface temperatures, and ocean acidification (Steffen et al., 2015), in turn affecting the frequency of wildfires, landslides, glacial retreat, and disease (Song et al., 2018). Coupled together, the direct and indirect effects of human-induced land-use change are causing widespread declines in biodiversity through habitat loss and fragmentation, overexploitation, invasive species and pollution (Dirzo et al., 2014; Tilman et al., 2017). We are now experiencing what is considered Earth's sixth mass extinction event (Ceballos et al., 2017), with extinction rates thought to be over 1000 times what would exist without human impact (Pimm et al., 2014). It is estimated that, on average, approximately 13% of species diversity has been lost since 1500 (Newbold et al., 2015).

Over the next century, biodiversity loss is predicted to be further exacerbated by human population growth if the current trends continue unabated (Ceballos et al., 2017). The impacts will be greatest in biodiverse regions where demographic and economic growth are rapidly increasing, particularly Africa, Asia, and South America (Barlow et al., 2018; Steffen et al., 2015; Tilman et al., 2017). This is particularly concerning given that the world's most biodiverse regions are found in the tropical global South, which covers just 40% of Earth's surface, but provides habitat for 75% of amphibian species, freshwater and marine fish, ants, flowering plants, and terrestrial mammals, as well as harbouring six times more endemic bird species than in temperature regions (Barlow et al., 2018).

Biodiversity is critical, as it underpins the functioning of Earth's natural systems and the support they provide to humanity, which can be conceptualised as 'ecosystem services' (Millenium Ecosystem Assessment 2003). The human population therefore places itself in harm's way by jeopardising the myriad ecosystem service benefits provided by the natural world, and it is vital that effective conservation efforts and good environmental governance are employed to stem future biodiversity losses and secure a sustainable future (Rands et al., 2010; Tilman et al., 2017).

1.2 Global urbanisation

1.2.1 Implications of urbanisation for society

Approximately 54% of the world's human population currently live in urban areas (UN-Habitat 2016) and, by 2050, it is expected that figure will reach nearly 70% (United Nations 2018). People are migrating to cities across the globe, attracted by the prospect of wealth, education, and socioeconomic progress, or seeking refuge from natural disasters or war (UN-Habitat 2016). To accommodate general population growth, as well as this influx of rural-to-urban migrants, the land cover of cities is projected to grow 114% and 315% between 2000 and 2050 in the global North and global South respectively (Angel et al., 2011).

Certainly, cities can offer opportunities for knowledge sharing and education, adequate housing, better healthcare and social equality, thus facilitating development opportunities (United Nations 2018). Yet, poor urban planning and inadequately managed expansion can lead to severe overcrowding, pollution, and poor sanitation, characteristics typical of global South cities (UN-Habitat 2016). These factors can then enhance the vulnerability of urban areas to the effects of global environmental change (e.g. extreme weather events, sea-level rise, pandemics), particularly where risk-assessment and mitigation strategies are largely absent (Parnell et al., 2007; Capolongo et al., 2020; Ward et al., 2016). As human-induced climate change increases the frequency with which natural disasters affect cities, those with poor capacity for response and adaptation will be the worst hit (Parnell et al., 2007). For example, Neumann et al., (2015) note that while over one third of the world's population live near a coastline, the considerable need to counter the risk of sea-level rise has yet to be addressed. Moreover, the multiple stressors caused by living in cities can lead to a prevalence of physical (e.g. respiratory illnesses, cardiovascular disease) and psychological health disorders (e.g. anxiety, depression) amongst urban populations (Abbot 2012; Peen et al., 2010; World Health Organization 2016a). Managing these economic, societal, and environmental challenges in the face of rapid urbanisation requires effective policies, good local governance and leadership (UN-Habitat 2016).

1.2.2 Implications of urbanisation for biodiversity

Urbanisation can have detrimental consequences for biodiversity. Worldwide, urban expansion is leading to habitat loss and fragmentation (Liu et al., 2016), and it is anticipated that urban growth could threaten an additional 290,000 km^2 of natural habitat between 2000 and 2030 (McDonald et al., 2018). The associated edge effects, decrease in habitat patch sizes, and lack of connectivity between remnant fragments further contributes to ecological degradation and limits the ability of biodiversity to persist in urban areas (McDonald et al., 2018; Beninde et al., 2015). Moreover, as centres of international movement and commerce, cities facilitate the colonisation of invasive species that compete with native biodiversity, and can be both economically and socially problematic (Güneralp and Seto 2013; Gallardo 2014; Francis and Chadwick 2015).

The relationship between biodiversity conservation and urbanisation is multifaceted and complex (McDonald et al., 2018). Urban landscapes can be highly heterogeneous, due to the variety of land-uses and plant diversity at small spatial scales (McKinney 2008), providing a more diverse set of ecological niches and resources to support other biodiversity (de Oliveira and Mell 2019). As such, urban green spaces such as parks, gardens, cemeteries, allotments, riparian corridors, green roofs, roadside verges, and informal greenery can provide opportunities for biodiversity to thrive in city landscapes (Baldock et al., 2019; Aronson et al., 2017; Ives et al., 2016; Buchholz et al., 2016; Dallimer et al., 2012; O'Sullivan et al., 2017; Theodorou et al., 2020; Goddard et al., 2010), although the size and composition of features within green spaces remains a key factor (Beninde et al., 2015).

1.2.3 Urban ecosystem services and disservices

Conserving urban green spaces and biodiversity can have economic, societal and environmental implications (TEEB 2011), providing an improved quality of life for city residents (Luederitz et al., 2015; Elmqvist et al., 2013; McDonald et al., 2018).

Urban green spaces have been recognised by the World Health Organisation (WHO) as a critical centrepiece of urban design due to the contribution they make to human health (World Health Organisaion 2016b). Highlighting how urban biodiversity can benefit people living in cities is critical where local budget cuts and competing priorities for other land-uses take precedent over green space in planning and management decision-making (Abbot 2012; van den Bosch and Nieuwenhuijsen 2016).

Urban biodiversity provides a wide range of ecosystem services specific to cities, such as horticulture (provisioning), reducing pollution and improving air quality (regulating), and promoting tourism (cultural) (TEEB 2011). In the face of global environmental change, urban green spaces and biodiversity can act as a flood defence as, for example, vegetation can absorb rainfall that is deflected off impervious surfaces (e.g. buildings, roads) (Silvennoinen et al., 2017; Douglas 2016). Moreover, shade-giving trees and greenery can in some instances contribute to temperature cooling at local-scales, important during heatwaves and mitigating local urban heat-islands (Ward et al., 2016). Similarly, evidence is emerging to show that biodiversity can promote human immune function through hosting a high diversity of microbiota (Aerts et al., 2018).

Aside from the tangible benefits, urban biodiversity has been associated with ‘(re)connecting people with nature’ at a time when urban populations are increasingly devoid of nature experiences (Miller 2005; Soga and Gaston 2016). As a consequence, there is a growing literature on the relationship between nature connection and education, pro-environmental attitudes and behaviours, and human wellbeing (see section 1.3) (Rogerson et al., 2017; Colléony et al., 2017; Shwartz et al., 2014; Prévot et al., 2018; Martin et al., 2020). However, the evidence for nature connection is currently muddled by the plurality of concepts (i.e. what exactly constitutes ‘nature’, an ‘experience’, or a ‘connection’), thereby detracting from the scientific rigour and limiting the ability to make actual policy recommendations (Ives et al., 2017; Clayton et al., 2017). The idea is further complicated by the fact that some individuals fear or avoid nature (Bixler and Floyd 1997; Bonta 2008) (see section 1.4.4), and that people hold existence value for nature they have never experienced (Cooper et al., 2016). Neuteleers and Deliège (2019) argue that a far more valuable research approach would be to demonstrate the ‘objective, external benefits of nature experiences… constitutive of, rather than instrumental to, flourishing human life’.

A number of ecosystem disservices are also associated with urban green spaces and biodiversity. Urban green spaces may provide habitat for vectors of disease (e.g. mosquitoes, bats) (Zhao et al., 2020). In some parts of the world, green spaces can be feared for a number of reasons, including them being hotspots for criminal activity (Kondo et al., 2017), and harbouring specific species perceived as dangerous or unappealing (Bixler and Floyd 1997). The spatial distribution of urban green spaces can also enhance social inequalities through gentrification and the displacement of lower-income earners (Wolch et al., 2014). Understanding both the benefits and disbenefits underpinned by urban green spaces and biodiversity is thus fundamental to the sustainable design and management of cities.

1.3 Defining human wellbeing

Human wellbeing is a multidimensional concept encompassing different contributions to quality of life, including health, education, balance of time, political voice and governance, social connections, environmental conditions, personal insecurity and economic security (Stiglitz et al., 2010). In 2010, the global Multidimensional Poverty Index (MPI) was established to measure deprivation of three such quantities (health, education, and living standards) and so uncover where regional inequalities might lie (Alkire et al., 2019). More recently, the United Nations Development Programme (UN Development Programme) has called for more universal dimensions of inequality that consider people’s own subjective assessments of their lives, in harmony with the objective measures collected at national-scale (UN Development Programme 2019). Indeed, many of the traditional measures of human development (e.g. life expectancy, social support, corruption) correlate with evaluations of life satisfaction (Helliwell et al., 2016).

Dolan and Metcalfe (2012) argue that human wellbeing is comprised of three accounts: objective lists, preference satisfaction, and mental states (or ‘subjective wellbeing’). The objective measures collected by the MPI, for instance, are considered an objective list, while preference satisfaction can be measured through GDP. The third account, subjective wellbeing, is thought to be composed of evaluative wellbeing (satisfaction with life), experiential wellbeing (positive and negative affect or emotion), and eudaimonic wellbeing (a sense of purpose and meaning in life) (Dolan and Metcalfe 2012).

Policy-makers are increasingly recognising the need to measure subjective wellbeing, given the interplay between the three accounts. For example, evidence implies that past a threshold of meeting basic needs, increases in GDP do not lead to improved life satisfaction (Pretty et al., 2016; Diener et al., 2018), and high-GDP countries still face issues including unemployment, work-life balance, and low life-expectancy (OECD 2015). Indeed, it is increasingly accepted that GDP is an inadequate measure of economic and social progress (Stiglitz et al., 2010; Costanza et al., 2014; O'Neill et al., 2018). On the other hand, subjective wellbeing is generally comparable across the global North and South, despite variations across life courses, societies, and cultures (Dolan and Metcalfe 2012). Subjective wellbeing is also a determinant of mortality, with studies showing that high levels of wellbeing are associated with favourable survival rates in both healthy populations and those with pre-existing health conditions (Chida and Steptoe 2008; Steptoe et al., 2015), as well as adding between 6 - 10 years of life compared to individuals with low wellbeing (Diener and Chan 2011). As such, policy efforts are being made to measure subjective wellbeing at national-scale globally, from Bhutan (Karma-Ura et al., 2012) to the UK (OECD 2013). Global reports on 'happiness' have also been produced, most notably by the Gallup World Poll, which interviews 1000 adults each day (Helliwell et al., 2020). Nonetheless, policy-makers must consider that the three accounts of subjective wellbeing are theoretically distinct, and therefore their use (and scale of measurement) must be tailored to the context within which they are being applied (Dolan et al., 2016).

1.4 A theoretical basis for biodiversity-wellbeing relationships

An exponentially increasing breadth of evidence has shown that human subjective wellbeing (hereafter 'human wellbeing') improves in natural environments. Several dominant theories have been proposed to try to substantiate these findings, although biodiversity itself is rarely explicitly considered. However, there is now growing interest as to whether more biodiverse natural environments, rather than generic 'green space’, could be more beneficial to human wellbeing (Lovell et al., 2014; Aerts, et al., 2018; Botzat et al., 2016).

1.4.1 Cultural ecosystem services

While the concept of ecosystem services has been widely accepted by policy-makers worldwide, human wellbeing in the context of nature experiences is not included as a constituent (Bratman et al., 2019). Rather, ‘cultural ecosystem services’ (life-enriching and life-affirming contributions to people; Fish et al., 2016) and the benefits they provide, including identities (e.g. belonging, sense of place), experiences (e.g. tranquillity, freedom), and capabilities (e.g. health, knowledge), could be used as indicators of human wellbeing (Bryce et al., 2016; Fish et al., 2016). Despite biodiversity underpinning cultural ecosystem services (Cardinale et al., 2012) and human wellbeing (Bryce et al., 2016), the mechanistic pathways through which this takes place are still relatively understudied in comparison to provisioning, regulating and supporting ecosystem services (Sandifer et al., 2015).

1.4.2 Attention Restoration Theory

Attention Restoration Theory (ART) postulates that spending time in natural environments restores an individual’s ability to concentrate and focus attention, thereby improving memory, the ability to process information, and to solve problems (Kaplan and Kaplan 1989; Kaplan 1995). There are four experiential qualities that improve depleted attentional fatigue in natural environments, including ‘fascination’ (interesting stimuli that effortlessly attract attention), ‘coherence’ (arrangement of stimuli), ‘compatibility’ (conceived ability to carry out purposes freely), and ‘being away’ (distance from everyday tasks or those that demand directed attention), which together constitute ‘perceived restorativeness’ (Kaplan and Kaplan 1989; Kaplan 1995). Empirical evidence supports that a more biodiverse environment stimulates these qualities (Marselle et al., 2016; Carrus et al., 2015).

1.4.2 Stress Reduction Theory

Natural environments are thought to facilitate recovery from stress (i.e. physiological arousal, psychological stress, reduced negative affect, increased positive affect) in the Stress Reduction Theory (SRT) (Ulrich et al., 1991). Upon entering the natural environment, an individual experiences an initial emotive reaction, which influences their behavioural response and cognitive appraisal, leading to additional emotional and physiological responses (Ulrich 1983). The role of biodiversity in SRT has been explored by comparing species richness with specific physiological outcomes, showing more biodiversity is associated with enhanced positive affect, mood, arousal, and reduced physiological indicators of stress (Wolf et al., 2017; Cracknell et al., 2017; White et al., 2017; Marselle et al., 2016).

1.4.2 Biophilia Hypothesis

Kellert and Wilson (1993) posit that people are inherently ‘biophilic’, emotionally affiliated and drawn to natural environments throughout evolution. As such, genetic adaptations to these environments predisposes people to exhibit certain responses to specific stimuli, such as approaching water or avoiding snakes (the latter termed ‘biophobia’). There remains contention as to whether biophilia is too broad a concept to be considered as a specific explanation for how people experience natural environments, and whether biophobia is in fact a contradiction of the concept itself (Joye and de Block 2011; Clayton et al., 2017). Some studies claim biophilia explains findings such as preferences for aquariums containing a higher diversity of species (Cracknell et al., 2016), and preferences for more complex birdsong rather than single species singing (Hedblom et al., 2014).

1.4.2 Human perceptions

Preferences for specific attributes within a natural environment could contribute to human wellbeing, although preference itself is not considered to be a wellbeing outcome (Lovell et al., 2014). Kaplan and Kaplan (1989) propose that human preferences in a natural environment are structured by what information visitors seek (exploration or understanding) and the level of interpretation required to derive it (immediate or predicted). A ‘preference matrix’ is therefore dictated by ‘coherence’ (the arrangement of stimuli), ‘complexity’ (the number of different elements, such as biodiversity), ‘legibility’ (ease of understanding and memory), and ‘mystery’ (the promise of additional information) (Kaplan and Kaplan 1989). Aesthetic preferences for complexity reoccur in an inverse-U shaped manner, with moderately complex environments being the most preferred (Ulrich 1983; Kaplan and Kaplan 1989).

This theory of preference for mid-range complexity is supported by evidence from mathematical ecology. A fractal is a shape comprised of similar copies of the whole. Ecologists have determined that fractal geometry, the extent of which is measured by a D score, is indicative of the biodiversity that can be found in an environment, such as habitat complexity or species richness (Dibble and Thomaz 2009; Stevens 2018). A mid-range fractal D score is most prevalent in nature and species-rich habitats (Hägerhäll et al., 2015; Stevens 2018). Concurrently, mid-range D scores are aesthetically preferred (Bies et al., 2016; Spehar et al., 2003), aligning with theories that propose people prefer intermediate levels of complexity (Ulrich 1983; Kaplan and Kaplan 1989), as they simplify the ease with which a brain can process its surroundings (Joye et al., 2016).

Human perceptions of the environment could be influenced by memories, ideas, and conceptions (sense of place, i.e. place attachment, place identity, meanings) (Proshansky et al., 1983), which then affect the emotional state felt in the moment (positive or negative). Biodiversity in the environment can thus influence people's perceptions. For instance, if biodiversity is connected to certain spiritual beliefs, the site where it resides may be perceived as sacred (Gopal et al., 2019). However, the contribution biodiversity makes to a sense of place is much less understood (Hausmann et al., 2016).

Given that perceptions influence emotions, anywhere perceived as positive could result in wellbeing gains. Indeed, Seresinhe et al., (2019) showed that people are happier in locations they perceive to be scenic, even when those locations are urban rather than natural environments. Furthermore, people's perceptions do not necessarily align with what objectively exists, which additionally complicates efforts to understand how biodiversity relates to human wellbeing. For example, Dallimer et al., (2012a) found that butterfly and plant species richness was not positively related to human wellbeing, yet perceived species richness for these taxonomic groups was. In an experimental manipulation of green spaces, Shwartz et al., (2014) showed that although people preferred sites that were species-rich, they were unable to detect changes in richness of plants, birds, and pollinators after manipulation, and species richness was largely underestimated.

1.5 Aligning conservation and public health challenges

International, national, and local government support is required for the effective implementation of policies that support both biodiversity conservation and human wellbeing. These twin goals are brought together by the United Nation's Sustainable Developments Goals (SDGs), which advocate how a thriving society depends on the stability, function, and resilience of Earth's natural systems (Griggs 2013). Under the umbrella of the SDGs, the linkage between biodiversity and human wellbeing has also been endorsed by the World Health Organisation and Convention on Biological Diversity (CBD), stating that human health and wellbeing are basic human rights and essential to securing longer-term insurance and resilience for future generations (World Health Organisation and Convention on Biological Diversity, 2015). For cities facing the impacts of climate change, surging migration, and rising insecurity and inequality, strong governance in relation to Goal 11 to 'make cities and human settlements inclusive, safe, resilient, and sustainable' is essential (Satterthwaite 2016; UN-Habitat 2016; United Nations 2016) The International Union for the Conservation of Nature (IUCN) have promoted urban protected areas, arguing that alongside contributing toward urban ecosystem services, climate change resilience, and protection of vulnerable species, they also serve to reconnect vast numbers of visitors, who might then learn about and change their attitude toward nature (Trzyna et al., 2014).

For international agreements to be implemented, local authorities and urban planners and managers require detailed scientific evidence about how they can enhance, restore, and conserve biodiversity in urban green spaces for the benefit of human wellbeing. This need has resulted in a call from researchers to move 'beyond the green' (Marselle et al., 2015; Wheeler et al., 2015; Wood et al., 2018), and work toward identifying what specific characteristics might be enhancing (or detracting from) human wellbeing in urban areas to inform policy and practice. For instance, Southon et al., (2017) identified that people exhibited preferences for urban meadows rather than manicured plant beds and herbivorous borders. Urban blue spaces (e.g. ponds, lakes, canals, riparian waterways, coastline, sea defences, reservoirs) are also now receiving more attention, because they too can make a positive contribution to human wellbeing (Gascón et al., 2017; Higgins et al., 2019; Mcdougall et al., 2020). It is essential to explore both urban green and blue spaces in-depth to discover where win-win solutions for both biodiversity and human wellbeing can be achieved (Hartig and Kahn 2016).

There will be instances where biodiversity is detrimental to human wellbeing. For example, dense vegetation can be perceived as unsafe and therefore undesirable (Jansson et al., 2013). As such, a mismatch can exist between the biodiversity characteristics that conservationists seek to support, and those that actually have a beneficial influence on human wellbeing (Pett et al., 2016). By understanding how people perceive the world around them, we can better inform the design of urban spaces. While trade-offs will be necessary in the instances where people prefer biodiversity-poor environments, these will be lessened by uncovering instances where win-wins can be achieved (Adams 2014; Gobster et al., 2007). Ultimately, decisions about which attributes of the urban environment are to be conserved for what purpose will be influenced by people's individual motivations, but a balance must be struck between prioritising people or biodiversity (Dearborn and Kark 2010).

1.6 Transcending disciplines to interrogate research gaps

Examining the linkage between biodiversity and wellbeing requires drawing on multiple disciplines, including ecology, psychology, epidemiology, landscape architecture, and urban planning, as well as acknowledging the typical methods, terminology, and paradigms championed by each (Sandifer et al., 2015; Luederitz et al., 2015). In a recent review of nearly 18,961 articles on green space and public health, Zhang et al., (2020) demonstrate the increasing frequency with which urban design, geography, and multidisciplinary science are focussing on the topic, with keywords such as 'environment', 'climate change' and 'green space' now appearing more frequently. It is clear that transcending these disciplines is crucial to producing effective research that translates into solid evidence for policy and practice, given that the problems that face both people and biodiversity today are so interlinked (Bosurgi and Horton 2017; Giles-Corti et al., 2016). Through collaborations between different disciplinary experts, the myriad and synergistic biopsychosocial pathways through which green and blue spaces influence wellbeing have been made apparent, from the role of social cohesion and physical activity to microbial biodiversity (Hartig et al., 2014; Markevych et al., 2017).

Conservation scientists are increasingly working with psychologists to understand human behaviour and its impact on the environment (Saunders et al., 2006; Selinske et al., 2018). Bennett et al., (2016) argue the term ‘conservation social science’ should be used in reference to the diverse branches of social science that can be harnessed for improved conservation policies and outcomes. Intriguingly, the frequency with which conservation journals have published research on green space and public health has tailed off in the past decade, despite the fact that biodiversity is a core attribute in the research agenda (Zhang et al., 2020). While this may reflect the rising prevalence and impact of multi/interdisciplinary research journals, it further emphasises how biodiversity conservation has not been given due consideration in the research agenda of late, despite its central role in the subject matter.

For scientific evidence to effectively translate into policy and practice that benefits both biodiversity conservation and human wellbeing, research must involve a diversity of stakeholders, including members of the general public, government urban planners and decision-makers, various third sector organisations with different remits (e.g. conservation, development), as well as scientists (from multiple disciplines) (Larson et al., 2016; Parris et al., 2018). Indeed, stakeholders must be properly engaged for planning or public health interventions to be effective, which can be hindered by differences in spoken and written language, the use of convoluted scientific terminology, and conflicting objectives (Rose et al., 2020). One way to involve diverse stakeholders and overcome some of these barriers is through participatory and co-research methods, which can help build trust and produce knowledge that is sympathetic to the people it involves (Sterling et al., 2017; Larson et al., 2016; Rose et al., 2020).

1.7 Biodiversity and wellbeing in South America

Biodiversity-wellbeing research encompasses a vast geographical bias toward the global North (Botzat, Fischer and Kowarik 2016; Keniger et al., 2013; Hossain et al., 2020; McMahan and Estes 2015; Zhang et al., 2020), as does the existing literature on urban ecosystem services (Luederitz et al., 2015). This is a significant issue given that the fastest rates of biodiversity loss, population growth, and urbanisation are taking place in the global South (Steffen et al., 2015; Seto et al., 2012). This bias is also likely to have skewed our interpretation of the evidence, as the patterns uncovered in other parts of the world are likely to vary based on differences in climate, culture, demographics, disease, and biodiversity (amongst other factors) (Markevych et al., 2017).

South America is globally important for biodiversity, with Amazonia containing the world's most diverse rainforest (Jenkins et al., 2013; Antonelli et al., 2018). Simultaneously, the continent is expected to undergo the world's largest urban expansion into biodiverse ecosystems (Güneralp and Seto 2013), with the smallest cities growing fastest (Andrade-Núñez and Aide 2018). Altogether, cities in South America are home to 81% of the continent's population (United Nations 2018), typically exhibit extreme social inequality, and are often characterised by a mosaic of sprawling informal settlements on ecologically important habitat such as riparian corridors (Pauchard and Barbosa 2013). In these regions, poor local governance and lack of financial resources are likely to exacerbate the negative impacts on biodiversity (Güneralp and Seto 2013). To date, there has been very little research on urban ecology or human wellbeing in South America (Pauchard and Barbosa 2013). The research presented in this thesis is therefore timely, with important implications for both public health and biodiversity conservation.

1.7.1 Biodiversity in Guyana

The Guiana Shield in northern South America is a biodiversity-rich expanse of ~1.3 million km^2 of intact tropical forest (26% of Amazonia) (Bovolo et al., 2018; Antonelli et al., 2018). The Guiana Shield plays a pivotal role in the climatic regulation of the entire continent, but is increasingly threatened by extractive industries (gold mining, deforestation) (Bovolo et al., 2018). Of the six countries that comprise the Guiana Shield (northern Brazil, southern Venezuela, eastern Colombia, Guyana, Suriname, and French Guiana), Guyana sits at its centre and is of comparable size to the UK, but is composed of nearly 85% tropical forest (Figure 1.1a).

Figure 1.1: (a) Location of Guyana in northern South America, (b) location of Georgetown, capital of Guyana, and (c) green spaces (green), waterways (blue lines), and impervious surfaces (i.e. buildings, roads) (grey) across the city. Photographic images from specific sites in the city, include (i) the sea wall, (ii) a waterway, (iii) a tree-lined avenue, and (iv) the Botanical Gardens. Images (i), (iii), and (iv) taken by Meshach Andre Pierre, (ii) by Ralph Blackburn.

The government of Guyana has promised to meet international commitments on biodiversity conservation through its Green Economy Development Strategy, in part funded by a Reducing Emissions from Deforestation and forest Degradation (REDD+) financial agreement set up with Norway in 2010 (Bicknell et al., 2017). This agreement requires that deforestation is maintained below 0.45% per annum and supports sustainable economic development. To help meet these targets, Guyana has a system of protected areas that are overseen by the government's Protected Areas Commission (PAC) (Protected Areas Commission Guyana, 2016). The network includes two urban green spaces (the National Park and Botanical Gardens) within the capital city, Georgetown.

Georgetown sits at the confluence of the Demerara River and Atlantic Ocean (Figure 1.1b). Once referred to as the 'Garden City of the Caribbean' (Edwards et al., 2005), it has numerous urban green spaces and an extensive network of waterways, the latter established during Dutch colonisation in the 19th century and maintained thereafter (Mycoo 2014) (Figure 1.1c). The city sits below sea level and is protected from the Atlantic Ocean by a long sea wall to the north of the city. As a wetland, Georgetown's urban green (e.g. urban parks, cemetery, university grounds, informal green spaces) and blue spaces (e.g. waterways and riparian corridors, coastline, ponds, open drainage systems) provide important habitat for avian biodiversity, with both endemic and species of conservation concern recorded in the city (Hayes et al., 2019). Just under 300 species of birds have been documented in the Botanical Gardens alone (eBird 2017). A population of West Indian manatees (*Trichechus manatus*) reside in the waterways of both the National Park and Botanical Gardens, introduced by British colonies in the late 19th century originally to clear aquatic vegetation from the waterways (Adimey et al., 2012), although they do not continue to serve this function today. Elsewhere in Georgetown, species of snake, frog, mongoose, opossum and cat, as well as feral dogs and domesticated animals including horses and cows, can be found. A population of caiman (*Caiman crocodilus*) are resident in the University of Guyana campus. Additionally, anecdotal evidence implies that exotic pets such as tamandua, toucan, and sloths are occasionally released into the Botanical Gardens, and there are reports that anaconda and caiman can be found in its waterways. People's attitudes toward urban biodiversity are highly variable, although no published reports on Georgetown exist. Some residents harvest fish and snails from the canals as a food resource (*pers. obs.*). People are fearful of both venomous and non-venomous snakes, as well as frogs, while attitudes toward feral dogs and horses are generally mixed (*pers. obs.*). A piece in the state-run newspaper commented on one of Georgetown's forest fragments as '…*infested with reptiles and creatures of all descriptions… a home for some dangerous species of animals, and a health hazard*…' (Mahipaul 2016). This fragment was subsequently paved over and now exists as a largely concrete structure used for independence celebrations and occasional music events.

The main objectives set out by the Protected Areas Act of the Guyanese government include the need to 'recognise the intrinsic values of biological diversity and its components', and to 'conserve biodiversity, ecosystem services, and ecosystems representative of all of Guyana's natural land and seascapes' (Protected Areas Commission Guyana, 2016). The local government department that holds jurisdiction over urban green spaces, PAC, is promoting their cause across Guyana's urban areas. Indeed, their strategy recognises the importance of urban green spaces for recreation, interacting with biodiversity, educating the public about Guyana's natural heritage, and tourism (Protected Areas Commission Guyana, 2016). Financed by the German Development Bank, the Cooperative Republic of Guyana, and more recently ExxonMobil, there are plans to improve Georgetown's urban green spaces via the 'Three Parks Initiative' (Protected Areas Commission Guyana, 2016). Plans currently include additional lighting, interpretation boards, advertisements, improvements to canal fortification and flood protection, bridges, capacity building, increased security patrol personnel, and new car parks. While these changes are beneficial for encouraging visitation to Georgetown's green spaces they do not, however, explicitly consider conserving, enhancing, or restoring the biodiversity that can be found in the city. Furthermore, no evidence thus far has ascertained whether visiting the city's urban green and blue spaces actually relates to improved human wellbeing. Understanding the interplay between human wellbeing, biodiversity, and specific features of Georgetown's urban green and blue spaces is therefore needed, and could result in multiple co-benefits.

1.7.2 Society in Guyana

Guyana has a small population of 782,766, which has remained relatively stable since 1980 (World Bank 2020), recording high levels of youth unemployment and emigration (Mycoo 2017). The magnitude of the latter, which results from a lack of employment opportunities, poor salaries, and political insecurity, has led to significant financial remittances from the Guyanese diaspora contributing toward the country's economy (Roberts 2009; Commonwealth Secreteriat 2015). Economically unified and culturally aligned with fifteen Caribbean nations as part of the Caribbean Community (CARICOM), Guyana now scores 0.6 on the UNDP Human Development Index as a lower-middle income country (UN Development Programme 2019). Economic inequality remains stark, visibly so in the capital city Georgetown. Here, the population stands at ~191,810 (Bureau of Statistics 2012), and is divided into 63 neighbourhoods (wards) typically characterised by socioeconomic status and ethnicity (Edwards et al., 2005; Mycoo 2017). As a result of several divergent periods of colonialisation, the Guyanese demographic is now a rich mosaic of ethnicities, primarily indigenous (Amerindian), African, East Indian, Portuguese, Chinese, and Mixed heritage (Bureau of Statistics 2012)

Guyana is rarely included on international reports on global wellbeing (Helliwell, et al., 2016; Helliwell et al., 2020; Graham et al., 2018), despite being reported in 2014 to have the highest global suicide rate, particularly among adolescents and in rural areas (Arora and Persaud, 2019; WHO, 2014). The prevalence of psychological health disorders among Guyanese is thought to be socially, culturally, and economically rooted, with significant societal stigmas attached to those exhibiting poor mental health, which prevents help being sought (Nicolas et al., 2020). Although some mental health support and resources exist in Guyana, the system remains in its infancy (Ministry of Health Guyana 2013). In the global North, nature-based interventions (promoting experiences in nature for mental and physical wellbeing) and social prescribing, are being championed (Drinkwater 2019; Shanahan et al., 2019), in particular within urban environments (van den Bosch and Ode Sang 2017). No such initiatives have been documented or explored in Guyana to date.

In 2018, a study found that people living in households that had experienced flooding on Guyana's coastline reported a greater prevalence of mental health disorders (Akpinar-Elci et al., 2018), suggesting that the wellbeing of Guyana's coastal inhabitants is intrinsically linked to the environment. With just under half Guyana's population living within 5 km of the coastline and at risk from sea-level rise induced by climate change (Mycoo 2017), there is a need for nature-based interventions to prevent further economic and societal damage. For instance, Guyana possesses 1,262 km^2 of mangrove forest (Alder and Kuijk 2009), which has been recognised by the Guyanese government, as well as conservation organisations (e.g. Conservation International Guyana), as important for flood protection, food security, and habitat for biodiversity (Parliament of Guyana 2010). As such, conserving these forests will likely also benefit the mental wellbeing of the coastal population.

The Government of Guyana is committed to sustainable economic development through the Green State Development Strategy, within which it considers 'human development and wellbeing' to be one of seven central themes (UN Environment Programme 2017). However, recent discoveries of vast quantities of offshore petroleum are set to convert Guyana into the highest GDP per capita country in South America (Panelli 2019). While political instability, corruption, and poor developmental infrastructure are likely to prohibit the smooth flow of capital, the transformation of Guyana's economy will be significant, with impact on agriculture, housing, and transportation (Panelli 2019). Whether Guyana's future economic development can follow sustainable principles, paradoxically financed by the fossil fuel industry, remains a challenge. For Georgetown, housing and infrastructural demand will likely lead to urban sprawl into the agricultural lands southeast of the city.

1.8 Thesis outline

Given the existing knowledge gaps surrounding urban biodiversity-wellbeing relationships in the global South, this thesis aims to explore how biodiversity in green and blue spaces relate to several dimensions of human wellbeing in the capital city of Guyana, Georgetown. This is done by capturing both objective measurements of specific attributes, as well as people's perceptions. The research is the result of a collaboration with the PAC and two conservation non-governmental organisations (WWF Guyana and Conservation International Guyana). The findings reported in the thesis have implications for sustainable land-use planning, urban management, and the optimisation of targeted public health campaigns.

Chapter 2 tests for a dose-response relationship between patterns of visitor use to urban green and blue space with four types of psychological wellbeing, and examines whether individual demographic characteristics or motivations affect visitation patterns.

Chapter 3 explores whether objective measures of bird diversity are related to psychological wellbeing in the moment, comparing green with coastal blue spaces directly. This is the first time biodiversity-wellbeing relationships have been explicitly tested *in situ* in a global South city to our knowledge, and the first time green and coastal blue spaces have been compared.

Chapter 4 employs the same methodology as **Chapter 3** but, instead, assesses people's perceptions of specific characteristics in green, blue, and dense urban spaces in Georgetown, and how these perceptions relate to wellbeing *in situ*.

Chapter 5 triangulates the findings in **Chapters 2, 3, and 4** through a participatory video project, which aimed to understand in-depth how Georgetown's green and coastal blue spaces affects participants' wellbeing. The project concluded with a film that summarised all content being screened to decision-makers (government ministries, park managers, the Mayor and City Council), who then articulated their intentions to change the way these spaces were managed for human wellbeing.

Chapter 6 provides a synthesis the findings from across the thesis, highlighting the empirical contributions made to the research field. I also discuss how they can be applied to policy and practice in Guyana, while extrapolating how they relate to biodiversity-rich cities across the global South. Throughout, some suggestions for future research directions are made.

Chapter 2. A dose of urban nature for human wellbeing in a neotropical city: understanding who visits urban green and blue space and why

Jessica Claris Fisher[1], Jake Emmerson Bicknell[1], Kate Nesbitt Irvine[2], Damian Fernandes[3], Jayalaxshmi Mistry[4], Zoe Georgina Davies[1]

[1] Durrell Institute of Conservation and Ecology (DICE), University of Kent, Canterbury CT2 7NR, UK

[2] Social, Economic and Geographical Sciences, James Hutton Institute, Craigiebuckler, Aberdeen AB15 8QH, UK

[3] Conservation International Guyana, 98 Laluni St, Georgetown, Guyana

[4] Department of Geography, Royal Holloway University of London, Egham Hill, Egham TW20 0EX, UK

Manuscript published as:

Fisher JC, Bicknell JE, Irvine KN, Fernandes D, Mistry J, Davies ZG. 2021. Exploring how urban nature is associated with human wellbeing in a neotropical city. Landscape and Urban Planning 212: 104119

2.1. Abstract

Human population growth and urbanisation are putting pressure on green and blue spaces in cities worldwide. These spaces provide habitat for biodiversity and, as we know from evidence from the global North, can provide health and wellbeing benefits to urban dwellers. Nonetheless, there is a paucity of evidence regarding the wellbeing benefits associated with urban green and blue spaces from the global South, where the fastest rates of population growth and urban expansion are occurring. Specifically, we examine whether frequency and duration of green and blue space use in Georgetown, Guyana, relates to: (1) nature-relatedness, safety concerns, or sociodemographic background characteristics, (2) visit motivations, and (3) wellbeing (positive and negative experiential, evaluative, eudaimonic, and mental wellbeing). Participants were more likely to visit green and blue spaces if they had higher nature-relatedness, had no personal safety concerns, were aged < 35 years old, and educated above secondary level. Visit frequency was not related to wellbeing. Visits to urban green or blue spaces of more than 30 minutes were associated increased positive experiential wellbeing. No comparable patterns were found for the other wellbeing dimensions. Visit duration did not differentiate according to visit motivations. Decision-makers should ensure the equitable distribution of green and blue spaces throughout the city to support wellbeing, including the provision of backyards. Not only should new spaces be incorporated into future development plans, but existing spaces could be enhanced by reducing people's safety concerns and encouraging older people to visit to maximise wellbeing across all sectors of society.

Keywords: Cultural ecosystem service; Exposure; global South; Mental health; Motivations; Nature-relatedness.

2.2. Introduction

By 2050, the human population living in cities is expected to double, reaching 5.6 billion people globally (United Nations 2018). Less-developed regions in the global South are expected to account for 87% of this total urban population (United Nations 2018), with the concomitant expansion of urban landcover projected to grow by 585% between 2000 and 2050 (Angel et al., 2011). As a result, there are increased pressures on the persistence and quality of urban green and blue spaces (e.g. parks, riversides, gardens) (Pauchard et al., 2006; Richards et al., 2017), which provide habitat for biodiversity (Baldock et al., 2015; Ives et al., 2016). Simultaneously, there is recognition across the global North that green and blue spaces also provide benefits for human health and wellbeing (World Health Organization 2016), although scant evidence exists from the global South (Rigolon et al., 2018). The provision of '*universal access to safe, inclusive, and accessible green and public spaces*' is now explicitly recognised in Sustainable Development Goal 11 (United Nations 2016). As such, there is a need to understand the role urban green and blue spaces play in underpinning human wellbeing in the global South, to inform sustainable land-use planning interventions that help tackle ecological and public health demands in the face of global environmental change.

Currently, cities in the global South are characterised by high levels of inequality and unequal provision of public green and blue space (UN-Habitat 2016). Understanding how patterns of use vary amongst different sociodemographic groups can provide insight into where these inequalities lie. For example, in Sweden, Ode Sang et al., (2016) showed women were more active in urban green spaces, and older people participated in more nature-related activities. In contrast, a UK-wide survey showed infrequent users of green spaces were more likely to be women, and older individuals (Boyd et al., 2018). What determines who, but also why, people visit urban green and blue spaces is important to elucidate patterns of use, and highlight locally specific nuances. For instance, when examining visit motivations for using green space in Colombia, users report seeking shade from the tropical sun (Ordóñez-Barona and Duinker 2014), while in the USA, users simply mention they are motivated by the close proximity of the green space (Sonti et al., 2020). Capturing the sociodemographic characteristics of green and blue space users (and non-users), as well as their visit motivations, can subsequently be used to target interventions that overcome barriers to use and encourage visitation (Irvine et al., 2013; Dallimer et al., 2014).

Understanding the frequency of use or duration of time that people need to spend visiting urban green and blue space to make quantifiable wellbeing gains is important for informing policy recommendations. Several dimensions of human wellbeing have been outlined: positive and negative experiential (emotions of pleasure and pain), evaluative (assessment of life as a whole), and eudaimonic (purpose and meaning in life) (Stiglitz et al., 2010). Increased visit frequency to natural environments relates to higher eudaimonic and positive experiential wellbeing (White et al., 2017), and spending at least 120 minutes of time in nature relates to improved evaluative wellbeing (White et al., 2019). Scales with clinical relevance have also been used in a dose-response context. For instance, the World Health Organisation WHO-5 mental wellbeing scale can be translated as a screening tool for depression (Topp et al., 2015). Using WHO-5 as a wellbeing outcome, Garrett et al., (2019) suggest that visiting blue spaces for recreation relates to a statistically lower risk of depression. Taken together, gauging the frequency and duration of use, or 'dose', alongside contextually and clinically relevant measures of wellbeing can help structure public health recommendations to maximise their efficacy.

A dose of nature may be dependent on geographical location, cultural relevance, or other factors that dictate how people derive wellbeing benefits from visiting green and blue spaces (Bell et al., 2019). These could include where people have grown up (Engemann et al., 2019), their perception of safety (Weimann et al., 2017), or how connected they are with nature (Shanahan et al., 2016). Measures of nature-relatedness, for example, have correlated with improved wellbeing (Nisbet et al., 2011), and reduced anxiety (Martyn and Brymer 2014), as well as positive attitude toward the environment, engagement with sustainable practices (Nisbet et al., 2009), and more visitation to green space (Lin et al., 2014). As such, considering these factors in the study of urban green and blue space use for human wellbeing will help capture the variability of experiences and help target any recommendations that arise (Ives et al., 2017).

The aim of this study was to explore the relationship between urban green and blue space for human wellbeing in a city in South America, a continent forecast to undergo the fastest rate of urban expansion into biodiversity-rich regions (Güneralp and Seto 2013). Subsequently, demonstrating the importance of urban green and blue spaces for human wellbeing could have knock-on benefits for biodiversity (Pauchard and Barbosa 2013). As a nation, Guyana, northern South America, is characterised by the fact that over 85% of its landcover remains tropical forest (Bicknell et al., 2017). High levels of bird diversity can also be found in the urban green and blue spaces of its capital city, Georgetown (Hayes et al., 2019). Guyana is set to become South America's fastest growing economy, propelled by the discovery of large petroleum deposits (Panelli 2019). However, simultaneously, the country has the highest global suicide rate (World Health Organization 2014). Therefore, this is a timely opportunity to highlight how sustainable land-use planning interventions, incorporated into new development plans for Georgetown, could positively contribute to both public health and conservation. We examine the role of Georgetown's green and blue spaces for the wellbeing of its residents through three main research questions: (1) Do nature-relatedness, safety concerns, or sociodemographic characteristics determine visit frequency and visit duration? (2) Do visit frequency and visit duration depend on the motivations for visiting green and blue spaces? (3) Do visit frequency or visit duration relate to human human wellbeing? To our knowledge, this is the first study from a developing city in the global South, to explore what motivates people to visit urban green and blue spaces, and whether a dose-response pattern exists between five dimensions of human wellbeing (positive and negative experiential, evaluative, eudaimonic, and mental wellbeing), and patterns of use.

2.3. Methods

2.3.1 Study design

Georgetown, capital of Guyana (Figure 2.1), has a human population of ~192,000 spread across 63 wards (neighbourhoods) (Bureau of Statistics, 2012). There are public outdoor spaces distributed across the city, including public parks, gardens, and a sea wall along the Atlantic coast. There is also a dense network of waterways throughout the city that are heavily vegetated in parts. Many residential properties have small backyards.

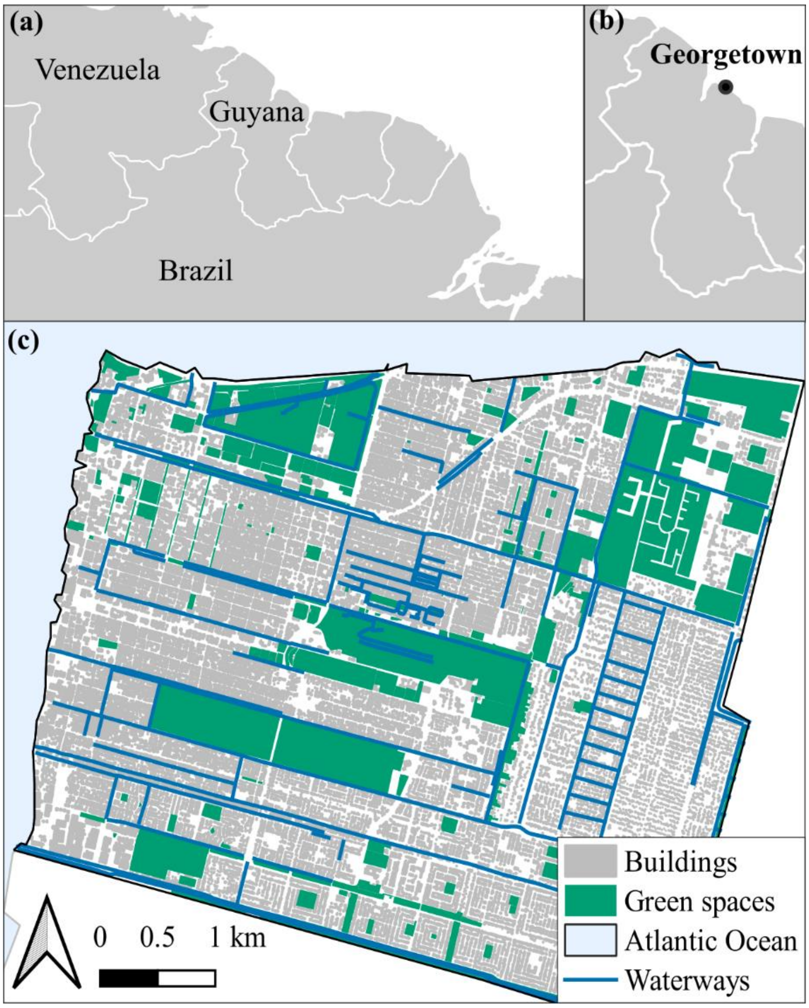


Figure 2.1: (a) Location of Guyana in northern South America, (b) location of Georgetown, capital of Guyana, and the distribution of (c) green spaces (green), waterways (blue lines), and impervious surfaces (i.e. buildings, roads) (grey) across the city

2.3.2 Questionnaire

A short questionnaire was conducted face-to-face, during daylight hours (9am to 6pm), in May-June 2017. The questionnaires were delivered in public locations, such as markets and malls, frequented by a wide range of socioeconomic groups. Participant numbers were monitored throughout the data collection period to ensure that the sample from each ward in Georgetown broadly matched the proportions from the most recent census (Bureau of Statistics, 2012) (see Table S2.1 in supplementary material).

Every third passer-by was approached, and first asked if they lived in Georgetown. If the response was affirmative, participants were invited to take part in a survey on what Georgetown residents thought about outdoor spaces in town. No monetary or other incentive was offered to secure participation. Individuals that declined to participate were recorded as non-respondents. The questionnaire was cognitively tested and piloted to ensure that it was understandable by all sectors of the population. Show cards were used throughout the questionnaire, following best practice for collecting wellbeing data (OECD 2013), allowing participants to consider and select answers. The study was approved by the University of Kent Faculty of Social Sciences Research Ethics Advisory Group for Human Participants (Ref. No. 0511617).

Participants were asked to identify how happy they felt yesterday (positive experiential, 'happiness') and how anxious they felt yesterday (negative experiential, 'anxiety'), how satisfied they feel about their life in general (evaluative, 'life satisfaction'), and the extent to which they feel the things they do in their life are worthwhile (eudaimonic, 'worthwhileness') (see supplementary text Section S1). While the first two questions focus on 'yesterday' specifically, which may not be a typical day for a participant, these measures are generally found to reliably reflect happiness and anxiety across the entire year (Graham et al., 2018). All responses were given on a continuous 11-point scale from 0 (*Not at all*) to 10 (*Completely*) (ONS 2016).

We also used WHO-5 (WHO, 1998) to capture and assess mental wellbeing. For each of five statements, participants indicated how they have felt over the past seven days on a six-point scale (1 = *At no time*, 2 = *Some of the time*, 3 = *Less than half the time*, 4 = *More than half the time*, 5 = *Most of the time*, 6 = *All of the time*) (Table S2.2). One of the statements used the word '*vigorous*', which caused confusion during testing and was replaced by '*energetic*'. The reference time frame was shortened from '*two weeks*' to '*the last seven days*' to reduce recall bias and align with data collected on green space use (see below). Scores for each statement were totalled to generate a raw overall score, ranging from five to 25, and multiplied by four to create a percentage. We calculated Cronbach's alpha to verify that the scale was internally consistent (α = 0.78).

We used the six-item Nature-relatedness (NR6) scale (Nisbet and Zelenski 2013) to measure connectedness with the natural world (Table S2.3). For each of six statements, participants gave an answer from one to five (1 = *Strongly disagree,* 2 = *Disagree a little,* 3 = *Neither agree nor disagree,* 4 = *Agree a little,* 5 = *Strongly agree*). All statement scores were averaged to create a continuous score ranging from one to five. NR6 was internally consistent ($\alpha = 0.77$).

We asked participants '*Which public spaces, if any, did you purposefully visit or spend time in over the last seven days*?', with examples provided (e.g. *city parks, sea wall, waterways, recreational spaces, or your own backyard*). For each space reported, we collected a categorical measure of visit frequency during the week (*Once, 2 – 3 visits, 4 – 6 visits, 7 or more visits*), and we asked '*What was the main reason for visiting*' (open question) and the average duration of time spent there (minutes). From this, we calculated weekly patterns of visit frequency, visit motivation, and estimated visit duration in minutes (midpoint of the visit frequency category multiplied by the average time spent visiting summed for the seven days). We collected the same information for any visits to '*the outdoors, or the bush*' outside of Georgetown, during the same week.

Participants were asked whether they were concerned about their personal safety in any of Georgetown's green or blue spaces (*yes* or *no*). Sociodemographic questions, comparable to the Guyana census (Bureau of Statistics 2012), and information about household income were included in the final section of the questionnaire. Participants were also asked where, if anywhere, they had lived prior to Georgetown. Two categories of 'residential history' were then derived from this data: (1) Georgetown only (entire life spent in Georgetown), or (2) other (time spent living in rural Guyana, or living abroad).

2.3.2 Data analyses

All statistical analyses were performed using R version 3.5.0 (R Core Team 2019). We first used a G-test to assess whether the sociodemographic background of our sampled participants was representative of Georgetown's wider population. We checked for associations between nature-relatedness, safety concerns, and sociodemographic characteristics (age, gender, ethnicity, education, household income, residential history) prior to modelling, using chi-squared tests for categorical variables, removing those that were associated to reduce inflated variance. We subsequently retained nature-relatedness, safety concern (yes or no), and dichotomous measures of age (< 35 years old or > 35 years old), education (low, defined as up to secondary, or high, post-secondary and above), gender (male or female), and residential history (Georgetown only, or other).

To examine whether nature-relatedness, safety concerns, or any particular sociodemographic background characterised visit frequency to green and blue spaces within Georgetown, we used a multinomial logistic regression model. For visit duration, a high proportion of the data contained zeros (non-users; 43.8%), so we used a hurdle model (Zeileis et al., 2008) ('pscl' package; Zeileis et al., 2008). This fits a binary logistic regression for zero counts, and a negative binomial regression for positive counts. We used the natural logarithm +1 for visit duration (rounded to the nearest whole number to reduce estimation errors) to normalise the residuals in the hurdle model. The hurdle model was better placed to manage the zero-inflated data than the negative binomial regression model (Vuong non-nested likelihood ratio tests: $z = -28.895$, $p < 0.001$). Goodness-of-fit was tested using rootograms (Kleiber and Zeileis 2016), and variance inflation factors presented no multicollinearity issues (VIF < 1.06).

To investigate motivations for visiting green and blue spaces, we looked at all the individual visits people had made and coded whether they were to green (e.g. park, backyard) or blue space (e.g. sea wall, waterways). We then conducted a content analysis of the qualitative visit motivations, classifying them into codes, before grouping the coding into themes, and domains (Table S2.4), using an adapted existing typology (Irvine et al., 2013). The coding was conducted independently by two authors (JCF, KNI), who showed high levels of agreement (Kappa = 0.68, $p < 0.01$). The points of disagreement were subsequently coded iteratively between the two authors. Decisions on coding were further informed by the space the participant was visiting (e.g. sea wall, backyard), and the frequency and duration of the visit. We tested for differences in visit motivations at the domain level due to sample size limitations. Kruskal-Wallis tests were used to assess associations between log visit duration and visit motivations, with Dunn's tests (Dunn 1964) to explore differences post-hoc, with *p* values adjusted for multiple comparisons. Wilcoxon rank-sum tests were used to compare the duration of visits to green versus blue spaces, for each motivation.

To assess whether visit frequency or log visit duration related to human wellbeing, we created ordinal logistic regression models for each of our four wellbeing outcomes (happiness, anxiety, life satisfaction, worthwhileness). We tested visit frequency and log visit duration as predictors in separate models as the latter was constructed from the former, and so inflated the variance. Models were adjusted for nature-relatedness, safety concerns, and sociodemographic characteristics (age, education, residential history). Due to the skewed distribution of the ordinal wellbeing outcomes, all models used the complementary log-log link function (probability of a high category is higher), and the cauchit link function for anxiety (higher probability of extreme values). We also checked our results for robustness by dichotomising the wellbeing scales around the median (below the median, or equal to and above the median), and modelled them using binomial general logistic regressions, following White et al., 2017. As the findings from both approaches were consistent, only the ordinal logistic regressions models are reported. For the ordinal regression models, we ensured the proportional odds assumption was not violated using the Brant test (Schlegel and Steenbergen 2018). Goodness-of-fit was then assessed using Lipsitz, Hosmer-Lemeshow, and Pulkstenis-Robinson chi-squared and deviance tests (Fagerland and Hosmer 2016). A generalised linear model was used for mental wellbeing (WHO-5) as an outcome with a negative-binomial error structure due to over-dispersion, assessed using model adequacy statistics in R (Harrison et al., 2018). Variance inflation factors presented no issues of multicollinearity in the remaining covariates for the visit frequency models ($VIF < 1.10$) and the log visit duration models ($VIF < 1.08$).

For the multinomial logistic regressions, hurdle model, ordinal logistic regressions, and negative-binomial generalised linear model, we standardised the models and model averaged using Akaike Information Criterion (AICc) for smaller sample sizes (Burnham and Anderson 2002) in the ‘MuMIn’ R package (Bartoń 2018). We averaged models across $\Delta AICc < 2$ (the difference between each model and the best model). We used this stringent threshold to reduce model selection to only those with substantial support. This higher level of certainty is important as the dose-response relationships identified could have important public health implications. Model averaged coefficients and corresponding 95% confidence intervals (CI) were used to calculate odds ratios. Log visit duration was then untransformed and plotted to visualise an easy to interpret dose-response curve.

2.4 Results

A total of 512 questionnaires were completed, with a response rate of 71% (n = 211 non-respondents). The sample was 52% female, 53% under the age of 35 years old, and was representative of the city's population according to Georgetown's most recent census (Bureau of Statistics 2012) (Table S2.5). Just under half the participants (47%) were educated up to secondary school level. A large proportion (78%) were concerned about personal safety in Georgetown's green and blue spaces. Just over half the participants (56%) had lived in Georgetown their whole lives, while 44% had either lived in rural Guyana or abroad. The mean nature-relatedness score for participants was 3.96 (SE = 0.04).

We excluded any participants who had made visits only, or in addition, to green or blue outside of Georgetown in the last seven days, as we were interested in the effect of Georgetown's green and blue spaces specifically. After rows containing missing values were removed, a total of 431 participants remained, who had either not visited any green or blue spaces in the past seven days (non-users, n = 212), or had visited spaces just within the city, including personal backyards (users, n = 219). Across the whole sample, the distribution of wellbeing was right-skewed for happiness, life satisfaction, worthwhileness, and mental wellbeing, and left-skewed for anxiety (Table 2.1).

Table 2.1: Summary of wellbeing scores from 431 participants responding to a questionnaire in Georgetown, Guyana about green and blue space use (n = 219 users, n = 212 non-users). Five measures of wellbeing were used. Happiness, anxiety, life satisfaction, and worthwhileeness are ordinal (median, range), while mental wellbeing is continuous (mean, standard error)

Wellbeing measures	Total sample	Users	Non-users
Happiness (Positive experiential)	8 (0 – 10)	8 (0 – 10)	7 (0 – 10)
Anxiety (Negative experiential)	5 (0 – 10)	5 (0 – 10)	4 (0 – 10)
Life satisfaction (Evaluative)	7 (0 – 10)	8 (0 – 10)	7 (0 – 10)
Worthwhileness (Eudaimonic)	8 (0 – 10)	8 (0 – 10)	8 (0 – 10)
Mental wellbeing (WHO-5)	64.25 (0.94)	65.61 (1.34)	62.62 (1.51)

2.4.1 Do nature-relatedness, safety concerns, or sociodemographic background characteristics determine visit frequency and visit duration?

The odds of visiting a green or blue space once, as opposed to not at all, increased significantly for participants who reported higher nature-relatedness (Table 2.2). Moreover, there were significantly higher odds of visiting more frequently if participants had no concerns for their personal safety. By contrast, those aged 35+ years old were significantly less likely to visit than younger participants. Gender, education, and residential history were not important predictors as they were not represented in the model set.

Table 2.2: Model-averaged (ΔAICc < 2 model set) odds ratios (OR) and 95% confidence intervals investigating whether sociodemographic background characteristics (nature-relatedness, safety concern, gender, education, residential history, age) predict visit frequency to green and blue spaces in Georgetown (multinomial regression) (n = 431). The odds ratio is significant if the confidence intervals do not cross 1 (bold values), with those above one positively related, and those below one negatively related, to visit frequency. Reference category = 0 visits

Variable	Once			2 - 3 visits			4 - 6 visits			7 or more visits		
	OR	2.5%	97.5%	OR	2.5%	97.5%	OR	2.5%	97.5%	OR	2.5%	97.5%
Nature-relatedness	**1.45**	**1.04**	**2.02**	**2.01**	**1.35**	**2.98**	1.37	0.87	2.15	**1.53**	**1.00**	**2.35**
Safety concern (No)	0.99	0.50	1.95	**2.28**	**1.22**	**4.26**	**2.69**	**1.23**	**5.88**	1.80	0.86	3.77
Age (35+ years old)	**0.53**	**0.31**	**0.91**	0.57	0.32	1.02	**0.32**	**0.14**	**0.70**	0.73	0.37	1.44

The odds of a participant spending at least 1 minute in a green and blue space (zero-hurdle) significantly increased with higher nature-relatedness, no safety concerns, and education to a high level (Table 2.3). Participants who were aged 35+ years old were significantly less likely to visit. The odds of spending a longer period of time visiting green and blue space (non-zero counts) was not related to any sociodemographic background characteristic in particular, implying that users belonged to a wide range of backgrounds. Gender, however, was not represented in either of the model sets.

Table 2.3: Model-averaged (ΔAICc < 2 model set) odds ratios (OR) and 95% confidence intervals investigating whether nature-relatedness, safety concern, and sociodemographic characteristics (gender, education, residential history, age) predict log visit duration to green and blue spaces in Georgetown, Guyana (hurdle model) (n = 431). Zero hurdle part gives a binary response (zero minutes versus everything above zero), while the count model represents increases in log visit duration (data that fall above zero). The odds ratio is significant if the confidence intervals do not cross one (bold values), with those above one positively related, and those below one negatively related, to log visit duration

Variable	Zero-hurdle			Non-zero counts		
	OR	**2.5%**	**97.5%**	**OR**	**2.5%**	**97.5%**
Nature-relatedness	**1.57**	**1.22**	**2.01**	0.99	0.92	1.07
Safety concern (No)	**1.79**	**1.13**	**2.85**	1.03	0.91	1.17
Education (High)	**1.66**	**1.11**	**2.49**	1.01	0.89	1.13
Residential history (Other)	1.09	0.77	1.54	0.99	0.93	1.06
Age (35+ years old)	**0.59**	**0.39**	**0.89**	0.93	0.82	1.05

2.4.2 Do visit frequency and visit duration depend on the motivations for visiting green and blue spaces?

During a seven-day period, the users were motivated to visit green and blue spaces mainly (39%) for physical reasons (Table 2.4). For analytical purposes, the Global Wellbeing domain was removed due to the low sample (n = 4). Visit motivations for visiting green as opposed to blue space were non-significant at the domain level (X^2 = 7.045, df = 4, p = 0.133).

Table 2.4: User visit motivations for green and blue spaces in Georgetown, Guyana, in the past seven days, in response to the question '*What was the main reason for the visits*?'. Table displays the number of times (total n = 384) each coded visit motivation was mentioned, grouped into Themes and Domains. *41 visits for 'purposeful work' in green spaces comprised purposeful work in backyards

Code	Green	Blue	Theme	Green	Blue	Domain	Green	Blue
Relaxation	25	32	Physical restoration	31	44	Physical	86	63
Chill out	5	9						
Eat	1	3						
Exercise	29	9	Physical pursuits	55	19			
Sport	17	0						
A walk	8	6						
Passing through	1	4						
Purposeful work	51*	8	Mental pursuits	53	11	Cognitive	57	13
Religious use	1	1						
Think	1	1						
Photography	0	1						
Peace and quiet	2	1	Attention restoration	4	2			
Reflection	1	0						
Relax my mind	0	1						
Get away	1	0						
Fresh air	6	13	Nature	20	22	Space qualities	36	26
See nature	5	2						
Trees, plants, flowers	6	0						
Get outside	0	2						
See ocean	0	3						
Sunrise/set	1	1						
Nature sounds	1	0						
Proximity	4	1	Feature	14	2			
View	4	1						
Zoo animals	4	0						
Atmosphere	2	0						
Beauty	1	0						
Monument	0	1						
Emotional attachment	1	1	Place attachment	1	1			
Distinct identity	0	1	Place identity	0	1			
Recreation	26	15	Passing time	37	19	Un-structured time	36	19
Unstructured time	6	1						
Sight-seeing	1	3						
Pets	4	0						
Family outing	12	5	Socialising	21	18	Social	21	18
Meet friends	6	5						

Hang out	0	7						
Romantic	3	1						
Depression	0	2	Health	1	3	Global wellbeing	1	3
Health	1	0						
Therapy	0	1						

Participants were more likely to visit just once in the week (49%) rather than more often (2-3 visits = 26%; 4-6 visits = 10%; 7 or more visits = 15%) (Table 2.5). Visit motivations were significantly related to visit frequency (X^2 = 32.82, df = 12, p = 0.001). Amongst green spaces, there was an association between visit frequency and visit motivation (X^2 = 37.53, df = 15, p = 0.001), with more frequent visits associated with physical or cognitive domains. No such pattern (X^2 = 7.967, df = 12, p = 0.787) was apparent for blue spaces.

Table 2.5: User visit motivations for green and blue spaces in Georgetown, Guyana, in the past seven days, in response to the question '*What was the main reason for the visits*?'. Table displays the number of times (total *n* = 384) each coded visit motivation was mentioned, grouped into Themes and Domains. The number of responses in each Domain per category of visit frequency is shown

Visit type	**Frequency**	**Domain**				
		Physical	**Cognitive**	**Space qualities**	**Unstructured time**	**Social**
All visits (*n* = 379)	Once	72	22	33	32	24
	2 - 3 visits	49	18	10	11	10
	4 - 6 visits	14	8	9	6	1
	7 or more visits	14	22	9	7	4
Green (*n* = 237)	Once	37	14	20	19	12
	2 - 3 visits	35	13	3	5	4
	4 - 6 visits	9	5	6	5	1
	7 or more visits	8	21	8	6	4
Blue (*n* = 142)	Once	35	8	13	13	12
	2 - 3 visits	14	5	7	6	6
	4 - 6 visits	5	3	3	1	0
	7 or more visits	6	1	1	1	0

Across a seven-day period, participants spent an approximately equal amounts of time visiting green and blue spaces across the visit motivation domains (All visits: X^2 = 3.33, df = 4, p = 0.50; Green: X^2 = 6.97, df = 4, p = 0.14; Blue: X^2 = 3.09, df = 4, p =

0.54) (Figure 2.2). When visit duration per visit motivation was compared between green and blue spaces, no significant differences were apparent.

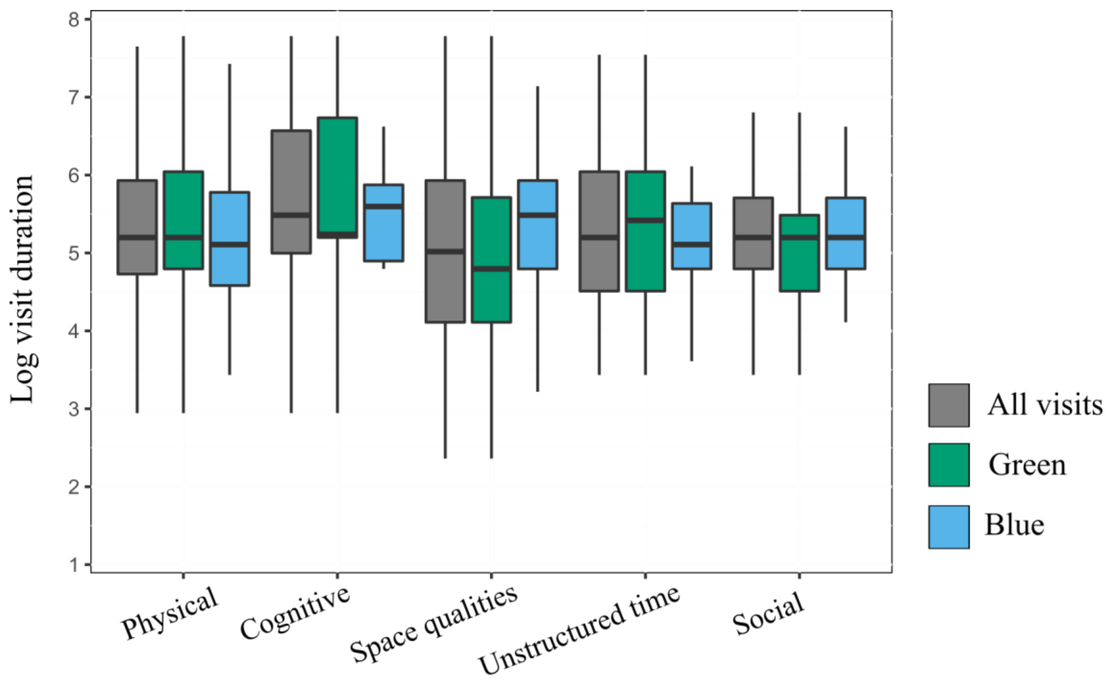


Figure 2.2: Responses to the open question 'What was the main reason for visiting?' green and blue spaces in Georgetown Guyana. Visit motivations were clustered into codes before being grouped into themes and domains. Plots present all visits (grey), visits to green spaces only (green) and visits to blue spaces only (blue). Log visit duration of time spent visiting green and blue spaces in the last seven days per domain of visit motivation, where boxplots depict the median (central horizontal line), with the coloured box depicting the interquartile range

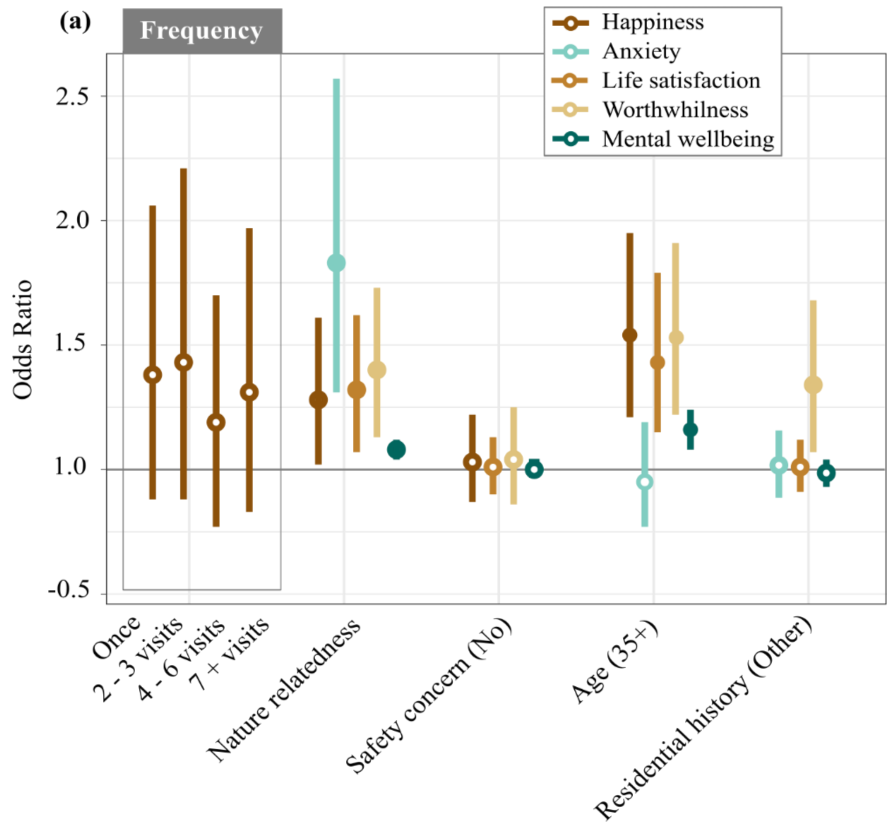
2.4.3 Do visit frequency or visit duration relate to human wellbeing?

Visit frequency to green and blue space in the last seven days was not related to any wellbeing measure (Figure 2.3a; Table S2.6). Nonetheless, an increase in log visit duration in the last seven days was associated with increased happiness (Figure 2.3b; Table S2.7).

In all models, participants who reported higher nature-relatedness, also had higher levels of happiness, life satisfaction, worthwhileness and mental wellbeing, but also higher anxiety. Concern for personal safety was not directly related to any wellbeing measure. The odds of higher wellbeing measures increased if participants were aged 35+ years old, although not for anxiety. Participants who had lived outside of

Georgetown (either in rural Guyana or abroad) felt more worthwhileness, when compared with people who had always only lived in Georgetown. Education did not pass the proportional odds assumption so was not retained.

We then plotted log visit duration of time spent in green and blue space in the last seven days against happiness as a continuous variable (Figure 2.4a), as well as log visit duration untransformed to identify the approximate amount of time (or 'dose') required to make quantifiable wellbeing gains (Figure 2.4b). To do this, we excluded outlying data that fell above the 95th percentile of observations (1201 minutes) (leaving n = 407). Increases were apparent above the median reported for non-users (happiness = 7) after ~30 minutes, and up until a period of ~120 minutes, after which there is fluctuation (Figure 2.4b).



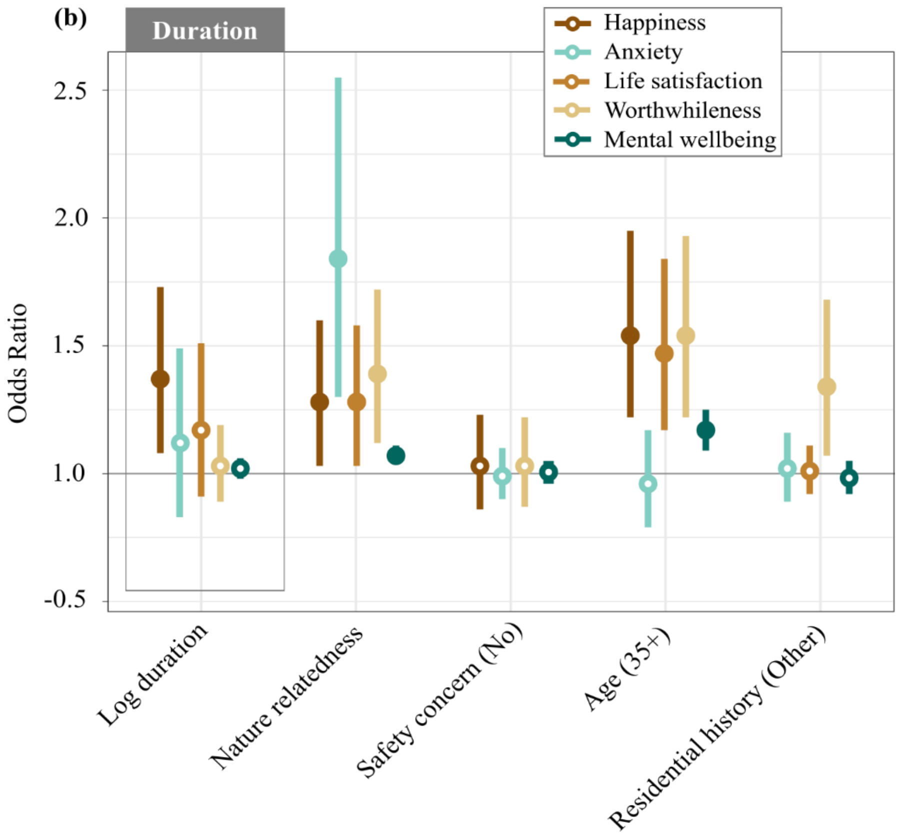


Figure 2.3: Model-averaged (ΔAICc < 2 model set) odds ratios and 95% confidence intervals for five models investigating whether (a) visit frequency and (b) log visit duration predict each of five measures of wellbeing (happiness = dark brown, anxiety = blue, life satisfaction = light brown, worthwhileness = yellow, mental wellbeing = dark green) of participants who visited green and blue spaces in Georgetown (*n* = 431). The centre circle is the odds ratio (filled = significant). 95% confidence intervals are determined to be significant if they do not cross one, with those above one positively related, and those below one negatively related, to wellbeing

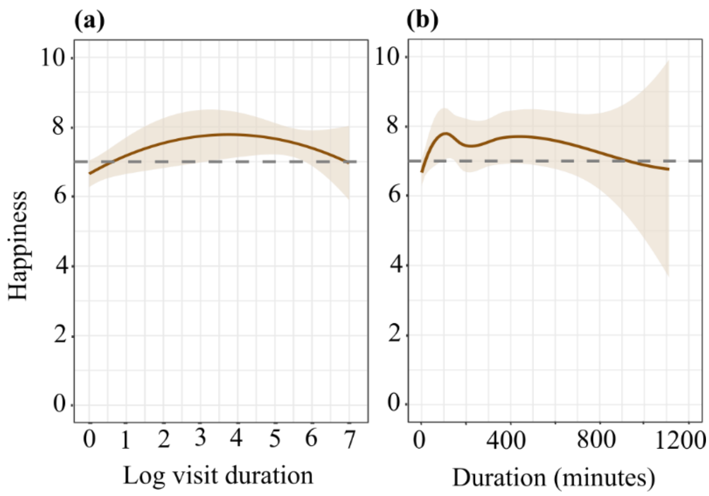


Figure 2.4: Measures of happiness as a function of (a) log visit duration and (b) visit duration untransformed (minutes) for green and blue spaces in Georgetown (*n* = 407), plotted using an

unadjusted bivariate smoothing (LOESS) curve (with 95% confidence intervals). Horizontal dashed line represents the median wellbeing value for non-users (0 minutes duration), revealing any increases reported for green and blue space users thereafter

2.5 Discussion

Identifying how urban green and blue spaces benefit human wellbeing can inform their prioritisation in urban land-use planning and management decision-making (Richards et al., 2017; van den Bosch and Nieuwenhuijsen, 2016). We find that intentionally spending more time in urban green or a blue space, for any reason, was associated with improved positive experiential wellbeing in Georgetown, Guyana. To the best of our knowledge, this is the first time that a that dose-response has been evaluated for this region of the world, and demonstrates the cross-cultural importance of exposure to urban green and blue space for improved wellbeing (Garrett et al., 2019; Nath et al., 2018; Shanahan et al., 2016; White et al., 2017, 2019). This finding is supported by our qualitative analysis of visit motivations, which identified codes that are illustrative of the mechanisms through which people derive wellbeing benefits in nature, including ‘restoring capacities’ (e.g. relaxation), and ‘building capacities’ (e.g. exercise) (Markevych et al., 2017). Public health authorities in Georgetown responsible for policy recommendations should note the minimum of 30 minutes exposure to urban green or blue spaces, while undertaking any activity, to increase positive experiential wellbeing. Campaigns based on this recommendation could be targeted specifically at older people from low educated backgrounds, as this sector of society is, currently, less like to visit. Ensuring that accessible urban green and blue spaces are spread across the city is another important consideration.

Although our dose-response finding supports the notion that nature-exposure is beneficial to particular aspects of human wellbeing, some subtleties were uncovered. Indeed, we show that log visit duration was not associated with improvements in the other four measures of wellbeing (anxiety, life satisfaction, worthwhileness, mental wellbeing), while visit frequency was not associated with any wellbeing measures. These findings differ from work conducted in the global North that uses the same measures, but found increased visit frequency related to higher life satisfaction (Coldwell and Evans, 2018) and greater eudaimonic wellbeing (White et al., 2017), and that increased duration (up to 120 minutes) was associated with higher life satisfaction (White et al., 2019) and improved mental wellbeing (past a threshold of 60 minutes) (Garrett et al., 2019). This illustrates the importance of researchers and decision-makers clearly distinguishing between the multiple dimensions of wellbeing when making recommendations and developing interventions to improve people's quality of life on the whole (Dolan et al., 2016).

The absence of an association between green and blue space use with anxiety, life satisfaction, worthwhileness and mental wellbeing, concurs with the outcomes of research conducted in Singapore (Saw et al., 2015). The authors argue that while people in temperate regions are drawn to urban green spaces for the cooling benefits these spaces offer (Lafortezza et al., 2009), the extreme temperature and humidity posed by the tropical climate in Singapore tends to drive people into air-conditioned buildings. Moreover, Saw et al., (2015) contend that as greenery is so abundant throughout Singapore, it is difficult to detect how urban green spaces *per se* might be affecting human wellbeing. In Georgetown, air conditioning is less common, but the city has a wealth of biodiversity (Hayes et al., 2019; Hunte et al., 2019) and participants may therefore gain incidental exposure to nature during, for example, a commute to work (Keniger et al., 2013). Moreover, the presence of balconies, porches, and backyards allow residents to spend time outside without leaving the safety of their properties, and are present in most of Georgetown's neighbourhoods regardless of socioeconomic status. Indeed, we found the majority of visits to green spaces for cognitive visit motivations were for purposeful work (e.g. 'kitchen garden', 'picking fruit', 'maintenance'), predominately in backyards. Further investigation is necessary to disaggregate the importance of public and private green spaces in Georgetown, to build on our understanding of the positive contribution of personal gardens to wellbeing in the global North (de Bell et al., 2020; Young et al., 2020). However, our results do emphasise the need to incorporate backyards into future land-use planning.

Higher nature-relatedness was strongly associated with increased visit frequency and log visit duration, as well as higher life satisfaction, worthwhileness, mental wellbeing and, although unintuitive, higher anxiety. While the latter finding for anxiety directly opposes existing evidence (Martyn and Brymer, 2014), the wide confidence intervals indicate substantial levels of uncertainty. Yet, it is possible that people were seeking respite from feelings of anxiety by spending more time visiting green and blue spaces, which merits further examination. Nonetheless, this study is the first to validate the nature-relatedness scale in Guyana, and supports findings from the global North that feeling connected with the natural world drives increased visit frequency and visit duration (Cox et al., 2018; Lin et al., 2014), and that nature-relatedness is positively associated with higher wellbeing (Cox et al., 2017, 2018; Nisbet et al., 2011; Zelenski and Nisbet, 2014). However, visits to green and blue space in the past week have also been shown to enhance nature-relatedness itself (Shanahan et al., 2017). Nature-relatedness is further associated with a number of pro-environmental behaviours and attitudes (Mayer and Frantz, 2004; Nisbet et al., 2009), although recreational and physical visits to green and blue spaces have also been associated with pro-environmental attitudes, mediated by increased wellbeing (Dean et al., 2019). While debates ensue about what it means to be ‘connected’ to nature, and whether people need to ‘experience’ nature to exhibit pro-environmental behaviours and attitudes (Clayton et al., 2017; Ives et al., 2017), it is clear that all these factors are cyclically interconnected. Furthermore, although attempts have been made to use the ‘Connectedness with Nature’ scale amongst farmers elsewhere in the Amazon (Mikołajczak et al., 2019), more work is needed to ascertain how attitudes toward the natural environment interact with pro-environmental behaviours, such as urban green and blue space use, to improve human wellbeing in Guyana.

Concern for personal safety was a key determinant of whether participants visited Georgetown’s green and blue spaces. Studies in the global South have shown that perceptions of safety strongly influence use of green space (Ambrey and Shahni, 2017; Hong et al., 2018), and in South America specifically (Parra et al., 2010; Wright Wendel et al., 2012). In Georgetown, crime and illegal activity is rife, compared with the country at large (Cummings et al., 2018), although there are no resolved data on crime within urban green or blue spaces. Understanding what attributes of these spaces influence personal safety concerns is necessary to identify how their design and management can be altered to encourage use. For instance, Pitt (2019) recommends improvements in cleanliness, lighting, and surveillance will influence perceptions of safety in urban waterways.

Before now, the wellbeing of the population of Guyana has not been examined, as the country has never been included in international assessments of human wellbeing, such as the Gallup World Poll (Graham et al., 2018; Helliwell et al., 2016, 2020). This is despite the high prevalence of psychological health disorders amongst the population (Arora and Persaud, 2019). All four positive dimensions of wellbeing (happiness, life satisfaction, worthwhileness, mental wellbeing) increased with age, which is thought to be related to an increased ability to process and regulate emotional experiences and prioritise emotional goals, regardless of the fact that ageing is concomitant with decreased physical, mental, and social health ('the paradox of aging') (Mackenzie et al., 2018). Moreover, we found that participants who had spent time growing up outside of Georgetown (either in rural areas or abroad) felt their life was more worthwhile than those that had only lived in Georgetown. This is of particular interest given the magnitude of emigration out of Guyana, which has kept the population consistent since the 1980's (Mycoo, 2017). High levels of emigration are thought to be the result of lack of employment, low salaries, and political insecurity (Commonwealth Secreteriat, 2015), all of which are factors known to contribute to subjective human wellbeing (Helliwell et al., 2020).

2.6 Conclusion

Accelerating urbanisation and population growth will place growing pressure on urban green and blue spaces, particularly in the global South (Pauchard et al., 2006; Richards et al., 2017), which offer habitat for biodiversity and can also benefit human wellbeing (WHO and CBD 2015). Guyana is a biodiversity-rich country with a rapidly emerging economy (Panelli, 2019) and a national mental-health crisis (Arora and Persaud, 2019). As a nation, policy-makers are looking to minimise trade-offs between ecological and public health demands in their land-use planning. Our results suggest that decision-makers could improve human wellbeing through the provision of urban green and blue spaces across the city, including ensuring that backyards are associated with dwelling. Not only should new spaces be incorporated into future development plans, but existing spaces could be enhanced by reducing people's safety concerns and encouraging older people to visit. It is important to guarantee that wellbeing benefits are available to all sectors of society, minimising the risk of gentrification and any subsequent health inequalities (Cole et al., 2017; Haase et al., 2017). Moreover, public health officials should seek to understand what nature-relatedness means for people living in Georgetown, given its clear link with improved wellbeing.

2.7 Acknowledgements

We thank our field assistants, H. Yang, W. M. Hayes, M. Pierre, A. Harris, S. K. Rampertab, N. Hunte, K. Joshi, and J. Crosse. Logistical support was provided by WWF Guyana and the Protected Areas Commission, most notably A. Bayney. We also thank S. Bharrat (Conservation International Guyana) and R. Caesar (Iwokrama) for useful discussions. JCF was supported by grants from RGS with IBG (Dudley Stamp Award), Gilchrist Educational Foundation, ESRC (ES/J500148/1) and NERC (NE/L002582/1). KNI was supported by the RESAS Division of the Scottish Government. KNI and ZDG are supported by the European Research Council (ERC) under the European Union's Horizon 2020 Research and Innovation Framework Programme (Consolidator Grant No. 726104). Permission for this research was provided by the Environmental Protection Agency of Guyana, reference number 051117 BR 006.

2.8 Supplementary information

Table S2.1: Sociodemographic background of the questionnaire participants (n = 512) compared with Georgetown's population, according to the most recent census (C%) (Bureau of Statistics 2012). Some rows were combined due to low n values. G-test for goodness-of-fit showed that the sample was representative of Georgetown's population (data unavailable for residential history).

Variable	*n*	%	C%	Variable	*n*	%	C%	Variable	*n*	%	C%
Gender				**Education**				**Religion**			
Male	245	47.9	47.5	Primary/None	40	7.8	29	Anglican	23	4.5	9.1
Female	267	52.1	54.5	Secondary	201	39.3	53	Muslim	34	6.6	2.3
Prefer not to say	0	0	0	Post-Secondary	31	6.1	6	Pentecostal	52	10.2	21.2
G test: G = -4711.3, X^2 df = 1, *p* = 1				Technical/Advanced	66	12.9	NA	Roman Catholic	76	14.8	11.8
				University	168	32.8	8	Hindu	39	7.6	12
Age				Other / Prefer not to say	6	1.2	4	Other Christian	172	33.6	23.6
18-24	148	28.9	26.8	**G test: G = -4711.3, X^2 df = 1, *p* = 1**				7th Day Adventist	22	4.3	4.3
25-34	122	23.8	24.3					Non/no religion	38	7.4	7.2
35-44	89	17.4	18.9	**Ethnicity**				Other / Prefer not to say	56	10.9	4.3
45-54	62	12.1	13.5	African	199	38.9	52.8	**G test: G = -4524.9, X^2 df = 8, *p* = 1**			
55-64	55	10.7	6.9	Amerindian	17	3.3	1				
65+	31	6.1	6.9	East Indian	105	20.5	19.6	**Residential history**			
Other / Prefer not to say	0	0	2.6	Mixed	169	33	23.8	Georgetown	288	56.3	NA
G test: G = -4.629.9, X^2 df = 6, *p* = 1				Other / Prefer not to say	20	3.9	2.7	+ rural Guyana	184	35.9	NA
				G test: G = -4639.6, X^2 df = 4, *p* = 1				+ Outside of Guyana	40	7.8	NA

Table S2.2: Psychological wellbeing scales

(a) ONS Wellbeing scale

Now I would like to ask you two questions about your feelings on aspects of your life in general. Response options: continuous scale (1 = *Not at all* to 11 = *Completely*)

Questions:
Overall, how satisfied are you with your life nowadays?
Overall, to what extent do you feel the things you do in your life are worthwhile?

The next two questions are about your feelings on aspects of your life yesterday.
Response options: continuous scale (1 = *Not at all*, 11 = *Completely*)

Questions:
Overall, how happy did you feel yesterday?
Overall, how anxious did you feel yesterday?

(b) WHO-5 mental wellbeing scale

Please indicate for each of the five statements which is closest to how you have been feeling over the past seven days
Response options: *At no time, Some of the time, Less than half the time, More than half the time, Most of the time, All of the time*

Statements:
I have felt cheerful and in good spirits
I have felt calm and relaxed
I have felt active and energetic
I woke up feeling fresh and rested
My daily life has been filled with things that interest me

Table S2.3: Nature-relatedness scale

(a) Nature-relatedness (NR6) scale
Nature-relatedness scale used in short face-to-face questionnaire (Nisbet and Zelenski 2013) *I would like you to indicate how much you agree or disagree with the following statements.* Response options: *Strongly disagree, Disagree a little, Neither agree or disagree, Agree a little, Strongly agree* Statements: My ideal vacation spot would be a remote wilderness area I always think about how my actions affect the environment My connection to nature and the environment is part of my spirituality I take notice of wildlife wherever I am My relationship to nature is an important part of who I am I feel very connected to all living things and the earth

Table S2.4: Illustrative participant motivations for visiting specific green or blue spaces in the past seven days in Georgetown, Guyana (open-ended question), grouped by domain and code

Domain	**Theme**	**Code**	**Examples**
Physical	Physical restoration	Relaxation	*relax; relaxation; relaxing; hammock under the trees*
	Physical pursuits	Exercise	*jogging; work out; move around; exercise*
		Sport	*cricket; sports; football; play hockey; frizbee*
Cognitive	Mental pursuits	Purposeful work	*maintenance; kitchen garden; picking fruit; fishing*
		Religious use	*religious pilgrim; prayers*
	Attention restoration	Peace and quiet	*to find peace, quiet*
Space qualities	Nature	Fresh air	*breezy; take breeze; fresh air; fresh breeze*
		See nature	*contact with nature; admire nature; see landscape*
	Feature	Proximity	*closest to me; live near; live near there*
Unstructured time	Passing time	Recreation	*leisure; recreation; recreational; an event*
		Unstructured time	*routine visit; day off; check around; checking*
		Sight-seeing	*sightseeing; wanted to sight-see*
Social	Socialising	Family outing	*family time; family outing; take kids; take children*
		Meet friends	*social gathering; friend meetup; see friends; party*
		Hang out	*hang out; hang out with friends*
Global wellbeing	Health	Depression	*Depression*
		Health	*health and nature*
		Therapy	*Therapy*

Table S2.5: Questionnaire participants (n = 512) compared with Georgetown's population, according to the most recent census (C%) (Bureau of Statistics 2012)

Ward	*n*	%	C (%)	Ward	*n*	%	Census (%)	Ward	*n*	%	C (%)
Agricola Village	4	0.8	2.1	Kingston	9	1.8	0.8	Pattensen	4	0.8	4.2
Albertown	9	1.8	2.0	Kitty	64	12.5	5.7	Prashad Nagar	8	1.6	0.9
Albouystown	9	1.8	3.2	La Penitence (Castello Housing Scheme)	11	2.1	0.9	Queenstown	14	2.7	1.3
Alexander Village	4	0.8	1.1	Lacytown	4	0.8	0.3	River View Ruimveldt	1	0.2	0.5
Bel Air	13	2.5	0.4	Lahama Park	3	0.6	0.9	Robbstown/Newtown	0	0.0	0.0
Bel Air Gardens	0	0.0	0.1	Lahama Springs	3	0.6	0.6	Roxanne Burnham Gardens	5	1.0	0.6
Bel Air Park	4	0.8	0.5	Laing Avenue	0	0.0	1.1	Section K. Campbellville	2	0.4	0.4
Bel Air Springs	0	0.0	0.0	Lamaha Gardens	4	0.8	0.5	Sophia	40	7.8	3.1
Botanical Gardens	0	0.0	0.2	Liliandaal	4	0.8	2.6	South Cummingsburg	13	2.5	1.6
Bourda	9	1.8	1.6	Lodge	16	3.1	4.2	South Ruimveldt Gardens	24	4.7	1.7
Campbellville	32	6.3	4.3	Lodge Housing Scheme	1	0.2	0.6	South Ruimveldt Park	17	3.3	3.2
Century Palm Gardens (Lodge)	0	0.0	0.2	McDoom	3	0.6	0.7	Stabroek	4	0.8	0.2
Charlestown	17	3.3	2.6	Meadow Bank (Houston)	1	0.2	0.4	Subryanville	0	0.0	0.4
Cummings Lodge	38	7.4	6.1	Meadowbrook Gardens	2	0.4	1.2	Thomas Lands	3	0.6	0.0
Durban Area	13	2.5	0.1	New Haven	0	0.0	0.2	Tucville	8	1.6	2.6
East La Penitence	4	0.8	1.7	Newburg	1	0.2	0.6	Turkeyen	17	3.3	5.6
East Ruimveldt	6	1.2	2.9	Newtown	7	1.4	2.3	Werk En Rust	7	1.4	3.1
Festival City (North Ruimveldt)	3	0.6	2.4	Non Pariel Park	1	0.2	0.0	West La Penitence	1	0.2	2.6
Guyhoc Park	7	1.4	0.8	North Cummingsburg	5	1.0	0.7	West Ruimveldt	13	2.5	3.6
Houston	1	0.2	0.8	North East La Penitence	4	0.8	1.0	Wortmanville	5	1.0	2.4
Industrial Estate	0	0.0	1.0	North Ruimveldt	9	1.8	2.0	Yarrow Dam	1	0.2	0.3

Table S2.6: Model-averaged (ΔAICc < 2 model set) odds ratios and 95% confidence intervals for models investigating whether visit frequency predicts five measures of wellbeing (happiness, anxiety, life satisfaction, worthwhileness, mental wellbeing) of participants in Georgetown (n = 431), while adjusting for sociodemographic characteristics (nature-relatedness, safety concern, gender, education, residential history, age). The odds ratio is significant if the confidence intervals do not cross 1 (bold values), with those above one positively related, and those below one negatively related, to visit frequency

	Happiness			**Anxiety**			**Life satisfaction**			**Worthwhileness**			**Mental wellbeing**		
	OR	**2.5%**	**97.5%**	**OR**	**2.5%**	**97.5%**	**OR**	**2.5%**	**97.5%**	**OR**	**2.5%**	**97.5%**	**OR**	**2.5%**	**97.5%**
Frequency															
Once	1.35	0.88	2.06	-	-	-	-	-	-	-	-	-	-	-	-
2 - 3 visits	1.40	0.88	2.21	-	-	-	-	-	-	-	-	-	-	-	-
4 - 6 visits	1.15	0.77	1.70	-	-	-	-	-	-	-	-	-	-	-	-
7 or more visits	1.28	0.83	1.97	-	-	-	-	-	-	-	-	-	-	-	-
Nature-relatedness	**1.28**	**1.02**	**1.61**	**1.83**	**1.31**	**2.57**	**1.32**	**1.07**	**1.62**	**1.40**	**1.13**	**1.73**	**1.08**	**1.04**	**1.12**
Residential history (Other)	-	-	-	1.02	0.89	1.16	1.01	0.91	1.12	**1.34**	**1.07**	**1.68**	0.98	0.93	1.04
Safety concern (No)	1.03	0.87	1.22	-	-	-	1.01	0.90	1.13	1.04	0.86	1.25	1.00	0.97	1.04
Education (High)	**1.36**	**1.07**	**1.72**	0.79	0.56	1.10	0.87	0.68	1.12	0.98	0.87	1.11	1.01	0.96	1.06
Age (35+ years old)	**1.54**	**1.21**	**1.95**	0.95	0.77	1.19	**1.43**	**1.15**	**1.79**	**1.53**	**1.22**	**1.91**	**1.16**	**1.08**	**1.24**

Table S2.7: Model-averaged (ΔAICc < 2 model set) odds ratios and 95% confidence intervals for models investigating whether log visit duration predicts five measures of wellbeing (happiness, anxiety, life satisfaction, worthwhileness, mental wellbeing) of participants in Georgetown (*n* = 431), while adjusting for sociodemographic characteristics (nature-relatedness, safety concern, gender, education, residential history, age). The odds ratio is significant if the confidence intervals do not cross 1 (bold values), with those above one positively related, and those below one negatively related, to visit frequency

	Happiness			**Anxiety**			**Life satisfaction**			**Worthwhileness**			**Mental wellbeing**		
	OR	**2.5%**	**97.5%**	**OR**	**2.5%**	**97.5%**	**OR**	**2.5%**	**97.5%**	**OR**	**2.5%**	**97.5%**	**OR**	**2.5%**	**97.5%**
Log visit duration	**1.37**	**1.08**	**1.73**	1.12	0.83	1.49	1.17	0.91	1.51	1.03	0.89	1.19	1.02	0.98	1.06
Nature-relatedness	**1.28**	**1.03**	**1.60**	**1.82**	**1.30**	**2.55**	**1.28**	**1.03**	**1.58**	**1.39**	**1.12**	**1.72**	**1.07**	**1.04**	**1.11**
Residential history (Other)	-	-	-	1.02	0.89	1.16	1.01	0.92	1.11	**1.34**	**1.07**	**1.68**	0.98	0.92	1.05
Safety concern (No)	1.03	0.86	1.23	0.99	0.90	1.10	-	-	-	1.03	0.87	1.22	1.00	0.98	1.03
Education (High)	**0.74**	**0.58**	**0.93**	0.78	0.56	1.09	0.86	0.66	1.10	0.99	0.89	1.10	1.01	0.96	1.05
Age (35+ years old)	**1.54**	**1.22**	**1.95**	0.96	0.79	1.17	**1.47**	**1.17**	**1.84**	**1.54**	**1.22**	**1.93**	**1.17**	**1.09**	**1.25**

Chapter 3. Bird diversity and psychological wellbeing: a comparison of green and coastal blue space in a neotropical city

Jessica Claris Fisher[1], Jake Emmerson Bicknell[1], Kate Nesbitt Irvine[2], William Michael Hayes[1], Damian Fernandes[3], Jayalaxshmi Mistry[4], Zoe Georgina Davies[1]

[1] Durrell Institute of Conservation and Ecology (DICE), University of Kent, Canterbury CT2 7NR, UK

[2] Social, Economic and Geographical Sciences, James Hutton Institute, Craigiebuckler, Aberdeen AB15 8QH, UK

[3] Conservation International Guyana, 98 Laluni St, Georgetown, Guyana

[4] Department of Geography, Royal Holloway University of London, Egham Hill, Egham TW20 0EX, UK

Manuscript published as:

Fisher JC, Bicknell JE, Irvine KN, Hayes WM, Fernandes D, Mistry J, Davies ZG. 2021. Bird diversity and psychological wellbeing: A comparison of green and coastal blue space in a neotropical city. Science of the Total Environment 793: 148653

3. 1. Abstract

Accelerating rates of urbanisation are contributing to biodiversity declines worldwide. However, urban green (e.g. parks) and blue spaces (e.g. coast) provide important habitat for species. Emerging evidence also shows that green and blue spaces can benefit human psychological wellbeing, although few studies originate from the global South and it is unclear whether more biodiverse spaces offer greater wellbeing gains. We examine how bird diversity (abundance, species richness, Shannon diversity, and community composition) in green and coastal blue space in Georgetown, Guyana, is associated with people's wellbeing (positive and negative affect, anxiety) *in situ*, using point counts and questionnaires. Bird community composition differed between green and coastal sites, and diversity was significantly higher in green sites. Positive affect and anxiety did not differ between green and coastal sites, but negative affect was higher in coastal sites. Mixed-effect models showed no associations between biodiversity and wellbeing, so other features are contributing to people's positive wellbeing. Despite no association between biodiversity and wellbeing, both green and coastal blue sites are important for wellbeing and supporting different bird communities. City planning authorities and public health professionals should ensure these social and environmental needs are met in developing cities in the global South.

Keywords: community; ecosystem service; global South; human-wildlife interactions; mental health; urban planning.

3. 2. Introduction

Urbanisation rates are increasing globally, with urban landcover forecast to triple between 2000 and 2030 (Angel et al., 2011), and 60% of people around the world will live in urban areas by 2030 (United Nations 2018). Residing in towns/cities can be detrimental to human wellbeing, as the prevalence of mental health issues (e.g. anxiety, depression) is greater than in rural regions (Peen et al., 2010, World Health Organisation and Convention on Biological Diversity 2015). The scale of urbanisation also places significant pressure on biodiversity (Güneralp and Seto, 2013) and, consequently, ecosystem functions that provide critical services to humanity (Cardinale et al., 2012). However, biodiversity can thrive in towns and cities (Ives et al., 2016), with urban green spaces (e.g. parks, gardens) providing a refuge for some species (Baldock et al., 2015; Fontana et al., 2011). Additionally, there is substantial evidence showing that visits to urban green spaces can benefit people's psychological wellbeing (Keniger et al., 2013, Lovell et al., 2014), by ameliorating stress and fatigue while restoring attention (Kaplan and Kaplan, 1989; Ulrich et al., 1991). The planning, design and management of urban areas is therefore important for both biodiversity conservation and public health services.

Emerging literature also highlights the importance of blue spaces (e.g. rivers, coast) for psychological wellbeing. Indeed, while often subsumed within the definition of green spaces (Coldwell and Evans, 2018; van den Berg et al., 2017; White et al., 2019), some research suggests stronger positive associations are apparent when blue spaces are considered independently. For instance, studies using national survey data show that people living near visible salt or freshwater experience lower psychological distress than those near visible green spaces (Nutsford et al., 2016), and a more pronounced reduction in the prevalence of anxiety and mood disorders associated with the availability of blue over green space (de Vries et al., 2016). Likewise, experimental evidence demonstrates people prefer viewing scenes containing water, rather than just greenery, and perceive them as more restorative (White et al., 2010). Suggested explanations for this include the specific characteristics of water, such as its visual properties (e.g. vastness, movement) and sounds (e.g. breaking waves) (Völker and Kistemann, 2015; White et al., 2010). Gascón et al's (2017) review of blue spaces, health and wellbeing indicates that a diverse array of psychological outcome measures have been studied to date (e.g. psychological distress, minor psychiatric morbidity), but that psychological wellbeing is rarely a focus. With over one third of the world's population living near a coastline (Neumann et al., 2015), there is considerable potential to develop a stronger evidence-base around how coastal blue spaces could influence psychological wellbeing.

Disentangling the impacts of green and blue space for psychological wellbeing, particularly where they co-occur, is important to identify effective land-use management/policy strategies (Higgins, Sahran et al., 2019). Achieving this requires a better understanding of which specific characteristics of green and blue spaces enhance or detract from wellbeing. Specifically, teasing apart the role biodiversity plays in human-nature relationships would be valuable for decision-makers tasked with improving environmental quality for people and species alike. Current empirical evidence to support the contribution of biodiversity to psychological wellbeing is equivocal. For instance, greater bird abundance has been associated with lower stress, depression and anxiety, but these relationships did not hold when species richness was used as the biodiversity metric (Cox et al., 2017). Conversely, other studies have found greater bird species richness to be associated with higher psychological wellbeing (reflection, place identity and place attachment) (Fuller et al., 2007; Dallimer et al., 2012).

No research has quantitatively examined the link between biodiversity in blue spaces and psychological wellbeing *in situ*, although there is qualitative and *ex situ* evidence that blue space biodiversity has a positive effect. In a laboratory setting, viewing videos of coastal bird flocks and charismatic species resulted in positive moods, compared with other wildlife (White et al., 2017b). In an aquarium, higher Shannon diversity of aquatic fish was, similarly, related to higher self-reported mood and interest (Cracknell et al., 2016). Garrett et al., (2018) found that people in Hong Kong were more likely to visit blue spaces if they felt there was wildlife to see.

There are also major geographical gaps in where biodiversity-wellbeing research has taken place, with a paucity of studies from the global South (Botzat et al., 2016; Keniger et al., 2013; Lovell et al., 2014). Global South nations are urbanising extremely quickly, with urban landcover expected to grow 315% between 2000 and 2050 (United Nations 2018, Angel et al., 2011). Simultaneously, there is a lack of urban conservation research and action which could help alleviate associated biodiversity loss (Shwartz et al., 2014). The largest urban expansion into biodiversity-rich ecosystems by 2030 is predicted for South America, with a ~3.5 fold increase in urban landcover (Güneralp and Seto, 2013), where cities are characterised by extreme social and economic inequality (Pauchard and Barbosa, 2013). Despite the presence of green spaces in South American cities, urban planners have yet to fully acknowledge their importance as key habitats for species, or the benefits they may provide to human wellbeing (Pauchard and Barbosa, 2013).

Here, we explore bird diversity and psychological wellbeing in Georgetown, Guyana. Birds were chosen as a model taxa as they are highly visible, inexpensive to monitor, and are indicators/providers of ecosystem functions (Herrando et al., 2017). Moreover, given its proximity to the Guiana Shield Amazonian forest, Georgetown contains more than 10% of Guyana's known bird species, found throughout the city's urban green and coastal blue space in differing levels of diversity (Hayes et al., 2019). By comparing sites within green and coastal blue space, we subsequently hypothesise that this observed variation in bird diversity will relate to variation in human psychological wellbeing (positive affect, negative affect, and anxiety). This study addresses important knowledge gaps, relating biodiversity to wellbeing in green versus coastal blue space in the global South.

3.3. Materials and methods

3.3.1 Study Design

Georgetown, the capital of Guyana in northern South America (Figure 3.1a-b), has a human population of ~192,000 (Bureau of Statistics 2012). Once a wetland, the city sits below sea level, protected from flooding by a sea wall (Edwards et al., 2005). There are many managed green spaces throughout the city, with two large public parks (National Park and Botanical Gardens), cemeteries, several smaller neighbourhood parks, and University of Guyana grounds.

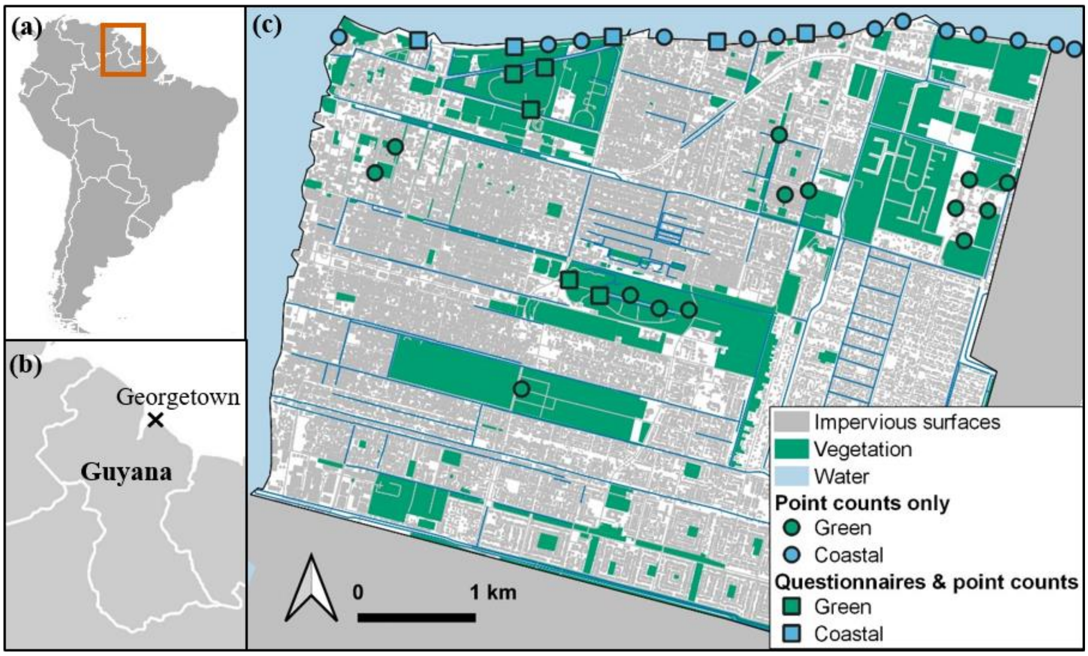


Figure 3.1: (a) Guyana, in northern South America, (b) Georgetown, along the north coast of Guyana and (c) sites in Georgetown (*n* = 19 green sites, *n* = 19 coastal sites) used for bird surveys (circles), and used for both bird surveys and questionnaires (squares) (*n* = 5 green sites, *n* = 5 coastal sites), and the distribution of the three environmental variables (impervious surfaces, vegetation, and water) across the city

We collected both questionnaire and bird point count survey data across Georgetown. First, sites were randomly selected (see Hayes et al., 2019 for full details) within green space (green sites, *n* = 19) and coastal blue space along the sea wall (coastal sites, *n* = 19). Sites were at least 250 m from one another to ensure spatial independence (Silva et al., 2015).

The green and coastal blue sites were defined and ground-truthed according to the predominant percent ground cover of a number of environmental variables within a 50 m radius of the site centre. This radius reflected the search area of the bird point count surveys, and the area participants were asked to consider when completing the questionnaire (see supplementary material Figure S3.1 for examples). The recorded environmental variables comprised impervious surfaces, vegetation (tree canopy, shrub, grass) and water (ocean, drains, pond, canals) (see supplementary material Table S3.1 for descriptions). As we were matching site-level biodiversity with people's momentary wellbeing, we delivered the questionnaire in 10 (*n* = 5 green sites, *n* = 5 coastal sites) of the 38 point count survey sites where people were known to visit (Figure 3.1c).

3.3.2 Questionnaire development and delivery

We invited participants to respond to a questionnaire about 'how people feel in Georgetown'. Three initial questions explored visit patterns that could affect momentary wellbeing, including how often they visit the site (visit frequency), who they were visiting with (type of company), and the reason for visiting on this occasion (visit motivation). These questions were asked first to reduce response bias (Robson and McCartan, 2016). To measure visit frequency, we asked: '*How frequently do you come past this spot*?' with five response options (*daily, weekly, monthly, less than monthly, yearly*), and '*Who are you with today*?' with six response options (*children, friends, partner, parents, alone, other*) to record type of company. These were followed by an open-ended question to gauge visit motivation: '*What is the main reason you are here today*?'.

Momentary psychological wellbeing was measured as positive affect, negative affect and anxiety, using existing validated scales commonly used in nature-wellbeing research (e.g. Cracknell et al., 2016, Wolf et al., 2017, Marselle et al., 2016). We asked participants to '*rate how you feel at the present moment in this spot*'. They were specifically and repeatedly asked to consider only a 50 m radius around them, to correspond with the area of the bird point count surveys. The Positive and Negative Affect Schedule (PANAS) asked participants for 10 positive and 10 negative emotions, on a five-point scale (1 = *not at all*, 2 = *slightly*, 3 = moderately, 4 = *quite a bit*, 5 = *extremely*) (Watson et al., 1988) (supplementary material Table S3.2a). Scores for each set of 10 emotions are summed to create a continuous measure (10 to 50) of positive and negative affect. The six-item State Trait Anxiety Inventory (STAI) (Marteau and Bekker, 1992) measures anxiety using the same stem question as for PANAS (supplementary material Table S3.2b). We modified response options from the original four-point to a five-point scale in keeping with PANAS, to reduce potential participant confusion. Negative items in STAI were reverse scored, then all scores were added together and multiplied by 3.33 to generate total in the range of 20-100 (Marteau and Bekker, 1992). Cronbach's α was used to check for internal consistency in each scale (Cronbach, 1951).

Using questions from the most recent Guyanese census (Bureau of Statistics 2012), we collected sociodemographic data on gender and age to ascertain whether our sample was representative of the Georgetown population. The questionnaire was piloted with 20 members of the public from varying demographic backgrounds. One adjustment was made to the original PANAS, replacing 'jittery' with 'uneasy' as participants found this easier to understand. Show cards were used to display response options from which participants selected answers, reducing the chance of skipped questions (OECD, 2013) and acting as a literacy aid. Questionnaires were delivered face-to-face to every third passer-by above the age of 18 during daylight hours (07:30-18:30) every day of the week, including weekends. Ethics approval was gained from University of Kent's Faculty of Social Sciences Research Ethics Advisory Group for Human Participants (Ref. No. 0511617).

3.3.3 Bird surveys

Bird point counts were conducted at green (n = 19) and coastal sites (n = 19), with one survey undertaken per site (see Hayes et al., 2019 for full details). Point counts took place on clear days, between 05:30 and 08:30, with each survey lasting 15 minutes. All birds seen within 50 m of the point count center, including those flying no more than 25 m above the highest structure, were recorded to species level. Anything flying higher than this threshold was deemed a flyover.

3.3.4 Analyses

Statistical analyses were performed using R version 3.5.0 (R Core Development Team 2019). Differences in the ground cover of environmental variables (impervious surfaces, vegetation and water) between green and coastal sites were compared using non-parametric two-sample Wilcoxon rank sum tests. Bird abundance, species richness, and Shannon diversity were also calculated for each of the 38 sites using the 'Vegan' package (Oksanen et al., 2018). No spatial autocorrelation was evident between sites (see supplementary text Section 3.1 for details). Non-metric multidimensional scaling (NMDS) was used to visualise the composition of bird communities in green and coastal sites (see supplementary text for details), using '*metaMDS*' (Oksanen et al., 2018), and statistical differences quantified with Analysis of Similarities (ANOSIM), using '*anosim*' (Oksanen et al., 2018). Sites where questionnaires were delivered (n = 5 sites per landcover type) contained bird communities representative of each type of landcover, with 80% falling inside each of the green or coastal NMDS minimum convex polygons (see supplementary text Section 3.1 for details). Comparisons between green and coastal sites where questionnaires were conducted were made using Wilcoxon rank sum tests.

The qualitative reasons for participants visiting a site (e.g. 'passing through') were coded iteratively by two authors (JCF, KNI) into codes (*n* = 27), themes (*n* = 9) and domains (*n* = 5) (supplementary material Table S3.4), based on a previously developed typology (Irvine et al., 2013). Chi-squared tests were used to compare differences in visit frequency, type of company and visit motivations between green and coastal sites. Analyses for visit motivations were conducted at domain level to overcome sample size limitations. A G-test was used to investigate if the sample population was representative of Georgetown.

Using the 'lme4' package (Bates et al., 2015), we created bivariate general linear mixed-effect models to assess initially whether levels of biodiversity could predict wellbeing, using 'site' as a random effect to control for independence. We used log-gamma error distributions for non-normal residuals for all wellbeing response measures. We also used an interaction term between the two NMDS axes from our bird community analysis (a measure of how the composition of species differs) as a fourth predictor in the bivariate models. Next, we produced adjusted general linear mixed-effect models that contained biodiversity measures alongside demographics (gender and age) and visit patterns (visit frequency, type of company, visit motivation) to see if these covariates were influencing the association between biodiversity and wellbeing. To improve power, we collapsed visit frequency categories into 'Daily', 'Weekly', and 'Monthly or Less', and visit company into 'Alone', 'Family', and 'Friends'. Numerical variables were centred, and we checked for multicollinearity using variance inflation factors, finding no issues. Checks for model fit, overdispersion and homoscedascity were carried out prior to analysis (Harrison et al., 2018; Zuur and Ieno, 2016).

3.4. Results

Both green and coastal sites contained a similar percentage ground cover of impervious surfaces (W = 17.5, p = 0.313) (Figure 3.2; supplementary Table S3.5).

Coastal sites were predominantly characterised by water (W = 25, $p < 0.05$) and green sites by vegetation (W = 0, $p < 0.001$).

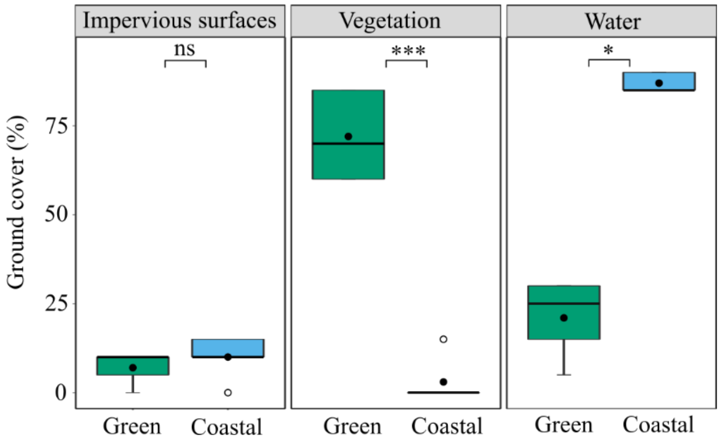


Figure 3.2: Percentage ground cover for the three environmental variables (impervious surfaces, vegetation, and water) across green and coastal sites where questionnaires were delivered (*n* = 5 per landcover type). Boxplots show range (whiskers) of data about the median (bold horizontal line), with the coloured box depicting the 25th and 75th quartiles. Hollow circles denote outliers, filled circles denote means. Star notation indicates significance level of analysis with Wilcoxon rank sum tests (ns = not significant; * = $p < 0.05$ *** = $p < 0.001$)

Across the 10 sites where questionnaires were conducted, 306 individuals participated (response rate = 70%), with 169 and 137 in green and coastal sites respectively. Overall, 58% of participants were women, and age ranged between 18 and 65+ years old. Although sample demographics were not representative of the wider Georgetown population (supplementary material Table S3.6), they were broadly similar between green and coastal sites (supplementary material Table S3.7). The frequency of visits to green and coastal sites was significantly different ($X^2 = 12.053$, df = 4, $p = 0.012$), with coastal sites visited more on a daily basis (41%) compared with green sites (30%), which had a higher percentage of yearly visits (23%) than coastal sites (59%) (supplementary material Tables S3.8-S3.10). For additional visit pattern outcomes, there were no significant difference between green and coastal sites (type of company: $X^2 = 6.689$, df = 4, $p = 0.153$; visit motivation at domain level: $X^2 = 6.625$, df = 4, $p = 0.157$), with almost half of all participants (47%) visiting both landcover types alone, and the majority (66%) visiting for physical activity.

All three scales measuring momentary psychological wellbeing showed good internal consistency (Cronbach's α: positive affect = 0.85; negative affect = 0.85; anxiety = 0.70). There were no significant differences in positive affect (W = 11396, p = 0.814) or anxiety (W = 21067, p = 0.931) between green and coastal sites. A significant difference in negative affect was identified (W = 9810.5, p = 0.014), whereby negative affect was lower in green space (Figure 3.3; supplementary Table S3.5).

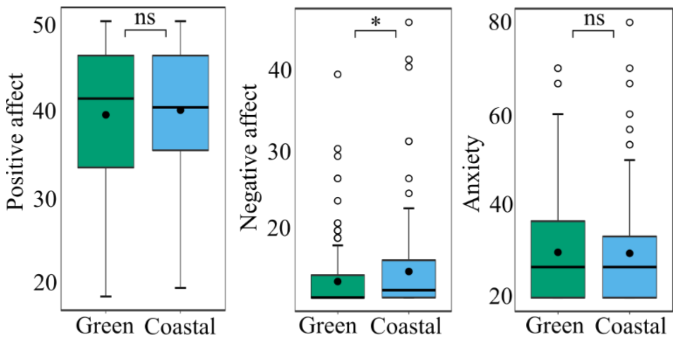


Figure 3.3: Momentary wellbeing measures (positive affect, negative affect, and anxiety) for visitors to green (n = 169 respondents, n = 5 sites) and coastal sites (n = 137 respondents, n = 5 sites) in Georgetown, Guyana. Boxplots show range (whiskers) of data about the median (bold horizontal line), with the coloured box depicting the 25th and 75th quartiles. Statistical significance level of analysis with Wilcoxon rank sum tests (ns = not significant; * = p < 0.05)

A total of 1298 individual birds were identified to species level during the point counts, with 72 and 26 species recorded at green and coastal sites respectively. Sampling effort was deemed adequate, based on species accumulative curves for green and coastal sites respectively (supplementary Figure S3.2). All measures of bird diversity were significantly higher in green compared to coastal sites (abundance: W = 25, p < 0.05; species richness: W = 25, p < 0.05; Shannon diversity: W = 23, p < 0.05) (Figure 3.4; supplementary Table S3.5).

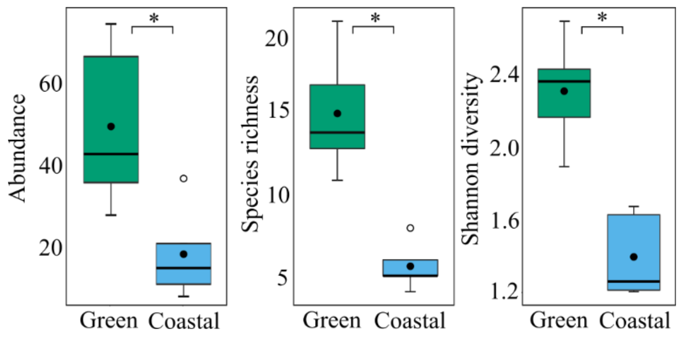


Figure 3.4: Measures of bird diversity (abundance, species richness, and Shannon diversity) measured from green sites (*n* = 5) and coastal sites (*n* = 5) where both point counts and questionnaires were delivered in Georgetown, Guyana. Boxplots show range (whiskers) of data about the median (bold horizontal line), with the coloured box depicting the 25th and 75th quartiles. Hollow circles denote outliers, filled circles denote means. Star notation indicates significance level of analysis with Wilcoxon rank sum tests (* = $p < 0.05$)

There were significant differences between the bird communities of green and coastal sites (ANOSIM: R = 0.79, p = 0.001) (Figure 3.5).

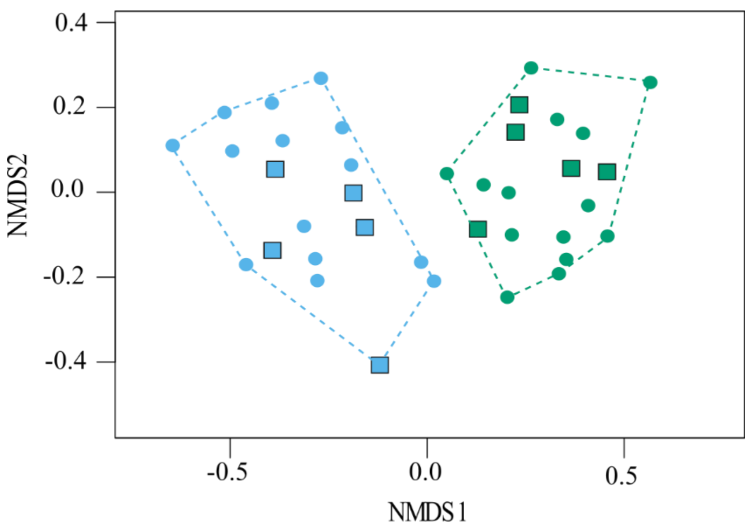


Figure 3.5: NMDS two-dimensional plot of bird assemblages from 38 sampled sites (19 coastal = blue circles and squares, 19 green = green circles and squares). Of these, questionnaires were delivered at 10 sites (5 coastal = blue squares, 5 green = green squares). A stress value of 0.16 was calculated. Green and coastal sites are grouped by their minimum convex polygon (dotted lines)

There was a statistically significant association between bird community composition and positive affect in green sites when tested with bivariate general linear mixed-effect models (supplementary material Table S3.11), which did not hold when adjusted for demographic covariates and visit patterns (Table 3.1). There were no associations between any other measures of momentary psychological wellbeing and bird diversity in the bivariate or adjusted models.

3.5. Discussion

Globally, the fastest rate of urbanisation into biodiversity-rich ecosystems is forecast for South America (Güneralp and Seto, 2013). Yet, the role of urban biodiversity for the provision of ecosystem services such as human wellbeing has yet to be fully acknowledged in this region (Pauchard and Barbosa, 2013). Here, we provide novel evidence from the global South that bird diversity (abundance, species richness, Shannon diversity, and community composition) is not associated with momentary psychological wellbeing (positive affect, negative affect, and anxiety). This is inconsistent with work from Europe that demonstrates bird species richness relates positively to wellbeing (continuity with the past, place attachment, Fuller et al., 2007; continuity with the past, place attachment, reflection, Dallimer et al., 2012, vitality, reduced anxiety, Wolf et al., 2017). Likewise, research from UK and Australia has shown that higher bird abundance relates to lower depression, anxiety, and stress (Cox et al., 2017), and to greater life satisfaction in a neighbourhood (Luck et al., 2011). However, comparisons between studies are complicated, not only because of their different geographical locations globally, but also due to the various measures of psychological wellbeing used and the context (e.g. back garden, neighbourhood). For example, Wolf et al., (2017) use STAI videos of birds in a laboratory setting to explore associations between biodiversity and anxiety, whereas Cox et al., (2017) use the Depression, Anxiety and Stress scale with bird point counts in a neighbourhood. Therefore, making generalised, overarching conclusions about associations between biodiversity and wellbeing remains difficult.

Table 3.1: Coefficients and 95% confidence intervals (CI) for log-gamma regression models testing whether three measures of psychological wellbeing (positive affect, negative affect and anxiety) can be predicted by four different measures of bird diversity (species richness, abundance, Shannon diversity, and community composition) across all sites (full questionnaire dataset; n = 306), green sites (*n* = 169 respondents, *n* = 5 sites) and coastal sites (*n* = 137 respondents, *n* = 5 sites). All models are adjusted for demographic covariates (age and gender) and visit patterns (visit frequency, type of company, and visit motivation at the domain level). Community composition represents an interaction between NMDS axes 1 and 2.

		Positive affect		**Negative affect**		**Anxiety**	
		Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Full dataset (*n* = 306)	Species richness	0.000	-0.006, 0.007	-0.006	-0.018, 0.005	-0.002	-0.015, 0.010
	Abundance	0.001	-0.000, 0.003	0.000	-0.003, 0.004	-0.001	-0.003, 0.000
	Shannon diversity	-0.027	-0.083, 0.028	-0.059	-0.141, 0.023	-0.017	-0.108, 0.073
	Community composition	-0.714	-2.036, 0.608	-0.597	-3.228, 2.035	-1.866	-4.049, 0.316
Green (*n* = 169)	Species richness	0.012	-0.003, 0.026	0.002	-0.019, 0.023	-0.014	-0.039, 0.010
	Abundance	0.050	-0.106, 0.206	0.027	-0.145, 0.199	-0.075	-0.003, 0.000
	Shannon diversity	-0.053	-0.132, 0.026	-0.001	-0.096, 0.094	0.017	-0.110, 0.144
	Community composition	-1.132	-3.836, 1.573	-0.378	-3.655, 2.899	-1.766	-5.803, 2.271
Coastal blue (*n* = 137)	Species richness	-0.018	-0.042, 0.007	0.015	-0.059, 0.090	-0.014	-0.116, 0.087
	Abundance	-0.002	-0.005, 0.001	-0.001	-0.006, 0.004	-0.008	-0.018, 0.003
	Shannon diversity	-0.003	-0.073, 0.080	-0.125	-0.261, 0.012	-0.126	-0.260, 0.007
	Community composition	-0.186	-0.903, 0.530	-0.385	-2.339, 1.569	-1.723	-3.575, 0.130

Momentary psychological wellbeing differed little between green and coastal sites. These findings contradict studies that report significantly higher levels of wellbeing associated with blue rather than green space (de Vries et al., 2016; Nutsford et al., 2016; White et al., 2010). As our findings suggest that bird diversity was unrelated to wellbeing, other features are likely to be driving the high positive affect and low anxiety observed. Attributes specific to coastal blue spaces, like crashing waves and oceanic smells, are reported as therapeutic (Bell et al., 2015), as well as vast panoramas and easy orientation, which relate to psychological wellbeing (Finlay et al., 2015; Völker and Kistemann, 2015). More research is needed into what factors of blue space influence psychological wellbeing, particularly to understand the higher levels of negative affect we found in coastal as opposed to green sites. Indeed, certain green space attributes like lighting, cleanliness, and tree abundance, as well as people's perceptions of attributes such as naturalness, comfort and beauty are known to influence wellbeing (Ayala-Azcárraga et al., 2019, Zhang et al., 2013, Francis et al., 2012, Akpinar 2016).

Disparity exists between how people's perceptions map onto objective reality, particularly in terms of biodiversity (Pett et al., 2016). This has been shown in two studies looking at the effects of actual and perceived biodiversity on psychological wellbeing, where bird species richness was incorrectly estimated (Dallimer et al., 2012; Fuller et al., 2007). Perceptions could be affected by specific species evoking positive or negative reactions based on cultural significance or childhood experience (Bell et al., 2018). For example, people have positive associations with culturally important songbirds (Brock et al., 2017; Clucas et al., 2015), and negative associations with local wildlife thought to be dangerous (Schuttler et al., 2019). These studies indicate that people's wellbeing experiences could relate to particular species or combinations of species present at the time (Bell et al., 2017; Palliwoda et al., 2017), and could explain why people's negative affect was significantly lower in green compared to coastal sites. Disparity between objective and perceived measures of biodiversity may also reflect the familiarity people have with local wildlife (Ratcliffe et al., 2018; Schuttler et al., 2019). For example, by assessing the identification skills of urban riparian green space visitors, Dallimer et al., (2012) showed that knowledge of birds was related to how accurately people estimate levels of biodiversity around them, with species common to domestic gardens more accurately recognised.

Bird diversity measures of abundance, species richness, and Shannon diversity of birds were much greater in green sites than at the coast, and the community composition was different between the two landcover types. The green spaces of Georgetown have been shown to contain sufficient tree cover and vegetation to support a high diversity of birds (Hayes et al., 2019), consistent with other studies in South American cities (Pauchard et al., 2006; Reis et al., 2012; Reynaud and Thioulouse, 2000). These findings emphasise the conservation value of green and coastal blue spaces in urban areas. Given evidence that cities can offer important habitat for threatened species (Ives et al., 2016), efforts should be made by urban planners to protect these spaces for both wildlife, as well as people.

3.6. Conclusion

As cities strive for sustainability, there are growing demands to simultaneously satisfy economic, social, and environmental needs (United Nations 2018). To meet these multiple demands, interdisciplinary studies are critical to highlight where co-benefits can be derived from particular land-use planning interventions (Hartig and Kahn 2016, Botzat et al., 2016). This study provides novel evidence regarding how wellbeing might be linked, or not, with biodiversity, comparing green and coastal blue space within the same global South city. Our evidence suggests that there is no direct association between bird diversity and wellbeing for people in Georgetown. It is likely that features specific to green and coastal blue space, as well as people's perceptions of these sites, are contributing positively to wellbeing, which require further work to uncover. Nonetheless, we suggest that conserving bird diversity and encouraging visits to Georgetown's green and coastal blue space could benefit the human and avian populations alike. The research is important for city planning authorities, conservationists and public health professionals who seek to manage urban environments to conserve wildlife, while improving the quality of life for people in rapidly developing cities.

3.7. Acknowledgements

We thank A.Harris, K.Hernandez, K.Joshi, J.Kennedy, L.Moore, B.O'Shea, M.Pierre, S.Rampertab, D.Somwaru, and H.Yang. Logistical support was provided by Guyana

Protected Areas Commission and WWF. The project was supported by grants to JCF from RGS with IBG (Dudley Stamp Award), ESRC (ES/J500148/1) and NERC (NE/L002582/1). KNI was supported by the RESAS Division of the Scottish Government. KNI and ZGD are funded by ERC Consolidator Grant 726104. Permission was provided by the Guyana Environmental Protection Agency (051117BR006).

3.8. Supplementary information

(a) **(b)**

Figure S3.1: Photographic images taken from Georgetown, Guyana, from a (a) green site, and (b) coastal site

Table S3.1: Description of ten environmental variables within three parent categories used to assess site type in Georgetown, Guyana. Percentage ground cover of each environmental variable was estimated within a 50 m radius of the site centre

Parent Category	Environmental Variable	Description
Impervious surfaces	Buildings	Permanent structure such as house, factory, or wall
	Roads	Paved area for vehicle travel, including off-road tracks
	Pavements	Compacted hard surface, such as pedestrian walkway, parking, and sea wall promenade
Vegetation	Tree canopy	Woody vegetation above 2 m
	Shrub	Woody vegetation below 2 m
	Grass	Herbaceous vegetation
Water	Ocean	Coastal water, including mud
	Drains	Roadside sewage drains
	Pond	Man-made water bodies as well as flooded areas
	Canals	Artificial waterways wider than 2 m

Table S3.2: Psychological wellbeing scales used in a short face-to-face questionnaire: (a) Positive and Negative Affect Schedule (PANAS), containing 10 positive and 10 negative words, and (b) State-Trait Anxiety Inventory (STAI) six-item short-form, containing six words that relate to anxiety

(a) Positive and Negative Affect Schedule (PANAS)

Please rate how you feel now, at the present moment, in this spot where you are standing.

Response options: *Not at all, A little, Moderately, Quite a bit, Extremely*

1. Enthusiastic	11. Uneasy
2. Scared	12. Nervous
3. Afraid	13. Ashamed
4. Interested	14. Active
5. Upset	15. Strong
6. Determined	16. Guilty
7. Excited	17. Proud
8. Distressed	18. Attentive
9. Inspired	19. Irritable
10. Alert	20. Hostile

(b) Spielberger State-Trait Anxiety Inventory (STAI) six-item short-form:

Please rate how you feel now, at the present moment, in this spot where you are standing.

Response options: *Not at all, A little, Moderately, Quite a bit, Extremely*

1. I feel calm
2. I feel tense
3. I feel upset
4. I am relaxed
5. I feel content
6. I am worried

Text Section 3.1:

Spatial autocorrelation

Given that sites that are geographically closer in space may produce data that are more similar than those that are further apart, we tested for spatial autocorrelation. Specifically, we tested whether the wellbeing measures from sites that were geographically closer together were more similar. Using a Mantel test with 999 permutations, we detected no evidence of spatial autocorrelation in our outcome variables of positive affect (r = -0.003 p = 0.55), negative affect (r = -0.001, p =0.49), and anxiety (r = -0.036, p = 0.985). We used the same method to test for spatial autocorrelation in the bird diversity measures. Similarly, we found no evidence of spatial autocorrelation for abundance (r = -0.069, p = 0.608), species richness (r = -0.069, p = 0.599), or Shannon diversity (r = -0.069, p = 0.589).

Non-metric multidimensional scaling

This enables visual representation of how communities at each site differ, represented in community dissimilarity space. Sites are coloured as either green or coastal, and connected to form a convex polygon. A 'stress' measure < 0.2 indicates good representation of points in this two-dimensional space (Kenkel and Orloci 1968).

Site-level biodiversity

We matched measures of bird diversity to the 10 sites where wellbeing data had also been collected. However, as only one point count was conducted per site, reliable estimates of diversity could only be made when all 19 sites per landcover type were considered. Using only a subset of sites in our analyses makes the assumption that the diversity measures in the subset (n = 5 per landcover type) represent the diversity in the total sample (n = 19 per landcover type). We test this assumption using a number of statistical analyses.

To compare the mean and variance of each diversity measure at the questionnaire sites with diversity measures at the point count only sites, we computed two-sample Kolmogorov-Smirnov tests and a two-sample F test for the mean and variance respectively. We found no significant differences in abundance, species richness, or

Shannon diversity between questionnaire sites and sites where only point counts were conducted.

Table S3.3: Two sample Kolmogorov-Smirnov and F-tests comparing the mean and variance between sites where questionnaires were conducted (*n* = 5 green, *n* = 5 coastal) with sites where only point counts were conducted (*n* = 14 green, *n* = 14 coastal)

	Kolmogorov-Smirnov		**F test**	
	D	***p***	**F**	***p***
Green				
Abundance	0.329	0.821	0.545	0.364
Richness	0.371	0.690	1.662	0.664
Shannon	0.643	0.066	1.953	0.544
Coastal blue				
Abundance	0.415	0.562	2.006	0.525
Richness	0.338	0.803	1.778	0.612
Shannon	0.523	0.212	1.254	0.901

We calculated a non-parametric Analysis of Similarity (ANOSIM) test of community composition between sites where questionnaires were conducted, and sites where the remainder of the point counts were conducted (*n* = 14 per landcover type). ANOSIM uses a Bray-Curtis dissimilarity matrix which indicates differences in community composition (0 = communities are identical; 1 = communities are highly distinguishable). We show that bird communities at green sites where questionnaires were conducted (*n* = 5) demonstrated a high degree of similarity to bird communities at the remainder of the green point count sites (*n* = 14) (ANOSIM: R = 0.03, *p* = 0.42). Likewise, the bird communities at coastal sites where questionnaires were conducted (*n* = 5) were very similar to communities at the rest of the coastal sites (*n* = 14) (ANOSIM: R = 0.11, *p* = 0.21).

To examine whether the detection of species differed between questionnaire sites (*n* = 5 per landcover type) and the rest of the point count sites (*n* = 14 per landcover type), we calculated Simple Matching Coefficients (SMC). This index assesses similarity in patterns of species occurrence between paired sites on a scale of 1 (sites are identical) to 0 (sites are unique). Initially, we partitioned the dataset into sites where questionnaires were conducted (*n* = 5 green, *n* = 5 coastal), and where only point counts were conducted (*n* = 14 green, *n* = 14 coastal). We then converted species data into a binary detection matrix (0 = absent; 1 = present), to facilitate pairwise species comparisons between each questionnaire site and each point-count-only site (n = 70 pairwise comparisons per landcover type). For each landcover type, patterns of detection were summed to assess similarities in species occurrence between questionnaire and point count sites. We found a high degree of community similarity between sites where questionnaires were conducted, compared to where sites where the rest of the point counts were conducted (Green: SMC mean = 0.72, sd = 0.18; Coastal: SMC mean = 0.72, sd = 0.14).

Thus, the collective results from the Kolmogorov-Smirnov and F tests, ANOSIM, SMC, and NMDS all suggest that our subset of diversity measures are representative of landcover type-level diversity.

Table S3.4: Table of the codes, themes, and domains associated with the reasons for visiting green (G) (*n* = 169) and coastal blue (C) sites (*n* = 137) in Georgetown. Participants were asked to provide one answer to 'What is the main reason you are here today?'. Answers to this question were subsequently coded by two authors (JCF and KNI). 27 codes were then grouped into nine themes and five overall domains. Numbers represent the number of coded answers at green and coastal sites

Code	**Green**	**Coastal**	**Theme**	**Green**	**Coastal**	**Domain**	**Green**	**Coastal**
A walk	6	12						
Walk dog	1	0						
Sport	4	0	Physical Pursuits	74	66			
Exercise	63	54						
Passing through	7	2	Casual pursuits	21	9	Physical	106	96
Route home/work	14	7						
Eat	1	0						
Relax	7	15	Physical Restoration	11	21			
Chill Out	3	6						
Fresh air	2	9						
Get outside	2	2	Nature	6	13			
View	1	2						
Atmosphere	2	2				Space qualities	18	16
Zoo	8	0	Features	11	3			
Nice place	2	1						
History of use	1	0	Place identity	1	0			
Purposeful work	5	2						
Photography	1	0	Mental pursuits	6	3			
Think	0	1				Cognitive	6	8
Take a break	0	1						
Relax my mind	0	4	Attention Restoration	0	5			
Hang out	9	3						
Family outing	4	1	Socialising	14	5	Social	15	5
Meet friends	2	1						
Unstructured time	1	3						
Visit	18	6	Passing time	24	12	Unstructured time	24	12
Recreation	5	3						

Table S3.5: Summary statistics for environmental variables and bird diversity measures, as well as momentary wellbeing measures, delivered at green sites (n = 5) and coastal sites (n = 5) in Georgetown, Guyana

	Green		Coastal	
	Mean (SE)	**Range**	**Mean (SE)**	**Range**
Environmental variables				
Impervious surfaces	7 (2)	0 - 10	10 (2.74)	0 - 10
Vegetation	72 (5.61)	60 - 85	3 (3)	0 - 15
Water	21 (4.85)	5 - 30	87 (1.22)	85 - 90
Momentary wellbeing				
Positive affect	39.12 (0.64)	18 - 50	39.66 (0.64)	19 - 50
Negative affect	12.15 (0.32)	10 - 40	13.50 (0.51)	10 - 47
Anxiety	29.88 (0.91)	20 - 70	29.66 (1.00)	20 - 80
Bird diversity				
Abundance	49.8 (9.06)	28 - 75	18.4 (5.13)	8 - 37
Species richness	15.2 (1.74)	11 - 21	5.6 (0.68)	4 - 8
Shannon diversity	2.31 (0.30)	1.89 - 2.69	1.40 (0.10)	1.20 - 1.67

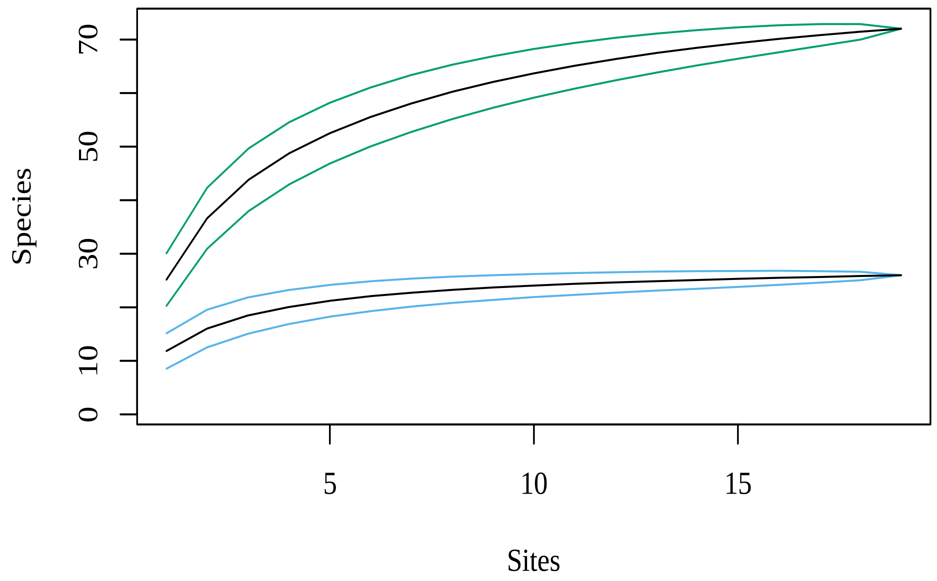


Figure S3.2: Estimated bird species richness rarefaction curves from 19 green sites (green lines) and 19 coastal sites (blue lines) sampled in Georgetown, Guyana. Coloured lines indicate 95% confidence intervals. Both curves tend toward asymptote, indicating sufficient sampling effort in both landcover types

Table S3.6: Comparison of sociodemographic background of questionnaire participants (*n* = 306) compared with Georgetown's population according to the most recent census (Bureau of Statistics 2012). G-test for goodness of fit showed that the sample was not representative of the city's population

Variable	Sample (*n*)	Census (*n*)	X^2	Df	*p* value
Gender			13.05	2	0.001
Female	130	62162			
Male	176	56207			
Other	0	0			
Age			35.34	6	< 0.001
18-24	93	26.8			
25-34	74	24.3			
35-44	46	18.9			
45-54	35	13.5			
55-64	40	6.9			
65+	18	6.9			
Other	0	2.6			

Table S3.7: Comparison of sociodemographic background of participants who took part in questionnaires in green space (*n* = 169) versus coastal sites (*n* = 137) in Georgetown. Chi-squared goodness of fit tests show that the sociodemographic composition samples were comparable

Variable	Green (%)	Coastal (%)	X^2	df	*p* value
Gender			1.441	1	0.230
Female	57.66	30.18			
Male	65.69	50.89			
Other	0	0			
Age			2.095	5	0.836
18-24	39.42	23.01			
25-34	30.66	18.93			
35-44	19.71	11.24			
45-54	12.41	10.65			
55-64	16.06	10.65			
65+	5.12	6.51			
Other	0	0			

Table S3.8: Participant answers in short questionnaire: visit company delivered at green (n = 169) and coastal sites (n = 137) in Georgetown, Guyana. Participants were asked: 'Who are you with today?'. Chi-squared goodness of fit tests find population probabilities are equal between green and coastal sites: $X^2 = 6.689$, df = 4, $p = 0.153$

Who are you with today?	**Green (%)**	**Coastal (%)**
Alone	42.6	52.67
Family	16.6	11.72
Friends	23.1	17.52
Kids	3.0	6.69
Partner	14.8	11.72

Table S3.9: Participant answers in short questionnaire: visit frequency delivered at green (n = 169) and coastal sites (n = 137) in Georgetown, Guyana. Participants were asked: 'How frequently do you come past this spot?'. Chi-squared goodness of fit tests find population probabilities are unequal between green and coastal sites: X^2 = 12.053, df = 4, p = 0.012

How frequently do you come past this spot?	**Green (%)**	**Coastal (%)**
Daily	30.25	40.96
Weekly	27.85	29.94
Monthly	13.02	13.92
Less than monthly	6.51	9.51
Yearly	22.54	5.88

Table S3.10: Participant answers in short questionnaire: visit motivation delivered at green (n = 169) and coastal sites (n = 137) in Georgetown, Guyana. Participants were asked: 'What is the main reason you are here today?'. Answers coded by two authors (JCF and KNI), then grouped into 27 codes, nine themes of codes, and five overall domains (presented here). Chi-squared goodness of fit tests find population probabilities are equal between green and coastal sites: X^2 = 6.625, df = 4, p = 0.157

Domain	Green (%)	Coastal (%)
Physical	77.37	56.80
Space qualities	13.14	9.47
Cognitive	4.38	4.73
Social	10.95	2.96
Unstructured time	17.52	7.10

Table S3.11: Coefficients and 95% confidence intervals (CI) for 36 bivariate log-gamma regression models testing whether three measures of psychological wellbeing (positive affect, negative affect and anxiety) can be predicted by four different measures of bird diversity (species richness, abundance, Shannon diversity, and community composition) across all sites (full questionnaire dataset; *n* = 306), green sites (*n* = 169), and coastal sites (*n* = 137). Bivariate models testing the effect of biodiversity measures (predictor) on wellbeing measures (response) for the full questionnaire dataset (*n* = 306

		Positive affect		**Negative affect**		**Anxiety**	
		Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Full dataset (*n* = 306)	Species richness	-0.002	-0.009, 0.005	-0.007	-0.018, 0.004	0.001	-0.010, 0.011
	Abundance	0.000	-0.002, 0.001,	-0.002	-0.005, 0.001	-0.001	-0.003, 0.002
	Shannon diversity	-0.041	-0.095, 0.014	0.004	-0.084, 0.091	0.004	-0.084, 0.091
	Community composition	-0.916	-2.262, 0.431	-1.102	-3.601, 1.398	-1.541	-3.418, 0.336
Green (*n* = 169)	Species richness	-0.002	-0.020, 0.016	0.005	-0.009, 0.019	0.000	-0.016, 0.015
	Abundance	0.000	-0.004, 0.003	0.000	-0.003, 0.003	-0.001	-0.004, 0.002
	Shannon diversity	-0.040	-0.120, 0.0411	0.034	-0.063, 0.131	0.034	-0.063, 0.131
	Community composition	**-2.369**	**-3.982, -0.756**	-0.029	-2.607, 2.548	-0.116	-2.717, 2.485
Coastal blue (*n* = 137)	Species richness	-0.008	-0.041, 0.026	0.008	-0.062, 0.078	-0.012	-0.093, 0.070
	Abundance	-0.001	-0.006, 0.003	-0.002	-0.011, 0.007	-0.006	-0.014, 0.003
	Shannon diversity	-0.043	-0.121, 0.035	-0.121	-0.254, 0.011	-0.068	-0.200, 0.064
	Community composition	-0.237	-1.105, 0.631	-0.401	-2.196, 1.395	-1.207	-2.872, 0.459

Chapter 4. Perceived biodiversity, sound, naturalness and safety enhance the restorative quality and wellbeing benefits of green and blue space in a neotropical city

Jessica Claris Fisher[1], Kate Nesbitt Irvine[2], Jake Emmerson Bicknell[1], William Michael Hayes[1], Damian Fernandes[3], Jayalaxshmi Mistry[4], Zoe Georgina Davies[1]

[1] Durrell Institute of Conservation and Ecology (DICE), University of Kent, Canterbury CT2 7NR, UK

[2] Social, Economic and Geographical Sciences, James Hutton Institute, Craigiebuckler, Aberdeen AB15 8QH, UK

[3] Conservation International Guyana, 98 Laluni St, Georgetown, Guyana

[4] Department of Geography, Royal Holloway University of London, Egham Hill, Egham TW20 0EX, UK

Manuscript published as:

Fisher JC, Irvine KN, Bicknell JE, Hayes WM, Fernandes D, Mistry J, Davies ZG. 2021. Perceived biodiversity, sound, naturalness and safety enhance the restorative quality and wellbeing benefits of green and blue space in a neotropical city. Science of the Total Environment 755: 143095

4.1 Abstract

Urban land cover expansion and human population growth are accelerating worldwide. This is resulting in the loss and degradation of green and blue spaces (e.g. parks, waterways, lakes) in cities, which provide resources to sustain biodiversity and improve human wellbeing. The specific characteristics of these spaces (e.g. sounds, species, safety) that enhance or detract from wellbeing are underexplored, yet this knowledge is needed to inform urban planning, management and policies that will ultimately benefit both people and biodiversity. Research of this kind is rarely conducted in the global South, where rapid urbanisation threatens biodiversity-rich ecosystems of worldwide significance. Here, we examine how perceptions of green, waterway, and dense urban spaces relate to wellbeing in Georgetown, Guyana. Specifically, we use mediation models to test how perceptions of sound, bird species richness, naturalness, and safety concerns contribute to sites being perceived as restorative which, subsequently, influences wellbeing. We assess the accuracy of these site perceptions with objective measures of sound (using a bioacoustic sound index), bird species richness, and percent coverage of vegetation, water, and impervious surfaces. Results showed that if sites were perceived as species rich, containing natural sounds like birdsong, natural rather than artificial, and safe, they were perceived as more restorative, resulting in improved wellbeing. In general, people's perceptions were consistent with objective measures. Green, compared with waterway and dense urban sites, contained more biophonic sounds, higher species richness, greater vegetation and water coverage. Although waterways were biodiverse, they were dominated by anthrophonic sounds, so were perceived as artificial and non-restorative. We shed light on how city planners might augment specific characteristics to improve the wellbeing of urban dwellers, with implications for biodiversity conservation. Our findings provide a scientific evidence base for urban design and management plans that could deliver multiple co-benefits, particularly in biodiversity-rich cities in neotropical regions.

Keywords: Birdsong; conservation; global South; Guyana; species richness; urban.

4.2 Introduction

Globally accelerating rates of urbanisation pose challenges for human health and wellbeing (Giles-Corti et al., 2016), with exposure to noise, environmental pollution and crime contributing to physical illnesses and psychological disorders for city dwellers (Abbot, 2012; Peen et al., 2010). Within the urban landscape of the global North, fragments of green space (e.g. parks, meadows, gardens) have been shown to benefit self-reported general health (Wheeler et al., 2015), reduce the risk of cardiovascular and respiratory disease (Lee et al., 2014; Liddicoat et al., 2018), and improve psychological wellbeing (White et al., 2017). More recently, the wellbeing benefits of blue spaces (e.g. inland waterways, lakes, rivers) have been related to improvements in anxiety, stress and emotional wellbeing (Maund et al., 2019), better self-reported general and mental health (Pasanen et al., 2019), improved subjective wellbeing and lower risk of depression (Garrett et al., 2019). Through carefully targeted interventions, such as incorporating new and/or enhancing existing green and blue spaces in cities, relatively small health and wellbeing gains at an individual level could scale-up to substantial benefits across entire populations.

Research into the characteristics of urban green and blue spaces that enhance or detract from human wellbeing is providing important detail to inform land-use planning and management decisions. For example, seeing trees relates to higher momentary mental wellbeing (Bakolis et al., 2018), and feeling safe in blue space relates to greater subjective wellbeing (Garrett et al., 2019). Similarly, unmanaged vegetation is perceived as more 'natural', and this perceived degree of naturalness is associated with increased perceived restorativeness (the potential for an environment to restore attentional fatigue or stress, Hartig et al., 1997) (Hoyle et al., 2019). However, evidence for the role that biodiversity plays in underpinning human wellbeing in urban green spaces is equivocal (Carrus et al., 2015; Cox et al., 2017; Dallimer et al., 2012; Fuller et al., 2007; Wolf et al., 2017). Species richness or abundance of taxa, such as birds and butterflies, have been found to improve wellbeing, although trends are inconsistent and complicated by the use of different metrics of wellbeing and biodiversity. The variation in results may also be explained by a mismatch in the levels of biodiversity people perceive to be present, compared with what objectively exists (Dallimer et al., 2012). These differences could be informed by personal preferences that influence whether the experience is positive or negative (Bell et al., 2019; Clayton et al., 2017; Pett et al., 2016). As such, characteristics that positively influence people's wellbeing may not be the same as those that conservationists seek to support. Pett et al., (2016) argue that it is crucial researchers consider this paradox if we are to effectively align public health and conservation objectives and outcomes within urban green (and blue) spaces.

People's perceptions of green and blue spaces characteristics can be informed by a variety of sensory cues (Franco et al., 2017). Evidence shows, for instance, that more colourful planting regimes in green spaces provide greater aesthetic enjoyment (Hoyle et al., 2018). The role of sound is increasingly been examined by researchers. For example, birdsong increases perceived restorativeness (Ratcliffe et al., 2018), while other natural sounds (e.g. breeze in the trees) are found to be more pleasant than anthropogenic sounds (e.g. mechanical, people) (Irvine et al., 2009), relating to more positive emotions and higher mental wellbeing (Bakolis et al., 2018; Moscoso et al., 2018). This might subsequently lead to features such as trees and birds being proactively managed for in public spaces. Nonetheless, understanding how people's perceptions of sound relate to objective measurements is needed to inform the actual design of urban green and blue spaces that maximise benefits to human health and wellbeing. To date, objective sound measures used within nature-health research have focussed on sound pressure, to inform policies aimed at reducing noise pollution and preserving 'urban quietness' (Evensen et al., 2016; Irvine et al., 2009; Payne and Bruce, 2019). Payne and Bruce (2019) highlight the need for additional metrics to help explore soundscape attributes that affect human wellbeing. Ecologists have developed a suite of bioacoustic indices for biodiversity monitoring, where recordings capture noise from specific features like animals, machinery or rain (Bradfer-Lawrence et al., 2019). Thus far, few studies have sought to relate bioacoustic indices to human perceptions, but Carruthers-Jones et al., (2019) found strong correlative associations between acoustic indices and people's perceptions of wildness across an urban-wild gradient.

To aid our understanding of how objective and perceived green and blue space characteristics influence health and wellbeing, there have been calls for studies to be structured around testing the pathways within existing conceptual frameworks (Hartig et al., 2014; Markevych et al., 2017). Additionally, to enable comparisons to be drawn between studies, there are calls for consistency in the choice of measures used to assess these pathways as well as outcome variables. For example, perceived restorativeness acts as a 'mediator' (a variable, 'M' that intervenes in the relationship between 'X' and 'Y'; Hayes, 2009) when explaining how perceived bird diversity and perceived naturalness influence positive and negative wellbeing ('affect') and happiness after an outdoor walk (Marselle et al., 2016). In the same way, outcome measures, including positive/negative affect (Hartig et al., 1997; Marselle et al., 2016) and 'state' anxiety (Lee et al., 2014; Wang et al., 2016; Wolf et al., 2017), have been identified as important short-term outcomes resulting from interactions with nature, although state anxiety has yet to be tested with perceived restorativeness as a mediator.

The majority of nature-wellbeing studies originate from the global North (Hossain et al., 2020). However, findings from this body of work may not be directly transferable to the global South, where the green and blue characteristics that are important for human wellbeing may vary as a result of differing climates, cultures, and socio-economic challenges (Rigolon et al., 2018; Saw et al., 2015). Global South cities are also subject to faster rates of urban land cover expansion (Angel et al., 2011) and population growth (United Nations, 2018), which concomitantly put pressure on existing urban green and blue spaces, and the incorporation of new ones into development plans (Richards et al., 2017). In South America, the rate of urbanisation into biodiversity-rich areas is predicted to be faster than elsewhere in the world (Güneralp and Seto, 2013). Here, we investigate how perceptions of urban green and blue spaces' characteristics are related to human wellbeing in Guyana, northern South America. Georgetown, Guyana's capital city, was historically referred to as the 'Garden City of the Caribbean' (Edwards et al., 2005) and contains a wealth of urban green and blue spaces that host a rich diversity of birds, given its proximity to the Guiana Shield Amazonian forest (Hayes et al., 2019).

Here, we investigate how people's perceptions of certain green and blue space characteristics within Georgetown relate to their momentary wellbeing (positive and negative affect, and anxiety), compared with dense urban spaces in the city centre that are predominately built infrastructure. Specifically, we explore how perceptions of sound, perceptions of bird species richness, perceived naturalness and concerns for personal safety all contribute to the perceived restorativeness of the green/blue spaces, and whether perceived restorativeness as a mediator of people's wellbeing. Finally, we assess people's perceptions of sound, bird species richness, and perceived naturalness in relation to objective measures. Taken together, these findings are valuable to decision-makers tasked with designing, restoring, maintaining and enhancing urban green and blue spaces in global South cities like Georgetown.

4.3 Methods

4.3.1 Study Area

Georgetown, capital of Guyana (Figure 4.1a), contains many green and blue spaces, including a large botanical garden, several public parks, and abundant vegetation alongside the roads and inland waterways. The neotropical city covers approximately 30 km^2 and contains 15 % (~192,000 people) of Guyana's population, characterised by a high diversity of ethnicities and socioeconomic backgrounds (Bureau of Statistics 2012).

We undertook point-count surveys for birds, made sound recordings, and conducted questionnaires across Georgetown. First, survey sites were randomly selected with a minimum distance of 250 m between them to ensure independence (Silva et al., 2015). We examined sites across three landcover types: public parks (National Park and Botanical Gardens) (green, n = 19); artificial freshwater waterways (waterways, n = 19); and built-up residential or commercial areas that predominately comprise buildings and roads (dense urban, n = 19) (Figure S4.1). Landcover types were defined and ground-truthed by the ground coverage (%) of nine environmental variables within a 50 m radius of the central point of the site, matching the search area of the point count bird surveys and the area participants were asked to consider around them during the questionnaire (see Section 4.3.3 for details).

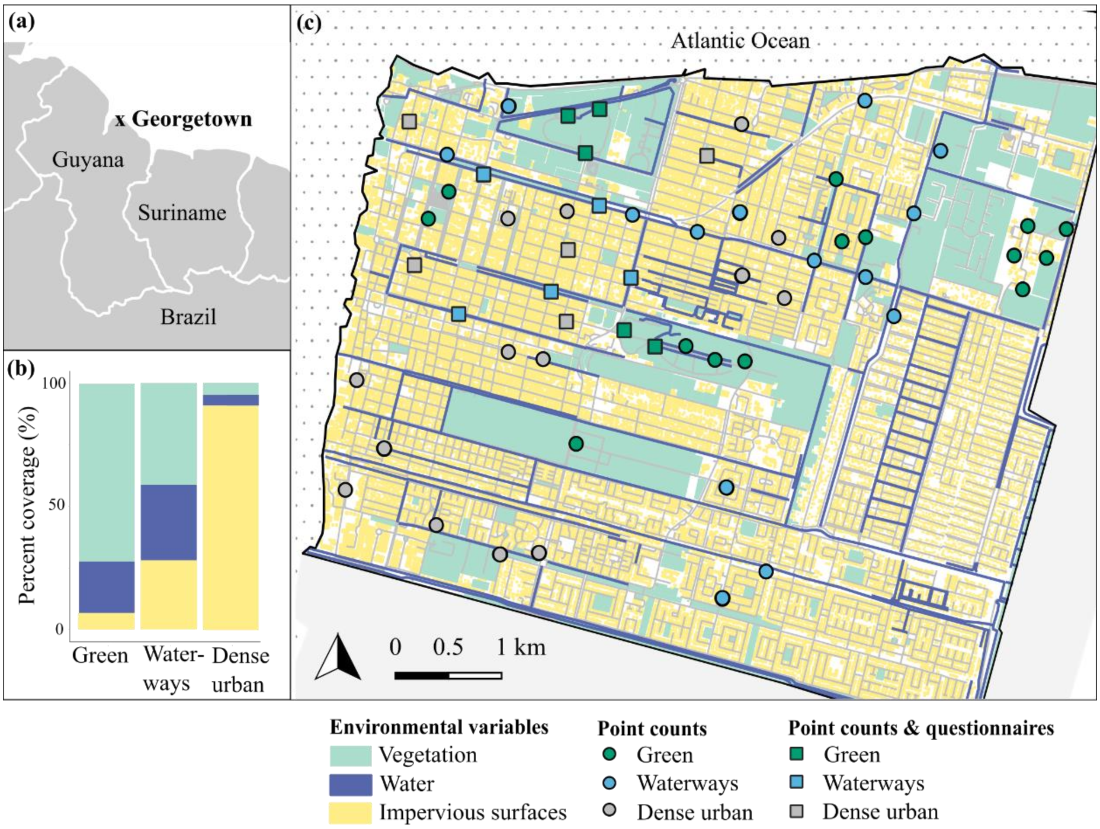


Figure 4.1: Map of the study area in Georgetown Guyana. (a) Location of Georgetown in Guyana, South America, (b) percent cover of environmental variables (vegetation = light green, water = dark blue, impervious surfaces = yellow), within each of three landcover types (green, blue, dense urban), (c) map of the landcovers and sites (*n* = 19 green sites, *n* = 19 waterway sites, *n* = 19 dense urban sites) used for bird point counts (circles), and for both bird point counts and questionnaires (squares) (green, *n* = 5 green sites, *n* = 5 waterway sites, *n* = 5 dense urban sites)

4.3.2 Objective measures

We grouped percent coverage of the nine environmental variables into three objective measures of landcover: vegetation (tree, shrub, grass); water (ponds, canals, drains); and impervious surfaces (buildings, roads, pavements) (Figure 4.1b). We conducted point count surveys for birds at each of the 57 sites (Figure 4.1c) as part of an associated study on bird diversity across Georgetown (Hayes et al., 2019). Point counts were carried out on clear days between 05:30 and 08:30, using a fixed radius of 50 m, and recording all birds seen or heard in 15 minutes (Huff et al., 2000) to species level. All birds were considered part of the survey if flying within 25 m of the highest structure, whereas birds above this threshold were deemed to be flyovers. Finally, we quantified the soundscape by taking sound recordings as the questionnaires were delivered (n = 5 per landcover type). We took sound recordings using a digital recorder (Zoom H4N Pro), with microphones set on maximum sensitivity (+100, at a sensitivity rating of −45 dB/1 Pa at 1 kHz) to capture the wide range of sounds that exist in an urban soundscape, and a microphone wind shield to remove distortion.

4.3.3 Questionnaire design

We delivered questionnaires at 15 of the 57 sites (n = 5 per landcover type), where a sufficient number of people passed by, so people's momentary wellbeing, as well as objective and perceived measures, could be compared. We first asked about people's visit patterns, including: visit frequency '*How frequently do you come to this spot*?' (*daily, weekly, monthly, less than monthly, yearly*); visit company '*Who are you with today*?' (*kids, friends, partner, parents, alone, other*); and visit motivations with an open question '*What is the main reason you are here today*?'. We asked these questions at the beginning to reduce response bias (Robson and McCartan, 2016).

To measure perceived restorativeness, we asked participants to rate the extent to which 16 statements reflected their experience '*in this spot where we are standing*' (Perceived Restorativeness Scale, Hartig et al., 1997). Participants responded on a five-point scale (1 = *not at all*, 2 = *a little*, 3 = *moderately*, 4 = *quite a bit*, 5 = *extremely*), modified from the original seven-point one to be consistent with the other scales used in the questionnaire and reduce potential participant confusion (Table S4.1). We created a single perceived restorativeness index by reversing negative statements then summing all 16 (index ranging from 10 to 80), resulting in good internal consistency (Cronbach's α = 0.85) (Cronbach, 1951).

To measure momentary wellbeing, we then asked participants to '*rate how you feel at the present moment in this spot*' for each of 10 positive (positive affect) and 10 negative (negative affect) emotions (Positive And Negative Affect Schedule, PANAS) (Watson et al., 1988), using the same five-point scale as for perceived restorativeness. Scores for each set of 10 emotions are summed to create a continuous measure (ranging from 10 to 50) of positive and negative affect (Table S4.2). To assess anxiety, we used the State-Trait-Anxiety-Inventory (STAI), which has the same stem question as PANAS (Marteau and Bekker 1992) (Table S4.2). Once again, we used a five-point rather than the original four-point response scale. Negatively-worded items were reverse-scored, then all scores were summed and multiplied by 3.33 to generate a range of 20 to 100. All scales were internally consistent: positive affect (Cronbach's α = .0.85), negative affect (Cronbach's α = 0.68), and anxiety (Cronbach's α = 0.7).

Enjoyment of nearby sounds was quantified on a continuous scale (1 = strongly disagree, 5 = strongly agree) in response to the statement '*I like the sounds I hear in this spot we are standing*'. We then asked participants 'What three sounds can you hear in this spot?. Perceived biodiversity was measured by asking '*how many different types of birds would you say could normally be found in this spot*?', with a seven-point scale offering options (< *5, 5 to 15, 16 to 25, 26 to 35, 36 to 50, 51 to 75, 75+*) that related directly to the bird point count data. The scale was based on the quartiles of average site-level diversity, with the lower tail offering an option for fewer species than could actually be found, and the upper half of the scale lengthened to incorporate the highest measure found at the most species-rich site. We assessed perceived naturalness with the question '*how natural would you say this area was*?' on a continuous scale (1 = *very natural*, 5 = *very artificial*). Participants also rated the extent to which '*I feel unsafe in this place*', using the same five-point scale used for perceived restorativeness.

To account for covariation amongst sociodemographic groups, we recorded gender, age, ethnicity, religion, and education using questions from Guyana's most recent census (Bureau of Statistics, 2012), and a household income question generated through conversation with experts. A measure of 'residential history' was created by asking participants where, if anywhere, they had lived prior to Georgetown, given evidence that it could influence perceptions (Colléony et al., 2017; Moscoso et al., 2018). We did this through two dichotomous questions: '*Do you live in Georgetown*?' and '*Have you ever lived outside of Georgetown*?'. Two categories were drawn out: (1) urban (entire life spent in Georgetown), (2) rural (some time spent living in the interior of Guyana, or time spent living outside the country).

We piloted the questionnaire with 20 members of the public from varying sociodemographic backgrounds. Within PANAS, the emotion '*jittery*' was subsequently replaced with '*uneasy*'. Show cards displaying response options for participants to pick from were used to reduce the number of skipped questions and act as a literacy aid (OECD, 2013). We conducted the questionnaires face-to-face with every third passer-by aged over 18 years old during the daytime (07:30 to 18:30) and across all days of the week. Ethics approval was granted from the University of Kent's Faculty of Social Sciences Research Ethics Advisory Group for Human Participants (Ref. No. 0511617).

4.3.4. Data analyses

Qualitative answers to visit motivations were iteratively analysed by two authors (JCF, KNI), clustered into codes (n = 24), themes (n = 9), and domains (n = 5), using an adapted typology from Irvine et al., (2013). Clustering was based on language used by participants (e.g. '*take some breeze*' and '*fresh air*' were both coded as '*fresh air*'). Visit motivation was analysed at the domain level (physical, space qualities, unstructured time, social, cognitive) due to sample size limitations.

The reported sounds were coded (JCF, KNI) as 'mechanical', 'people', 'natural' and 'bird-related' (Irvine et al., 2009; Schafer et al., 1977). For example, 'mechanical' sounds included '*traffic*', '*horns*', and '*machinery*', 'people' sounds included '*gym*', '*footsteps*', and '*chattering*', 'natural' sounds were coded as '*wind*', '*water*', and '*trees*', and 'bird-related' included '*birds*', '*peaceful birds*', and '*birds chirping*'. Coding was done independently but resulted in high inter-rater reliability (kappa = 0.91). Only the first mention sound for each participant was used in subsequent analysis, as these were deemed the most salient to people's perceptions.

Analyses were performed using R version 3.5.0 (R Core Development Team 2020). There was no evidence of spatial autocorrelation between sites (see supplementary text). To generate an objective measure of sound, we calculated the Normalised Difference Soundscape Index (NDSI), which is the ratio of biological (biophony) to anthropological sound (anthrophony) ('soundecology' package, (Villanueva-Rivera and Pijanowski, 2018). We used NDSI because previous research has suggested that natural sounds, particularly birdsong, are related positively to psychological wellbeing (Irvine et al., 2009; Ratcliffe et al., 2018). The spectral profile of each sound recording was split into two ranges of frequency bands: biophonic (2 to 8 kHz) or anthrophonic (0.2 to 2 kHz) (Ji et al., 2007), with NDSI calculated as a ratio from -1 to +1, respectively.

From the questionnaire, we first conducted G-tests to ascertain whether our sample represented Georgetown's population. To compare perceived and objective measurements, and to compare them between landcover types, we used Kruskal Wallis rank sum tests for numerical variables (with Dunn's test for post-hoc comparisons) and chi-squared tests for categorical variables.

Prior to building models to investigate the mediating role of perceived restorativeness between site perceptions and wellbeing, we ran a series of exploratory analyses. We tested for associations between covariates using chi-squared goodness-of-fit tests for categorical data, subsequently removing income, education, and religion, leaving age and ethnicity. We also removed visit motivation, as the majority of answers fell into the 'physical activity' domain (92% green, 79% waterway, 78% dense urban), and visit company, as the most participants were visiting 'alone' (43% green, 87% waterway, 86% dense urban). We tested for an association between participant safety concerns and perceived naturalness to gauge whether to use an interaction term following Weimann et al., (2017), but found no significant result. Visit frequency was collapsed into 'daily', 'weekly', and 'monthly or less' (monthly, less than monthly, yearly) to improve power. We used Variance Inflation Factors to check for multicollinearity (Zuur and Ieno, 2016), and all scores were below 1.7, indicating no issues.

We used linear mixed-effect models ('lme4' package, Bates et al., 2015) to examine the relationships between perceptions (perceived sound enjoyment, perceived bird species richness, perceived naturalness, safety concerns) and momentary wellbeing (positive affect, negative affect, anxiety), while adjusting for sociodemographics and visit patterns (age, residential history, ethnicity, gender, visit frequency) within single mediation models (Figure 4.2a). Site was treated as a random effect to control for independence, and landcover type (green, waterways or dense urban) was included as a fixed effect. We ran separate models for each wellbeing measure, including all perceived measures to account for their combined effects on perceived restorativeness, the mediator. To compare landcover type, we also built linear mixed-effect models using site as a random effect, following the same structure used for the full dataset. To improve power, we trichotomised perceived bird species richness into 'low' (< 5), 'medium' (5 to 25), and 'high' (> 26), and safety concerns into 'low' (not at all), ‘medium’ (a little, moderately), and ‘high’ (quite a bit, extremely). As perceived bird species richness and safety concerns were multi-categorical, we used indicator coding to specify ‘low’ as the reference category for both. The pathways between these predictors and the wellbeing outcome variables are therefore estimated by multiplying the *a* pathways between each category with *b* to estimate the indirect effects separately, relative to the reference category (Figure 4.2b) (Hayes and Preacher 2014).

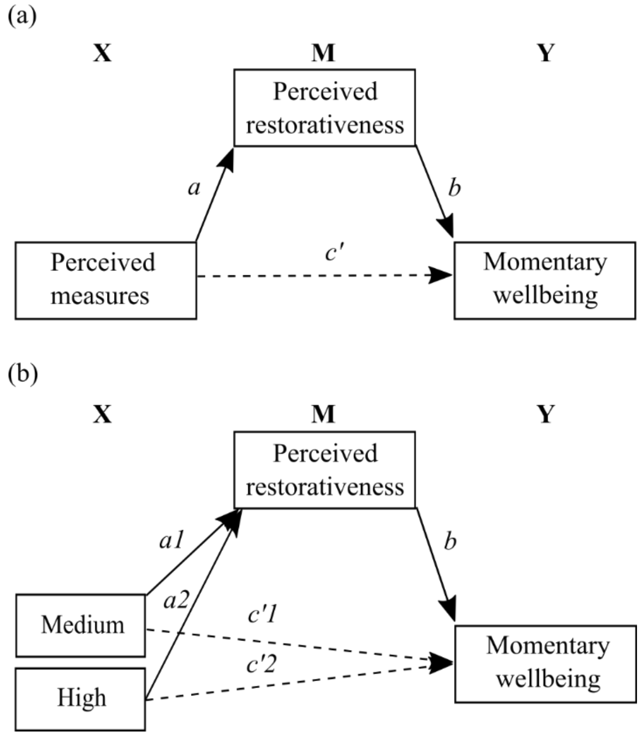


Figure 4.2: Single mediation models to investigate how perceptions relate to wellbeing via perceived restorativeness. (a) Single mediation model with perceived restorativeness mediating the relationship between X, people’s perceptions and Y, their momentary wellbeing (positive affect, negative affect, anxiety). This model simultaneously calculates regressions between X on M (the mediator) (path *a*, solid arrow), X on Y while holding M constant (direct effect, *c*’, dashed arrow), and between M and Y (*b*, solid arrow). The indirect effect (*a***b*) measures how X affects Y as a result of the effect of X on M which, in turn, also affects Y. (b) Amendment to the single mediation model when X is a multicategorical variable with > 2 categories (e.g. perceived bird species richness at low, medium or high level). As there is no single *a* pathway that represents the effect of X on M, or on Y, indicator coding of X is used to reflect quantifications of the effect size of each category relative to a reference category (in this case, ‘low’). We therefore interpret the indirect effect *ab* to represent the difference in one sequentially higher step relative to the reference

All models were checked for model fit adequacy statistics (Burnham et al., 2011; Harrison et al., 2018), including overdispersion and homoscedasticity (Feld et al., 2016; Zuur and Ieno, 2016). Using the 'mediation' package (Tingley et al., 2014), we ran 5000 simulations for each model (Hayes, 2009), using the bias-corrected and accelerated bootstrapping method for estimating mediation effects to correct for non-normality and address power limitations (Preacher and Hayes, 2008). We report the indirect effects to infer results (Hayes, 2009), recommended where some predictors are multi-categorical (Hayes and Preacher, 2014), drawing statistical significance where confidence intervals do not include zero.

4.4 Results

4.4.1 Summary statistics

The composition of sites differed significantly between each landcover (Table 4.1; Table S4.3). The highest bird species richness was found in green sites, compared to waterways and dense urban sites. The sounds recorded in green sites were, on average, biophonic (NSDI > 0), while sounds at waterways and dense urban sites were anthrophonic (NSDI < 0).

Table 4.1: Objective measures for environmental variables, bird species richness and NDSI (n = 19 sites per site type), wellbeing measures and perceived characteristics (green sites = 148 participants, waterway sites = 134 participants, dense urban sites = 121 participants). Median and range provided unless noted. Symbols indicate significant differences between green and waterways (*), waterways and dense urban (†), and green and dense urban (§) landcover types using Dunn's test. Symbol (‡) indicates significant differences between all site types using chi-squared test for categorical variables (details in Table S4.3)

Variable	Green	Waterway	Dense urban
Objective measures			
Vegetation (%)	70 (60-85)*§	40 (30 - 60)*†	5 (0 - 10)†§
Water (%)	25 (5 - 30) *§	30 (20 - 40)*†	0 (0 - 10)†§
Impervious surfaces (%)	10 (0 - 10)*§	20 (10 - 45)*†	90 (80 - 100)†§
Bird species richness	14 (11 - 21)*§	7 (5 - 18)*†	7 (3 - 10)
NDSI	0.08 (-0.52 – 0.84)*§	-0.30 (-0.75 - 0.47)*	-0.30 (-0.93 - 0.39)§
Outcome: Wellbeing			
Positive affect	41 (18 - 50)§	38 (10 - 50)	35 (13 - 50)§
Negative affect	10 (10 - 40)§	10.5 (10 - 42)†	12 (10 - 43)†§

Anxiety	26.67 (20 - 70)*	33.3 (20 - 86.67)*§	36.67 (20 - 90)§
Mediator			
Perceived restorativeness	64 (24 - 80)*	48.5 (18 - 80)*§	46 (23 - 70)§
Predictors: Perceived measures			
Perceived sound enjoyment	5 (1 - 5)*§	3 (1 - 5)*†	3 (1 - 5)†§
Perceived bird richness‡			
Low	*n* = 21 (12.5%)	*n* = 44 (31.2%)	*n* = 58 (42.3%)
Medium	*n* = 125 (74.4%)	*n* = 79 (56.0%)	*n* = 70 (51.1%)
High	*n* = 22 (13.1%)	*n* = 18 (12.8%)	*n* = 9 (6.6%)
Perceived naturalness	1 (1 - 5)*§	2 (1 - 5)*†	3 (1 - 5)†§
Safety concerns			
Low	*n* = 104 (57.4%)	*n* = 77 (53.9%)	*n* = 76 (55.5%)
Medium	*n* = 48 (28.0%)	*n* = 41 (29.1%)	*n* = 37 (27.0%)
High	*n* = 17 (14.6%)	*n* = 24 (17.0%)	*n* = 25 (17.5%)
Sounds heard‡			
bird-related	*n* = 97 (57%)	*n* = 9 (6%)	*n* = 7 (5%)
Natural	*n* = 12 (7%)	*n* = 3 (2%)	*n* = 3 (2%)
People	*n* = 22 (13%)	*n* = 3 (2%)	*n* = 11 (8%)
Mechanical	*n* = 37 (22.0%)	*n* = 126 (89%)	*n* = 116 (85%)

A total of 449 participants completed the questionnaire (70% response rate, green = 148, waterways = 134, dense urban = 121), 55% of whom were male (*n* = 247) and 72% under the age of 45 years old (*n* = 322). The sample was representative of Georgetown's population (Table S4.4). Participants were generally alone (70%, *n* = 313), and mostly visited sites daily (49%, *n* = 219) rather than weekly (22%, *n* = 100) or 'monthly or less' (29%, *n* = 130) (Table S4.5). The majority of participants were either passing through or on route to/from work (76%, *n* = 284) (Table S4.6), within the 'Physical' (84%, *n* = 376) motivation domain.

Momentary wellbeing varied between landcover types (Table 4.1; Table S4.3). Positive affect at green sites was significantly greater than at dense urban sites. Negative affect at green and waterways did not differ, but both were significantly lower than at dense urban sites. Anxiety levels were significantly lower at green sites, than both waterways and dense urban sites. Participants perceived green sites to be more restorative than both waterways and dense urban sites, with there being no difference between the latter two.

Participants reported liking the sounds they could hear significantly more in green sites compared with waterways and dense urban sites (Table 4.1; Table S4.3). Perceptions of bird species richness differed between sites, with more high answers for green and waterways than dense urban sites. Green sites were perceived to be significantly more natural than waterways which, in turn, were perceived as more natural than dense urban sites. Participants felt ‘low’ levels of safety concern in all landcover types equally, responding with ‘low’ most often. Participants mentioned hearing more bird-related sounds in green than waterways or dense urban sites, and more mechanical sounds in the latter two landcover types.

4.4.2 Mediation

Single mediation models indicated that, for all sites combined, participants who enjoyed the sounds they could hear reported higher levels of positive affect, as a result of the positive relationship between enjoying the sounds and increased restorativeness (Figure 4.3a; Figure 4.4a; Table S4.7). There was a significant direct effect of disliking sounds on negative affect, independent of perceived restorativeness (Figure 4.3b). Participants who disliked sounds were more anxious, but only when they perceived the site as not restorative (Figure 4.3c). Within green sites, there was a direct effect of sound enjoyment on positive affect (Figure 4.4a; Table S4.8). Perceiving waterways as restorative resulted in higher levels of positive affect when participants enjoyed sounds (Figure 4.4a; Table S4.9).

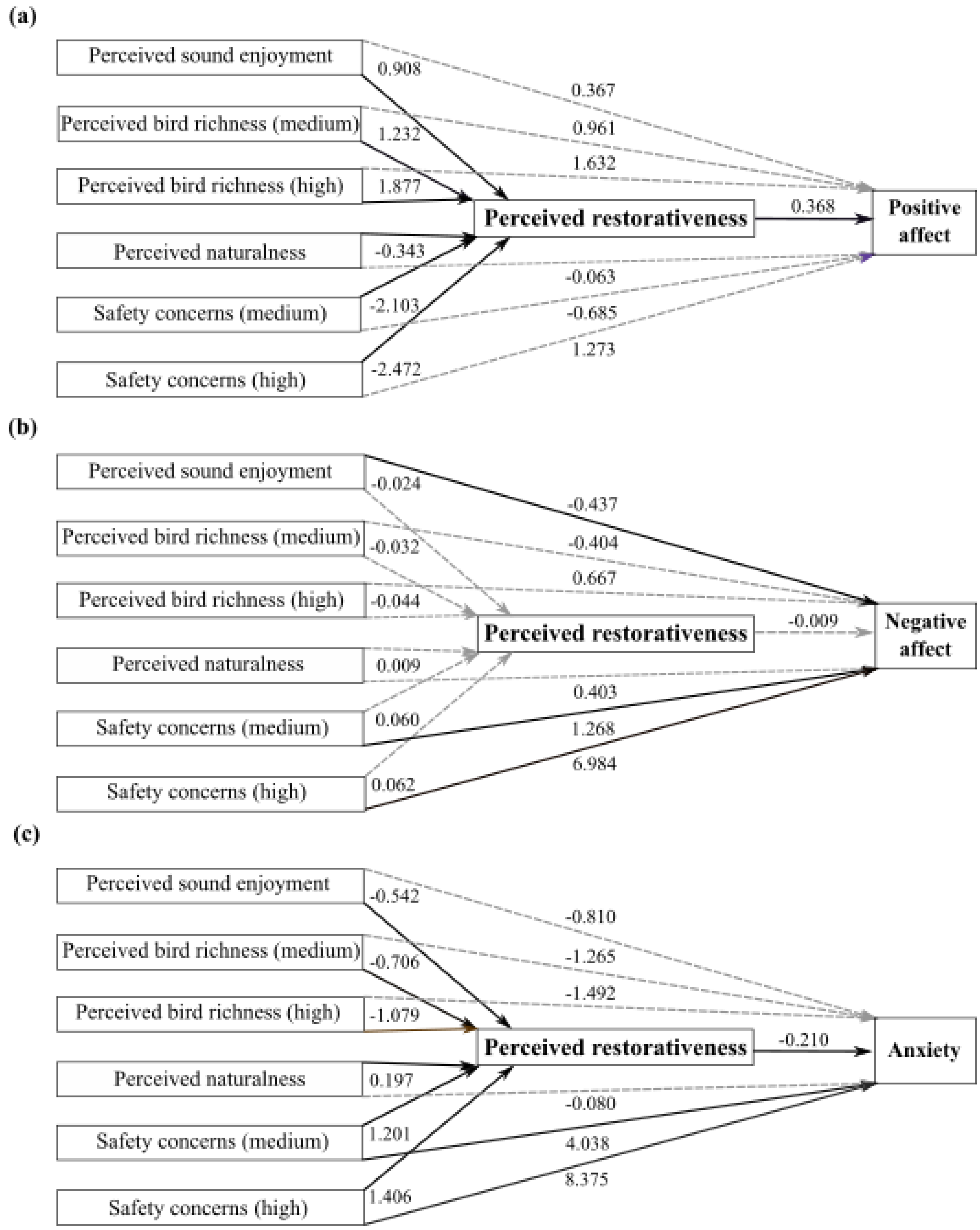


Figure 4.3: Diagrammatic representation of single mediation models. Perceptions (perceived sound enjoyment, perceived bird species richness, perceived naturalness, safety concerns) influencing momentary wellbeing (a) positive affect, (b) negative affect, (c) anxiety, adjusted for covariates (age, residential history, ethnicity, gender, visit frequency, landcover type) at all sites combined across landcover types. Plots display direct effect (*c'*), and the mediating effect of perceived restorativeness (indirect effect = *ab*), with significant paths in bold. Reference category for both perceived bird richness and safety concerns is 'low'

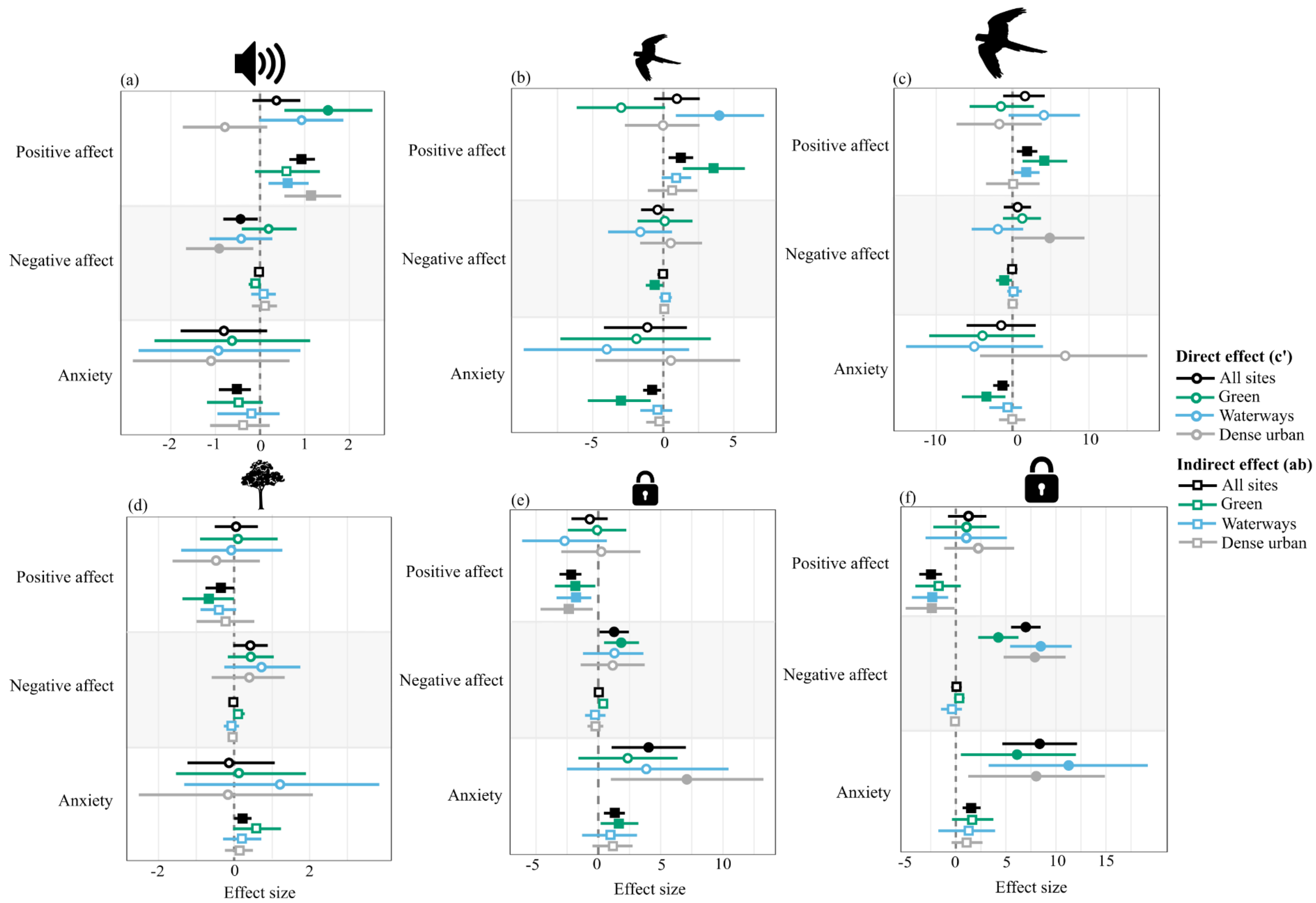

(a)
(b)
(c)
(d)
(e)
(f)
Positive affect
Negative affect
Anxiety
-2 -1 0 1 2
-5 0 5
-10 0 10
-5 0 5 10 15
Effect size
Direct effect (c')
All sites
Green
Waterways
Dense urban
Indirect effect (ab)
All sites
Green
Waterways
Dense urban

Figure 4.4: Direct and indirect of single mediation models at each site type for each perception. Single mediation models showing direct effect (circles) and indirect effect via perceived restorativeness (squares) of (a) perceived sound enjoyment (b) perceived bird species richness ('medium'), (c) perceived bird species richness ('high'), (d) perceived naturalness, (c) safety concerns ('medium'), and (f) safety concerns ('high'), influencing momentary wellbeing (positive affect, negative affect, anxiety). Models (all sites combined = black, green sites = green, waterway sites = blue, dense urban = grey) are adjusted for covariates (age, residential history, ethnicity, gender, visit frequency). The reference category for both perceived bird richness and safety concerns is 'low'. Perceived naturalness measured on a continuous scale (1 = *very natural*, 5 = *very artificial*). Plotted unstandardised regression coefficients (β) and their bias-corrected and accelerated bootstrap confidence intervals are from 5000 simulations. Statistically significant variables (filled symbols,) do not cross zero (grey dotted line), with those above zero positively related, and those below zero negatively related, to wellbeing

Overall, participants who perceived species richness at 'medium' and 'high' relative to 'low' levels, reported higher positive affect as a result of the positive influence of species richness on perceived restorativeness which, in turn, increased positive affect (Figure 4.3a; Figure 4.4b; Figure 4.4c). There was no relationship between perceived species richness and negative affect but, for anxiety, individuals who perceived 'medium' or 'high' species richness reported less anxiety than people who perceived 'low' species richness, inversely mediated by perceived restorativeness (Figure 4.3c). At green sites, 'medium' and 'high' perceived species richness positively influenced positive affect, and negatively influenced negative affect and anxiety due to mediation by perceived restorativeness (Figure 4.4b; Figure 4.4c; Table S4.8). At waterway sites, perceiving 'medium' species richness was directly associated more positive affect, while perceiving 'high' species richness resulted more positive affect mediated by perceived restorativeness (Figure 4.4b; Figure 4.4c; Table S4.9). Conversely, at dense urban sites, perceiving 'high' species richness was directly related to more negative affect (Figure 4.4c; Table S4.10).

Participants who perceived sites as artificial, as opposed to natural, reported lower levels of positive affect and more anxiety, as the sites were also less restorative (Figure 4.4d). When the different landcover types were examined individually, perceived naturalness showed no significant relationships with any wellbeing measure other than at green sites (Figure 4.4d; Table S4.8), where sites perceived as more artificial negatively influenced positive affect via the mediator, although this finding could be spurious as the confidence interval almost crosses zero.

If participants had safety concerns (i.e. 'medium' or 'high' levels), they reported lower positive affect, than those who felt safer (i.e. 'low' levels), as feeling more unsafe was inversely related to perceived restorativeness (Figure 4.4e; Figure 4.4f). There was a direct effect between participants with safety concerns ('medium' or 'high') reporting significantly more negative affect and more anxiety than those individuals who felt safer. Anxiety was also mediated by perceived restorativeness (partial mediation, where the outcome variable is influenced by the independent variable both directly and indirectly via the mediator). Negative affect and anxiety were both positively and directly influenced by safety concerns ('high') for all landcover types (Table S4.8; S4.9; S4.10).

4.4.3 Perceived and objective measures

Perceptions of sound enjoyment were related to NDSI. Participants mentioned they enjoyed the sounds at sites where more biophonic sounds were recorded ($X^2 = 35.249$, df = 4, $p < 0.001$), most often in green sites (Figure 4.5a). When we asked what sounds participants were hearing, biophonic sounds were generally mentioned first and tended to be 'bird-related' ($X^2 = 83.78$, df = 3, $p < 0.001$), particularly at green sites (Figure 4.5b). Perceptions of bird species richness were significantly associated with objective measurements of species richness ($X^2 = 16.801$, df = 2, $p < 0.001$) (Figure 4.5c). Participants also perceived sites to be more natural, as opposed to artificial, when they contained more vegetation (trees, shrubs, grass) ($X^2 = 60.354$, df = 4, $p < 0.001$), more water (ponds, canals, drains) ($X^2 = 109.45$, df = 4, $p < 0.001$), and less impervious surfaces (buildings, roads, pavements) ($X^2 = 113.26$, df = 4, $p < 0.001$) (Figure 4.5d).

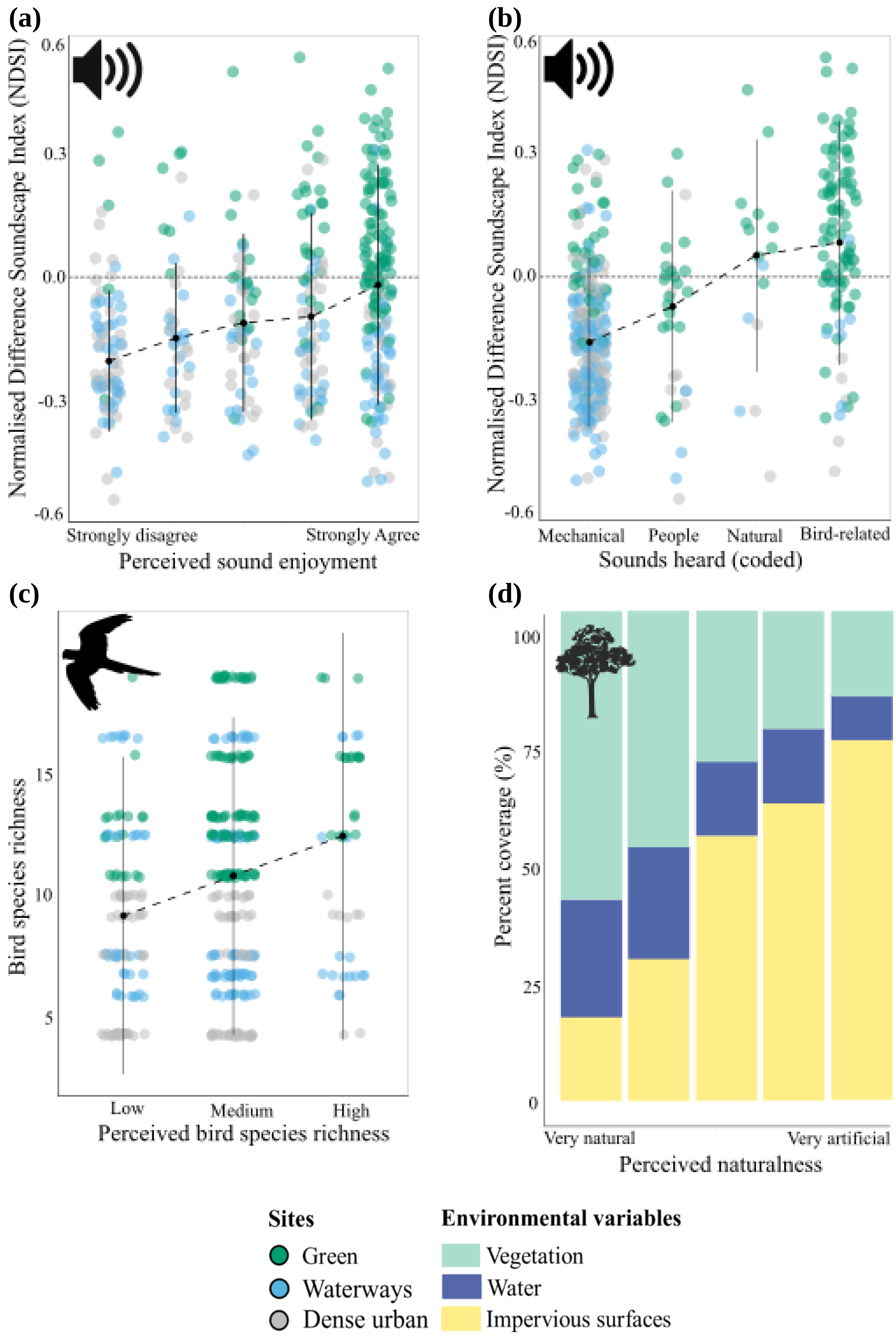


Figure 4.5: Perceived characteristics against objective measures. Relationships between (a) perceived sound enjoyment and NDSI, (b) sounds heard and NDSI, (c) perceived bird species richness and measured species richness, where coloured circles (green sites = green, waterway sites = blue, dense urban sites = grey) represent participants at each site (green sites = 148 participants, waterway sites =

134 participants, dense urban sites = 121 participants), median and range are indicated by black points and vertical lines, respectively, while the dashed line shows the trend, (d) the percent coverage of environmental variables for each point on the five-point scale of perceived naturalness, where vegetation = teal, water = dark blue, impervious surfaces = yellow. Perceived naturalness measured on a continuous scale (1 = *very natural,* 5 = *very artificial*). Central vertical line in (a) and (b) show divide between biophonic (> 0) and anthrophonic (< 0) sounds

4.5 Discussion

Decision-making authorities that manage human-dominated landscapes have to deliver, and trade-off between, multiple biodiversity, individual and societal benefits. Urban green and blue spaces can simultaneously support biodiversity and enhance human wellbeing, but understanding exactly how people perceive and respond to specific characteristics of these spaces is key to maximising their effectiveness for both humans and conservation. Here, we show that the restorativeness of green and blue spaces is considered greater if an individual perceives a site as safe, species-rich, natural (as opposed to artificial) and a place where they can enjoy biophonic sounds that are principally bird-related. This increased perceived restorativeness then results in improved wellbeing (increased positive affect, and decreased negative affect and anxiety). To date, a paucity of such research has been conducted in the tropics. Comparing perceptions with objective measures gave insight into how people respond to local environmental characteristics. Participants accurately estimated bird species richness around them, perceived sites that contained greater proportions of vegetation and water as more natural, and enjoyed and recognised sounds that were objectively measured as biophonic. In Georgetown, these features could be enhanced across the city to support biodiversity and the subsequent benefits this brings to human wellbeing.

For the first time, we tested how people's perceptions of sound matched with a bioacoustic index (NDSI) traditionally used in ecological monitoring research and connect it to human wellbeing. By classifying sound recordings taken while participants were completing the questionnaire, we demonstrate the importance of biophonic sounds, perceived as bird-related, in contributing positively to perceived restorativeness and, subsequently, improving wellbeing for people in species-rich green spaces. This aligns with findings from the UK that show birdsong influences perceived restorativeness and stress recovery (Ratcliffe et al., 2013), that people report higher momentary wellbeing when they can hear birdsong (Bakolis et al., 2018), and that a diverse birdsong provides greater benefits than single species singing (Hedblom et al., 2014). Higher NDSI values in the biophonic range have been associated with higher species richness (Bradfer-Lawrence et al., 2020), and characterise sites that contain more biodiversity, including in South America (Machado et al., 2017). While the use of NDSI to monitor biodiversity in urban environments has been contested (Fairbrass et al., 2017), we discovered that it accurately reflected the types of sounds participants reported hearing and enjoying. Using bioacoustic indices as a tool to explore the role ecological sounds play in supporting human wellbeing in cities therefore shows promise.

Higher perceived bird species richness positively enhanced the perceived restorativeness of sites, resulting in improved wellbeing. This is consistent with research from the global North (Marselle et al., 2016), thus advancing our understanding of how this relationship might persist cross-culturally. Future work needs to uncover what factors shape perceptions of species richness. For instance, Dallimer et al., (2012) show that individuals with better identification skills are more likely to accurately perceive species richness. In Georgetown, there was a positive trend between perceived and objective species richness across all three landcover types. This could be driven by the individuals visiting green and waterway sites having better identification skills, amongst other pro-environmental attitudes and behaviours (Alcock et al., 2020). However, it could also be that anywhere people perceive as biodiverse could aid wellbeing, regardless of whether the site is biodiverse or not. This has implications for decision-makers raising people's awareness of urban biodiversity through environmental education campaigns, with the ultimate goal to influence their wellbeing positively.

The mechanistic role of perceived restorativeness influencing how perceptions relate to wellbeing was shown through the use of mediation models, building on work from the global North (Hartig et al., 1997; Marselle et al., 2016, 2015; Wang et al., 2016). Perceived restorativeness was highest in green sites; it did not differ between waterway and dense urban sites, despite significant differences in the composition of vegetation, water, and impervious surfaces. Georgetown's waterways are often heavily vegetated, supporting high species richness of birds relative to dense urban sites (Hayes et al., 2019). While participants did perceive the waterway sites as more natural than dense urban sites, likely due to these ecological features, participants reported an abundance of mechanical sounds, objectively classed as anthrophonic. This abundance of anthrophony is likely explained by the location of many waterways alongside roads. As such, despite the presence of ecological features which might enhance perceived restorativeness, the presence of anthrophonic sounds that are typically loud and overwhelming of biophonic sounds (Pijanowski et al., 2011), may have led to waterway sites being perceived as less restorative. Similarly, at dense urban sites, participants only reported more positive affect if they found the sounds enjoyable which led to higher perceived restorativeness. Certainly, instances of inconsistent mediation (where the coefficient switched from negative to positive once perceived restorativeness was considered a mediator) have helped elucidate the mechanism through which perceived restorativeness can influence how people perceive and, consequently, react to their surroundings in terms of wellbeing. From an urban planning perspective, if pathways were installed and/or improved alongside waterways for pedestrians and cyclists, vehicle-use and anthrophonic sounds may be reduced, thereby improving the restorative quality of waterways and the wellbeing of Georgetown's public.

Participants with safety concerns reported lower positive affect, higher negative affect and anxiety, either directly or mediated by perceived restorativeness, across all landcover types combined and separately. The relatively high effect size implies that feeling unsafe has a comparatively stronger influence on wellbeing than other site characteristics. Participants who feel unsafe will be alert to the threat of danger and, as such, will not recover from mental fatigue or feel reduced levels of stress, and will not perceive the sites as restorative (Kaplan, 1995). It was beyond the scope of our study to ask participants why they felt unsafe. However, green space visitors in the global North have reported that criminal activity, poor visibility, and pest species contribute to safety concerns (Sonti et al., 2020). Similarly, in blue spaces, characteristics including cleanliness, lighting, and surveillance can increase people's sense of safety (Pitt, 2019).

Overall, sites perceived as more natural were perceived as more restorative, which related to increased positive affect, whereas sites perceived as more artificial were thought less restorative, which related to increased anxiety. Sites containing more vegetation and water were perceived as more natural. When green sites were examined alone, sites perceived as more artificial resulted in less positive affect via the mediator, despite all sites being typically dominated by vegetation. Specific green sites may have been perceived as more artificial when vegetation was more manicured or 'tidy'. This conflicts with evidence from the global North that wilder vegetation can evoke fear (Bixler and Floyd, 1997; Jansson et al., 2013; Jorgensen et al., 2007), and manipulating the arrangement of vegetation can influence the perception of safety (Jorgensen et al., 2002; Tabrizian et al., 2018). We did not ask participants to specify what characteristics contributed to the feeling of a site being 'natural' or 'artificial', which would require additional qualitative work in the future.

4.6 Conclusion

Within cities, urban green and blue spaces provide a wealth of human health and wellbeing benefits, as well as resources for biodiversity. Specifically, we show how certain perceived green and blue space characteristics (birdsong, bird species richness, perceived naturalness, and safety concerns) contribute positively to the perceived restorativeness of a site through multi-sensory pathways. By comparing these perceptions with objective measurements (species richness of birds, biophonic and anthrophonic sounds, and vegetation and water coverage), we shed light on how city planners might augment these specific characteristics to improve the wellbeing of urban dwellers. Given the high levels of biodiversity that can be found throughout Georgetown, such efforts could have positive implications for conservation. Interdisciplinary studies such as this are important as they highlight where careful urban design and management could deliver multiple co-benefits in the face of increasing urbanisation and biodiversity loss across the global South, particularly in biodiversity-rich neotropical regions.

4.7 Acknowledgements

We thank H. Yang, A. Harris, S. Rampertab, M. Pierre, R. Bacchus, J. Kennedy, R. Gibbons, D. Somwaru, K. Hernandez, K. Joshi, R. Blackburn and J. Crosse. Logistical support was provided by Protected Areas Commission and WWF Guyana. We thank M. Marselle and S. Payne for constructive discussion. This work was supported by grants to JCF from Royal Geographical Society with IBG, Gilchrist Educational Foundation, ESRC (ES/J500148/1), and NERC (NE/L002582/1). KNI is supported by the RESAS Division of the Scottish Government. KNI and ZDG are supported by the European Research Council (ERC) under the European Union's Horizon 2020 Research and Innovation Framework Programme (Consolidator Grant No. 726104). Permission was provided by the Environmental Protection Agency of Guyana (051117 BR 006).

4.8 Supplementary information

(a)

(b)

(c)

Figure S4.1: Photographs taken from Georgetown, Guyana. Examples of the landcover types (a) green, (b) waterway, (c) dense urban. Photos (a) and (c) were taken by Meshach Pierre

Table S4.1: Perceived Restorativeness Scale used in the questionnaire (Hartig et al., 1997)

Perceived Restorativeness Scale

Please rate the extent to which each statement reflects your experience in this spot where we are standing:

Response options: *Not at all, a little, moderately, quite a bit, extremely*

Statements

1. I would like to spend more time looking at the surroundings
2. I have a sense that I belong here
3. There is a great deal of distraction
4. This setting has fascinating qualities
5. Being here suits my personality
6. Spending time here gives me a good break from my day-to-day routine
7. There is too much going on
8. I could find ways to enjoy myself in a place like this
9. It is an escape experience
10. It is chaotic here
11. I would like to get to know this place better
12. I have a sense of oneness with this setting
13. My attention is drawn to many interesting things
14. I can do things I like here
15. It is a confusing place
16. There is much to explore and discover here

Table S4.2: Momentary wellbeing scales used in the questionnaire. (a) Positive and Negative Affect Schedule (PANAS) (Watson et al., 1988), containing 10 positive and 10 negative words, and (b) State-Trait Anxiety Inventory (STAI) six-item short-form (Marteau and Bekker, 1992), containing six anxiety words

(a) Positive and Negative Affect Schedule (PANAS)	
Please rate how you feel now, at the present moment, in this spot where you are standing. Response options: *Not at all, A little, Moderately, Quite a bit, Extremely*	
21. Enthusiastic	31. Uneasy
22. Scared	32. Nervous
23. Afraid	33. Ashamed
24. Interested	34. Active
25. Upset	35. Strong
26. Determined	36. Guilty
27. Excited	37. Proud
28. Distressed	38. Attentive
29. Inspired	39. Irritable
30. Alert	40. Hostile
(b) Spielberger State-Trait Anxiety Inventory (STAI) six-item short-form:	
Please rate how you feel now, at the present moment, in this spot where you are standing. Response options: *Not at all, A little, Moderately, Quite a bit, Extremely*	
7. I feel calm	
8. I feel tense	
9. I feel upset	
10. I am relaxed	
11. I feel content	
12. I am worried	

Table S4.3: Pairwise comparisons between objective measures, momentary wellbeing, and perceived measures (green sites = 148 participants, waterway sites = 134 participants, dense urban sites = 121 participants) using (a) Dunn's tests, and (b) chi-squared tests for categorical variables

(a)

Variable	**z value**	**Adjusted *p***	**Variable**	**z value**	**Adjusted *p***
Vegetation (%)			Negative affect		
waterway versus dense urban	9.444	0.000	waterway versus dense urban	-2.246	0.037
waterway versus green	-9.954	0.000	waterway versus green	1.796	0.072
dense urban versus green	-19.716	0.000	dense urban versus green	4.122	0.000
Water (%)			Anxiety		
waterway versus dense urban	16.790	0.000	waterway versus dense urban	-1.599	0.110
waterway versus green	6.762	0.000	waterway versus green	4.129	0.000
dense urban versus green	-10.783	0.000	dense urban versus green	5.763	0.000
Impervious surfaces (%)			Perceived restorativeness		
waterway versus dense urban	-9.671	0.000	waterway versus dense urban	0.862	0.389
waterway versus green	9.656	0.000	waterway versus green	-9.837	0.000
dense urban versus green	19.657	0.000	dense urban versus green	-10.659	0.000
Bird species richness			Perceived sound enjoyment		
waterway versus dense urban	5.568	0.000	waterway versus dense urban	2.076	0.038
waterway versus green	-8.862	0.000	waterway versus green	-7.231	0.000
dense urban versus green	-14.595	0.000	dense urban versus green	-9.337	0.000
NDSI			Perceived naturalness		
waterway versus dense urban	-0.823	0.410	waterway versus dense urban	-7.810	0.000
waterway versus green	-11.387	0.000	waterway versus green	2.589	0.010
dense urban versus green	-10.214	0.000	dense urban versus green	10.705	0.000
Positive affect					
waterway versus dense urban	1.899	0.058			
waterway versus green	-1.903	0.086			
dense urban versus green	-3.866	0.000			

(b)

Variable	**X^2**	***df***	***p***
Perceived bird species	36.880	4	0.000
Safety concerns	5.041	4	0.283
Sounds heard	202.000	6	0.000

Table S4.4: Sample sociodemographics in comparison to Guyana's most recent census (Bureau of Statistics 2012). G-tests for goodness of fit comparing sample data (n; %) with census (where available) (%C) showed that the sample was representative of the city's population. Non-respondents (*n* = 196) were 54% male, 46% female, aged 53% under 40, and 47% over 40

Characteristic	*n*	%	%C	Characteristic	*n*	%	%C
Gender				**Education**			
Female	202	45	47.5	Primary/None	27	6	29
Male	247	55	52.5	Secondary	174	39	53
Other/Prefer Not To Say	0	0	0	Post-Secondary	28	6	6
G test: G = -4134.3, X^2 df = 1, *p* = *1*				Technical/Advanced	58	13	NA
Age				University	159	35	8
18-24	120	27	26.8	Other / Prefer Not To Say	3	<1	4
25-34	121	27	24.3	**G test: G = -3222.5, X^2 df = 4, *p* = *1***			
35-44	81	18	18.9	**Household income**			NA
45-54	51	11	13.5	Less than GY$40,000	39	9	
55-64	47	10	6.9	GY$40,001 to $100,000	83	18	
65+	29	1	6.9	GY$100,001 to $160,000	54	12	
Other / Prefer Not To Say	0	0	2.6	GY$160,001 to $220,000	37	8	
G test: G = -4100.9, X^2 df = 5, *p* = *1*				GY$220,001 to $280,000	21	5	
Ethnicity				> GY$280,001	55	12	
African	187	42	52.8	Other / Prefer Not To Say	160	36	
Amerinidian	13	3	1.0				
East Indian	97	22	19.6	**Residential history**			NA
Mixed	128	29	23.8	Georgetown	115	26	
Other / Prefer Not To Say	24	5	2.7	+ Interior	221	49	
G test: G = -4098.7, X^2 df = 4, *p* = *1*				+ Outside of Guyana	113	25	
Religion/denomination				Other / Prefer Not To Say	0	0	
Anglican	23	5.1	9.1				
Muslim	33	7.8	2.3	**Job inside/outside (if employed)**			NA
Pentecostal	26	5.8	21.2	Inside	82	18	
Roman Catholic	32	7.1	11.8	Outside	191	43	
Hindu	34	7.6	12.0	Both	104	23	
Other Christian	219	48.8	23.6	(Unemployed)	72	16	
7th Day Adventist	20	4.5	4.3	Other / Prefer Not To Say	0	0	
Non/no religion	42	9.4	7.2				
Other / Prefer Not To Say	20	4.5	4.3				
G test: G = -3873.5, X^2 df = 8, *p* = *1*							

Table S4.5: Participant responses to 'How frequently do you come past this spot?' (visit frequency) and 'Who are you with today?' (visit company) in Georgetown, Guyana (*n* = 449 comments). Responses to 'Monthly', 'Less than monthly', 'Yearly' and 'Other' were collapsed into single category 'Monthly or less' for modelling

Visit frequency	n	%	Visit company	n	%
Daily	219	49	Alone	303	68
Weekly	100	23	Family	34	8
Monthly	53	12	Friends	56	13
Less than monthly	30	7	Kids	12	3
Yearly	47	11	Partner	34	8
Other	0	0	Other	0	0

Table S4.6: Participant motivations for visiting the site (green sites = 148, waterway sites = 134, dense urban sites = 121) where they were stopped by researchers and asked to complete the questionnaire in Georgetown, Guyana. Participants provided one answer to the open-ended question 'What is the main reason you are here today?'

Domain	n	Theme	n	Code	n
Physical	376	Physical Pursuits – Walking through	284	Route home/work	155
				Passing through	129
		Physical Pursuits	80	Exercise	66
				A walk	8
				Sport	4
				Walk animal	2
		Physical Restoration	12	Relax	8
				Chill Out	3
				Eat	1
Unstructured time	25	Passing time	25	Visiting	18
				Recreation	5
				Unstructured time	2
Social	23	Socialising	23	Hang out	10
				Family outing	6
				Meet friends	7
Space qualities	17	Features	13	Zoo	8
				Atmosphere	2
				Nice place	2
				Monument	1
		Nature	4	Fresh air	2
				View	2
Cognitive	8	Mental pursuits	7	Purposeful work	6
				Photography	1
		Attention Restoration	1	Take a break	1

Supplementary text: Spatial autocorrelation

We conducted a Mantel test to check for spatial autocorrelation (whether sites situated closer together in geographical space produced similar data than those that were distanced further apart). We tested for autocorrelation at the sites where both questionnaires and point counts were conducted ($n = 5$ per landcover type), finding no similarities in species richness across sites (r = 0.085, $p = 0.232$). We also detected no spatial autocorrelation in positive affect (r = -0.016, $p = 0.915$), negative affect (r = -0.006, $p = 0.650$), and anxiety (r = -0.003, $p = 0.587$).

Table S4.7: Separate single mediation models fitted for each wellbeing measure (positive affect, negative affect, anxiety), with all perceptions (adjusted for each other) and the mediator (perceived restorativeness) as predictors, at all sites combined across landcover types (*n* = 446). Models are adjusted for sociodemographics, visit patterns (age, residential history, ethnicity, gender, visit frequency) and landcover type. Regression coefficients and 95% CIs from 5000 bias-corrected and accelerated bootstrap simulations are reported. Bold = significant pathways (CIs do not cross zero

Variables		Direct effect (path *c'*)			Indirect effect (path ab)		
		β	2.5%	95%	*β*	2.5%	95%
Positive affect	**Perceived restorativeness (path *b*)**	**0.368**	**0.302**	**0.437**	-	-	-
	Perceived sound enjoyment	0.367	-0.171	0.904	**0.948**	**0.648**	**1.281**
	Perceived bird richness (medium)	0.961	-0.671	2.580	**1.232**	**0.370**	**2.122**
	Perceived bird richness (high)	1.632	-1.019	4.073	**1.877**	**0.546**	**3.250**
	Perceived naturalness	-0.063	-0.511	0.632	**-0.343**	**-0.704**	**-0.010**
	Safety concern (medium)	-0.685	-2.235	0.797	**-2.103**	**-3.062**	**-1.260**
	Safety concern (high)	1.273	-0.777	3.051	**-2.472**	**-3.658**	**-1.380**
Negative affect	**Perceived restorativeness (path *b*)**	-0.009	-0.056	0.039	-	-	-
	Perceived sound enjoyment	**-0.437**	**-0.823**	**-0.055**	-0.024	-0.157	0.104
	Perceived bird richness (medium)	-0.404	-1.577	0.744	-0.032	-0.219	0.141
	Perceived bird richness (high)	0.667	-1.150	2.427	-0.044	-0.332	0.222
	Perceived naturalness	0.430	-0.021	0.892	0.009	-0.041	0.068
	Safety concern (medium)	**1.268**	**0.097**	**2.453**	0.060	-0.222	0.359
	Safety concern (high)	**6.984**	**5.515**	**8.463**	0.062	-0.283	0.408
Anxiety	**Perceived restorativeness (path *b*)**	**-0.210**	**-0.330**	**-0.089**	-	-	-
	Perceived sound enjoyment	-0.810	-1.782	0.160	**-0.542**	**-0.925**	**-0.204**
	Perceived bird richness (medium)	-1.265	-4.206	1.671	**-0.706**	**-1.435**	**-0.158**
	Perceived bird richness (high)	-1.492	-6.028	3.028	**-1.079**	**-2.177**	**-0.235**
	Perceived naturalness	-0.080	-1.236	1.078	**0.197**	**0.003**	**0.460**
	Safety concern (medium)	**4.038**	**1.057**	**7.022**	**1.201**	**0.450**	**2.142**
	Safety concern (high)	**8.375**	**4.644**	**12.111**	**1.406**	**0.494**	**2.571**

Table S4.8: Separate single mediation models fitted for each wellbeing measure (positive affect, negative affect, anxiety), with all perceptions (adjusted for each other) and the mediator (perceived restorativeness) as predictors, at green sites only (n = 148). Models are adjusted for sociodemographics, and visit patterns (age, residential history, ethnicity, gender, visit frequency). Regression coefficients and 95% CIs from 5000 bias-corrected and accelerated bootstrap simulations are reported. Bold = significant pathways (CIs do not cross zero)

Variables		Direct effect (path *c'*)			Indirect effect (path *ab*)		
		β	2.5%	95%	β	2.5%	95%
Positive affect	**Perceived restorativeness (path *b*)**	**0.502**	**0.393**	**0.612**	-	-	-
	Perceived sound enjoyment	**1.524**	**0.544**	**2.519**	0.594	-0.114	1.341
	Perceived bird richness (medium)	-2.988	-6.143	0.121	**3.430**	**1.383**	**5.779**
	Perceived bird richness (high)	-1.530	-5.626	2.790	**4.137**	**1.312**	**7.157**
	Perceived naturalness	0.102	-0.902	1.154	**-0.661**	**-1.370**	**-0.005**
	Safety concern (medium)	-0.095	-2.444	2.243	**-1.805**	**-3.488**	**-0.237**
	Safety concern (high)	1.075	-2.244	4.361	-1.724	-4.035	0.500
Negative affect	**Perceived restorativeness (path *b*)**	**-0.078**	**-0.146**	**-0.010**	-	-	-
	Perceived sound enjoyment	0.192	-0.412	0.821	-0.090	-0.258	0.020
	Perceived bird richness (medium)	0.101	-1.833	2.066	**-0.539**	**-1.240**	**-0.019**
	Perceived bird richness (high)	1.277	-1.265	3.725	**-0.640**	**-1.546**	**-0.030**
	Perceived naturalness	0.441	-0.168	1.051	0.104	-0.007	0.282
	Safety concern (medium)	**1.838**	**0.470**	**3.267**	0.279	-0.002	0.729
	Safety concern (high)	**4.245**	**2.235**	**6.266**	0.259	-0.084	0.786
Anxiety	**Perceived restorativeness (path *b*)**	**-0.413**	**-0.605**	**-0.221**	-	-	-
	Perceived sound enjoyment	-0.628	-2.367	1.124	-0.488	-1.190	0.062
	Perceived bird richness (medium)	-1.908	-7.297	3.369	**-2.822**	**-5.361**	**-0.887**
	Perceived bird richness (high)	-3.935	-10.900	2.965	**-3.421**	**-6.623**	**-0.929**
	Perceived naturalness	0.187	-1.537	1.902	0.538	-0.027	1.243
	Safety concern (medium)	2.358	-1.592	6.358	**1.482**	**0.186**	**3.213**
	Safety concern (high)	**6.113**	**0.505**	**11.995**	1.421	-0.385	3.748

Table S4.9: Separate single mediation models fitted for each wellbeing measure (positive affect, negative affect, anxiety), with all perceptions (adjusted for each other) and the mediator (perceived restorativeness) as predictors, at waterway sites only (*n* = 134). Models are adjusted for sociodemographics, and visit patterns (age, residential history, ethnicity, gender, visit frequency). Regression coefficients and 95% CIs from 5000 bias-corrected and accelerated bootstrap simulations are reported. Bold = significant pathways (CIs do not cross zero)

	Variables	**Direct effect (path *c'*)**			**Indirect effect (path *ab*)**		
		β	2.5%	95%	β	2.5%	95%
Positive affect	**Perceived restorativeness (path *b*)**	**0.215**	**0.094**	**0.333**	-	-	-
	Perceived sound enjoyment	0.931	-0.014	1.867	**0.584**	**0.188**	**1.090**
	Perceived bird richness (medium)	**3.959**	**0.884**	**7.140**	0.795	-0.118	1.978
	Perceived bird richness (high)	4.103	-0.516	8.823	**1.586**	**0.190**	**3.532**
	Perceived naturalness	-0.075	-1.401	1.277	-0.349	-0.889	0.058
	Safety concern (medium)	-2.706	-6.111	0.687	**-1.761**	**-3.342**	**-0.559**
	Safety concern (high)	1.051	-3.024	5.099	**-2.332**	**-4.388**	**-0.756**
Negative affect	**Perceived restorativeness (path *b*)**	0.027	-0.059	0.118	-	-	-
	Perceived sound enjoyment	-0.423	-1.132	0.274	0.073	-0.198	0.355
	Perceived bird richness (medium)	-1.635	-3.908	0.613	0.100	-0.280	0.600
	Perceived bird richness (high)	-2.047	-5.345	1.400	0.192	-0.529	1.042
	Perceived naturalness	0.725	-0.258	1.753	-0.045	-0.272	0.131
	Safety concern (medium)	1.190	-1.240	3.616	-0.221	-1.071	0.576
	Safety concern (high)	**8.485**	**5.421**	**11.578**	-0.315	-1.415	0.689
Anxiety	**Perceived restorativeness (path *b*)**	-0.086	-0.313	0.154	-	-	-
	Perceived sound enjoyment	-0.935	-2.723	0.906	-0.225	-0.953	0.439
	Perceived bird richness (medium)	-4.013	-9.900	1.833	-0.313	-1.637	0.642
	Perceived bird richness (high)	-5.020	-13.951	3.992	-0.648	-3.047	1.233
	Perceived naturalness	1.252	-1.320	3.843	0.140	-0.293	0.721
	Safety concern (medium)	3.849	-2.524	10.455	0.737	-1.305	3.106
	Safety concern (high)	**11.275**	**3.285**	**19.190**	0.909	-1.739	3.919

Table S4.10: Separate single mediation models fitted for each wellbeing measure (positive affect, negative affect, anxiety), with all perceptions (adjusted for each other) and the mediator (perceived restorativeness) as predictors, at dense urban sites only (*n* = 121). Models are adjusted for sociodemographics, and visit patterns (age, residential history, ethnicity, gender, visit frequency). Regression coefficients and 95% CIs from 5000 bias-corrected and accelerated bootstrap simulations are reported. Bold = significant pathways (CIs do not cross zero)

	Variables	**Direct effect (path *c'*)**			**Indirect effect (path *ab*)**		
		β	2.5%	95%	β	2.5%	95%
Positive affect	**Perceived restorativeness (path *b*)**	**0.430**	**0.319**	**0.544**	-	-	-
	Perceived sound enjoyment	-0.788	-1.730	0.161	**1.134**	**0.545**	**1.819**
	Perceived bird richness (medium)	-0.025	-2.716	2.569	0.602	-1.100	2.415
	Perceived bird richness (high)	-1.737	-7.335	3.823	0.085	-3.475	3.534
	Perceived naturalness	-0.477	-1.630	0.683	-0.210	-0.994	0.535
	Safety concern (medium)	0.236	-2.975	3.379	**-2.442**	**-4.638**	**-0.451**
	Safety concern (high)	2.242	-1.161	5.824	**-2.396**	**-5.001**	**-0.133**
Negative affect	**Perceived restorativeness (path *b*)**	0.031	-0.062	0.124	-	-	-
	Perceived sound enjoyment	**-0.916**	**-1.660**	**-0.151**	0.085	-0.184	0.380
	Perceived bird richness (medium)	0.519	-1.651	2.749	0.042	-0.215	0.381
	Perceived bird richness (high)	**4.865**	**0.228**	**9.435**	0.011	-0.526	0.574
	Perceived naturalness	0.378	-0.593	1.340	-0.016	-0.157	0.088
	Safety concern (medium)	1.205	-1.417	3.724	-0.179	-0.866	0.404
	Safety concern (high)	**7.903**	**4.776**	**10.958**	-0.169	-0.870	0.435
Anxiety	**Perceived restorativeness (path *b*)**	-0.150	-0.365	0.066	-	-	-
	Perceived sound enjoyment	-1.099	-2.852	0.662	-0.392	-1.121	0.219
	Perceived bird richness (medium)	0.334	-4.812	5.443	-0.200	-1.220	0.461
	Perceived bird richness (high)	6.892	-4.254	17.642	-0.032	-1.777	1.691
	Perceived naturalness	-0.201	-2.522	2.084	0.074	-0.245	0.499
	Safety concern (medium)	**7.104**	**1.012**	**13.251**	0.842	-0.469	2.750
	Safety concern (high)	**8.028**	**1.239**	**14.889**	0.804	-0.428	2.662

Chapter 5. Exploring the wellbeing benefits of urban green and blue space in neotropical South America: A participatory video approach

Jessica Claris Fisher[1], Jayalaxshmi Mistry[2], Meshach Andre Pierre[3], Huichang Yang[3], Arianne Harris[4], Nadia Hunte[5], Damian Fernandes[6], Jake Emmerson Bicknell[1], Zoe Georgina Davies[1]

[1] Durrell Institute of Conservation and Ecology (DICE), School of Anthropology and Conservation, University of Kent, Canterbury CT2 7NR, UK

[2] Department of Geography, Royal Holloway University of London, Egham, Surrey TW20 0EX, UK

[3] Iwokrama International Centre for Rainforest Conservation and Development, 77 High Street, Kingston, Georgetown, Guyana

[4] University of Guyana, Turkeyen, Georgetown, Guyana

[5] Protected Areas Commission Guyana, Georgetown, Guyana

[6] Conservation International Guyana, 98 Laluni St, Georgetown, Guyana

Manuscript published as:

Fisher JC, Bicknell JE, Irvine KN, Fernandes D, Mistry J, Davies ZG. 2021. Using participatory video to share people's experiences of neotropical urban green and blue space with decision-makers. The Geographical Journal. doi:10.1111/geoj.12406.

5.1 Abstract

Urban green and blue spaces benefit human wellbeing, and also provide resources for biodiversity, as shown by a wealth of evidence from the global North. Yet in the global South, where rapid urbanisation is posing challenges for biodiversity conservation and the mental wellbeing of urban human populations, there has been little research on understanding the social and environmental benefits of urban green and blue spaces, which could inform decision-makers seeking sustainable land-use planning interventions. Here, we use participatory video (using film to co-produce research) to explore the relationships people have with urban green and blue spaces in Georgetown, Guyana, and communicate these findings to decision-makers. Short films created and discussed by city residents highlighted how specific characteristics of green and blue spaces contributed to restorative quality, alleviated stress, and place attachment, similar to patterns ascertained in the global North. At the same time, locally specific nuances, such as folklore associated with urban wildlife and the importance of monuments framing Guyana's complex history, was also revealed. A composite film was screened to government ministries, park managers, and the Mayor and City Council, who articulated intentions to change the way these spaces were managed (e.g. maintaining specific features, encouraging visitation, raising awareness, and increasing the planned distribution of new spaces). We demonstrate how participatory video can allow participants to reflect on and change their interactions with the urban environment, while facilitating a unique and engaging dialogue between multiple stakeholders, with important implications for both public health and biodiversity conservation.

Keywords: Biodiversity; Conservation; Green Spaces; Guyana; Human Wellbeing; Participatory Video.

5.2 Introduction

By 2050, urban areas are predicted to be home to nearly 70% of the world's population (United Nations, 2018). The concomitant expansion of urban landcover is expected to cause considerable detriment to biodiversity, particularly in the global South (Seto et al., 2012), where the world's most biodiverse regions are disproportionately located (Barlow et al., 2018). The impact of urbanisation on biodiversity in global South cities is exacerbated by particularly fast rates of population growth and land-use change, as well as low levels of governance (Pauchard et al., 2006; Richards et al., 2017). Urbanisation also has implications for the health and wellbeing of urban dwellers, who experience a high prevalence of mental health disorders (Abbot, 2012).

Urban green spaces (e.g. parks), and blue spaces (e.g. coastline) provide resources for biodiversity (Baldock et al., 2015; Ives et al., 2016), which then deliver critical provisioning (e.g. medicinal), regulating (e.g. air purification), and cultural (e.g. inspiration) ecosystem services to humanity (Schwarz et al., 2017). These spaces provide opportunities for people to spend time outside which can result in improved health and wellbeing, as documented by a wealth of empirical evidence, albeit predominately from the global North (Gascón et al., 2017; van den Bosch and Ode Sang, 2017). With this in mind, it is important to understand the multiple benefits that could be offered by urban green and blue spaces in the global South, and communicate these findings to decision-makers who require sustainable land-use planning interventions that optimise trade-offs between diverse social and environmental needs (Hartig and Kahn, 2016).

The ways in which urban green and blue spaces influence human wellbeing can be highly heterogeneous amongst stakeholders. For example, green space users from particular ethnic groups linked urban green spaces to specific respiratory conditions in the UK (Cronin-de-chavez et al., 2019). The views of decision-makers can also differ from that of users (Guenat et al., 2019; Ives et al., 2017b). For example in Ghana, users valued green spaces for their beauty and income-generation potential, while decision-makers valued them for recreation, education, and legacy (Guenat et al., 2019). Capturing such a diversity of viewpoints is best achieved through the use of participatory methodologies that incorporate a variety of stakeholders into the research process (Larson et al., 2016). This approach results in better informed decisions about urban green and blue space management that could benefit a wider sector of society (Larson et al., 2016). Moreover, participation can lead to altered visitation behaviour and attitudes, for instance leading to wellbeing improvements (Kruize et al., 2019), or a sense of agency that results in environmental stewardship actions (e.g. planting trees, community gardens) (Campbell et al., 2016).

Participatory research methods that facilitate creativity can elicit a more in-depth understanding of how people's interactions with urban green and blue space relate to their wellbeing (Bell et al., 2016; O'Brien and Varley, 2012). Visual methodologies, like video or photography, can be advantageous in circumstances where individuals find difficulty expressing themselves using typical written or spoken mediums. For example, Kaley et al., (2019) used ethnographic video to explore the therapeutic effects of 'green care' interventions for people with intellectual disabilities. Furthermore, given that people's experiences of urban green and blue space are highly multisensory (Franco et al., 2017), visual (e.g. photos) (Chang et al., 2020), audio (Hedblom et al., 2014), and virtual reality (Yu et al., 2018) have proved to be effective tools to interrogate their impact on wellbeing. Indeed, *in situ* video-based methodologies are best placed to capture rich and detailed data on sensory experiences, particularly when paired with explanations of the subjectivities behind the footage (Dinnie et al., 2013; O'Brien and Varley, 2012).

Participatory video is characterised by a group of people co-creating films about a topic, drawing together collective perspectives according to what they feel is important and how they want it to be represented (Mistry and Berardi, 2012). By engaging in an audio-visually enriched research process, which strengthens and amplifies the narrative, participants can be faced with new issues and ideas that may challenge or enhance their own perceptions (High et al., 2012). For example, by taking part in a participatory video process on soil conservation practice, Malawian farmers were encouraged to adopt new methods after their perceptions were changed about the value of composting methods and their own ability to apply the practice (Cai et al., 2019). Similarly, Tremblay and Harris (2018) illustrated this in urban Ghana and South Africa, where participants described how video enabled them to feel an embodied, empathetic understanding of the issues surrounding (in)access to water and sanitation.

Therefore, participatory video can facilitate social transformation both at the participant-level, building capacity for people to voice their opinions, and at the community-level, through the actions or behaviours that are subsequently more inclusive and informed about their impacts on other people.

The sharing aspects of participatory video are beneficial for influencing policy and practice. The methodology often concludes with the production of a composite film that summarises the content collected, put together by participants, facilitators, or project team members (High et al., 2012). This film can be shared with the wider community, external agencies, or decision-makers, as an engaging research product that directly incorporates the voices of participants (Thompson et al., 2017). Film screenings with decision-makers can also prompt critical discussions that generate new perspectives, which could impact future policy. For example, a participatory video on climate change mitigation produced by a community in the Philippines was screened to government officials, who subsequently aimed to help push through a piece of supportive legislation (Haynes and Tanner, 2015). In the Turks and the Caicos Islands, participatory video was used to communicate the voices of stakeholders in a sea turtle fishery, which resulted in amendments to the fishery legislation (Christie et al., 2014). This is particularly important where participants represent the wider community as the intended beneficiaries of top-down decisions. Sharing the perspectives of the public with decision-makers that manage tropical urban parks is needed to communicate the multiple social and environmental benefits that might otherwise be overlooked (Ibrahim et al., 2020).

Here, we used participatory video to explore how people relate to urban green and blue space in Guyana, South America. Guyana is forecast to become South America's fastest growing economy due to recent discoveries of extractable oil (Panelli, 2019), so the urban landscape is likely to transform markedly. Just under half Guyana's population live within 5 km of the coastline (Mycoo, 2017), with ~192,000 resident in its capital city, Georgetown (Bureau of Statistics, 2012). Participants, representing a range of socio-economic backgrounds, co-created participatory films which were then shared with the decision-makers tasked with managing the city's green and blue spaces. We uncover the ways in which people derive wellbeing benefits and show how participatory video influenced perspectives in both participants and decision-makers.

We ultimately highlight the implications of our findings for both public health and biodiversity conservation in developing global South cities like Georgetown.

5.3 Participatory video approach

We focussed on three sites in Georgetown: two of the primary recreational green spaces (National Park and Botanical Gardens), and one coastal space (the sea wall) which runs along the North coast of the city (Figure 5.1). The green spaces are managed by the Guyana government's Protected Areas Commission (PAC), which collaborated with us throughout.

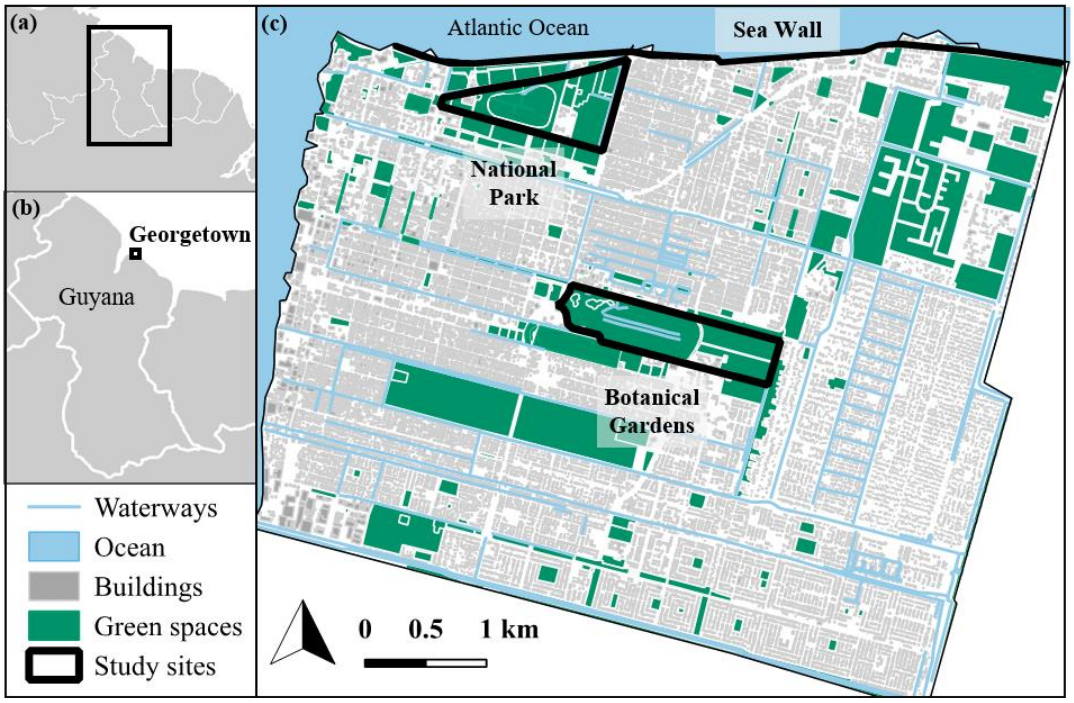


Figure 5.1: Map of Georgetown, Guyana, (a) Guyana in northern South America, (b) Georgetown on the north coast of Guyana, (c) study sites within Georgetown

5.3.1 Participants

The participatory video process, conducted between January 2018 and April 2019, followed on from a broad questionnaire-based survey of people's attitudes toward Georgetown's urban green and blue spaces in 2017. Survey participants were invited to take part in this second phase of research and, of those that responded positively, eleven were selected for the participatory video process. These individuals represented a range of socioeconomic backgrounds and varied in the frequency with which they visited outdoor spaces. We sorted the eleven participants into smaller groups (due to equipment constraints) according to age, because it is known to influence green space use and perceptions (e.g. Astell-Burt et al., 2014; Laatikainen et al., 2016; Ode Sang et al., 2016). The core groups consisted of two groups of under 35 year olds, with three and four participants respectively, and one group of four participants all over 35 year olds (Supporting Information, Table S5.1). Group membership was kept consistent throughout the process to encourage participants to feel comfortable through their shared experiences and build up a collective response over time. Participants were incentivised by covering the cost of their travel and subsistence, and a complimentary meal was provided during the weekly workshops with the researchers.

Six additional participants who expressed interest in the project took part in the film screenings and discussions on an ad-hoc basis, depending on their availability (Supporting Information, Section S5.1). While the core groups remained consistent throughout, the flexibility and inclusivity of a wider group during discussions was useful for collecting a broader range of opinions (with Georgetown's general public being the intended beneficiaries) and highlighting areas of consensus.

5.3.2 Project structure

We designed a seven-stage process (Figure 5.2), beginning with participants meeting the research team on a Saturday in January 2018 (stage 1). Groups were assigned and then given a full week to collect data in their own time before returning the following Saturday (stage 2). This cycle was repeated across the three sites (stages 2-4), with the Botanical Gardens re-visited (stage 5) to allow participants to capture any experiences they felt were important but failed to realise in week 2 due to lack of knowledge, skills, or ideas. Following analysis, a composite film was produced representing the collective opinion across all three groups (stage 6), before being screened to decision-makers (government ministries, Mayor and City Council, and park managers) in April 2019 (stage 7).

5.3.3 Filming, editing and screening

Each core group was lent a tablet (Samsung Galaxy Tab A), tablet stabiliser to improve image quality, and access to a video editing application (PowerDirector for Android).

The participants were asked to think about each of the three sites while considering the question: ‘What affects your emotions in a positive or negative way in Georgetown’s outdoor public spaces?’. Prompt questions included: ‘What makes this place come alive?’, ‘What are the features that you notice and how do they make you feel?’, ‘What makes this place important or meaningful and why, and what adds or takes away from that?’, ‘What experiences might you want to capture?’ and ‘Are there any stories you heard about this area?’. These were repeated throughout the storyboarding, filming, editing, screening, and discussion processes.

Participants were asked to collect footage from the allocated site during the week as a core group, when they had time or felt there was something important to capture. At each workshop, the core groups edited their footage into a one-minute film, supported by three experienced Guyanese facilitators (MAP, HY, AH) to ensure all group members contributed equally, however dominant their personality.

Films from each site were screened and discussed with the wider group. Discussions followed no strict format, but began with people offering their opinions about quality of filming and were allowed to progress until they came to a natural close. Focussed discussions were then held within each core group to understand the intended meaning of the film content. This enabled a richer understanding, because it exposed opinions not captured in the films themselves. Finally, evaluation forms were issued to collect feedback on the process and capture attitudes toward the project (see Supplementary Text Section 5.1).

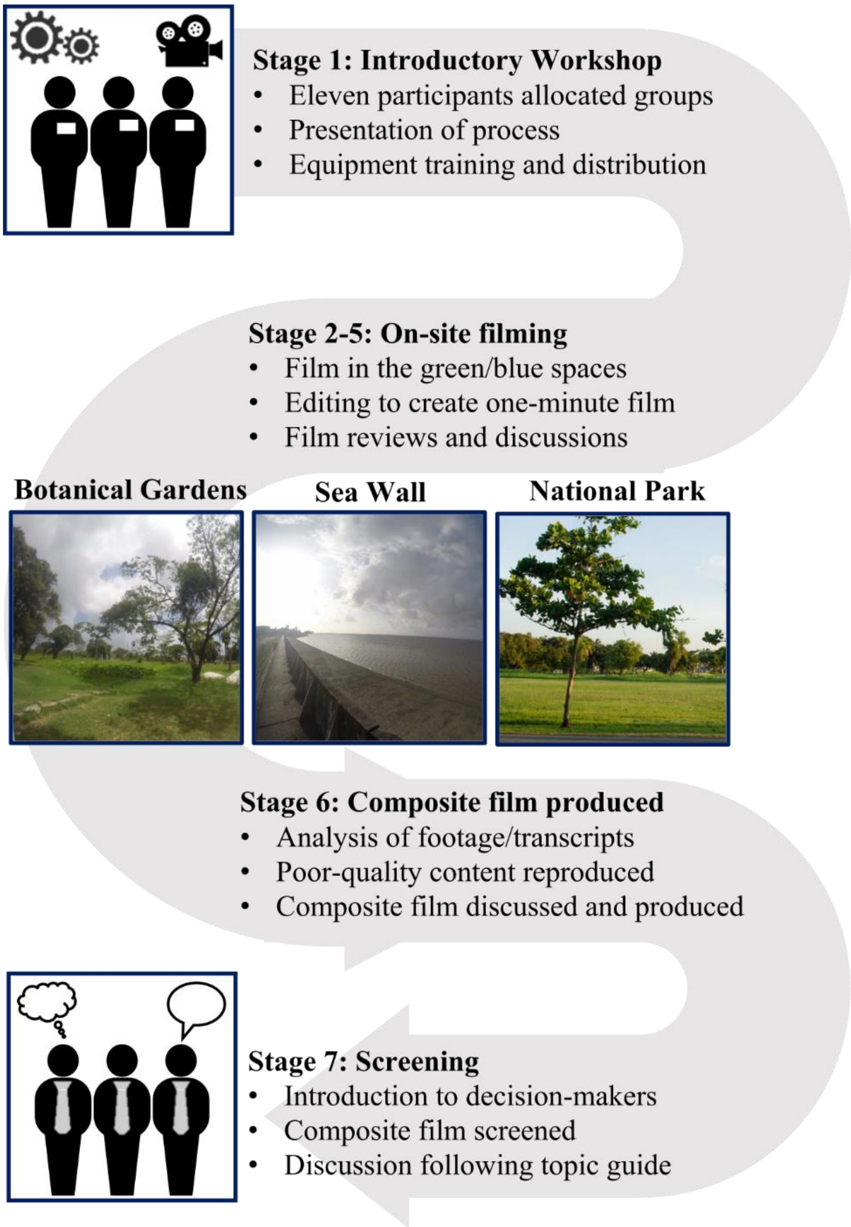


Figure 5.2: Diagram of the project stages, highlighting the key steps in the participatory video process

5.3.4 Transcription and coding analysis

Our analysis set out to explore participants' perspectives in-depth, capturing recurrent themes and highlighting individual nuances. We first transcribed all the films, footage, and recordings from the focus groups and wider discussions verbatim. All transcripts were coded using NVivo (Version 11, QSR International Ply Ltd.), taking a deductive grounded theory approach (Bradley et al., 2007), indicating whether the sentiment of the content was positive, negative, or neutral. Similar codes were grouped into parent codes and domains, which we then interpreted with reference to quotes from individual participants. Five transcripts (from stages 2-4) were independently coded by three authors (JCF, JM, MAP) to validate the approach taken to coding. As interpretations of the dialogue were consistent, the remaining content was subsequently coded by one author (JCF).

5.3.5 Screening to decision-makers

A six-minute composite film, representing the views of all seventeen participants (eleven from the core groups and six additional wider group members) across the three sites, was produced by two authors (JCF, MAP). The composite film used participant's footage with some content reproduced to improve the visual/sound quality. The film framed the domains and narratives that emerged from the analysis, but was kept short to maintain audience interest. The draft composite film was screened to all available participants prior to producing the final edit to attain their agreement that it accurately portrayed their opinions, as well as to gauge feedback on the film itself.

Ten individuals from seven decision-making authorities with jurisdiction across Georgetown's public outdoor spaces (see Supplementary Text Section 5.2) were invited to the composite film screening. The screening was an integral part of a three-hour deliberative workshop entitled 'The benefits of Georgetown's green and blue infrastructure'. The workshop was co-led with a Guyanese facilitator (NH). We introduced the project by stating our intention to communicate opinions from the public, and to inspire decision-makers to take action to improve delivery of several of Guyana's national development policies and biodiversity commitments (Green Sustainable Development Strategy (GSDS); United Nations Sustainable Development Goals; Guyana National Pledge; Protected Areas Commission strategy). During the screening of the composite film, we asked attendees to think about answers to six questions, designed to stimulate engagement with the film content (see Supplementary Text Section 5.2), which subsequently formed the basis of a 45-minute discussion.

5.3.6 Ethical considerations

Participatory video raises a number of ethical dilemmas around data ownership, gaining the consent of people filmed by the participants, confidentiality, and the power dynamics between the researcher and the 'researched' (Asan and Montague, 2014; Kindon, 2003; Milne, 2016; Mistry, et al., 2015). Primarily, we sought to counter these issues by being transparent in our consent form (see Supplementary Text Section 5.3). The participatory process received considerable review both internationally (University of Kent in the UK) and in-country (PAC in Guyana). We endeavoured to be both adaptive and reflective to participants and decision-makers throughout the project. As the data were owned by participants, they were encouraged to keep copies of the footage with consent from fellow group members, but not to share them publicly.

5.4 Results

We identified 80 codes across the films, footage, and transcripts (Table 5.1). Five domains emerged from this iterative deductive process (Features, Perceptions, Context, Wellbeing benefits/dis-benefits, Methodological). The latter referred to the learning experience associated with the participatory video process, management recommendations, and ways participants felt the film should be used. The overall sentiment of the content was 62% positive, 20% negative, and the remainder either mixed or neutral.

Table 5.1: Codes that emerged from films, footage, and transcript materials from five participatory video workshops across three sites (two green spaces, the Botanical Gardens and National Park, and one coastal blue space, the sea wall) in Georgetown, Guyana. Participants were asked 'What affects your emotions in a positive or negative way in Georgetown's outdoor public spaces?'. Codes were grouped into parent codes and five major domains. Similar codes were congregated, denoted by a slash '/'

Code	Parent code	Domain
blue space feature; breeze/wind; facilities; grey space; historic monument; lighting/light/dark; litter; outdoors; pathway; sky; vendors; waves; weather; zoo	Abiotic	Features
abundance of wildlife; birds; caiman; fish; flowers; horses/ponies; manatees; nature; snakes; species richness; stray dogs; trees; vegetation; wildlife; wildlife movement	Biotic	
atmosphere; beauty; cleanliness; colour; fresh air; manicured nature; safety/security; scenery; seclusion; smell; sounds; views		Perceptions
children and family; drugs and homelessness; gender issues; holiday events; human-nature interactions; memories; physical activity/exercise; religious practice; romantic space; rumours or stories; socialising; socioeconomic importance; visit frequency; weekends	Social	Context
accessibility; back of the gardens; flooding; spacious/open space	Spatial	
alive/brought to life; attention restoration or stress reduction theory; attraction; clear your mind; cosiness; excitement/mystery/adventure; fascination/amazement; freedom/escape; patriotism; peace/calm; relaxing/chill; scared; serenity; shade; value		Wellbeing benefits/ dis-benefits
cooperation and agreement; film critique; learning experience; management recommendations; raise awareness; tourism		Methodological

Certain urban green/coastal blue space characteristics affected people's wellbeing. For instance, participants filmed large trees, plants, and green grass, then remarked on the presence of vegetation relating to positive emotions. Manicured vegetation was frequently captured, including flowerbeds and the tree-lined promenade at the entrance to the Botanical Gardens. One participant mentioned these in the context of a social gathering:

'The grass, the palm trees, the flowers, and so forth. It feel kind of cosy whenever you're here. I don't know, it's away from home, it's just different… all the green, it's really nice, and as I say it's really cosy and you can be under the tree with your family and some little thing with your family and you have the privacy there.' (female, 18-35).

Vivid descriptions of the sea wall were used to illustrate how it positively influenced wellbeing, highlighting its length as a space for exercise, or the repeated motion of the waves helping people 'get away' from busy lifestyles. Others captured the sense of landscape change. For example, how low tides exposed the sand and mud, which made one participant feel 'dreary', while high tides elicited feelings of being relaxed and comfortable. For another, the aesthetic qualities of the water were associated with a sense of mystery and fascination:

'*Mostly for me it's the water, that's the only thing I really go there to look at, the water. And the ships, how they passing. Sometimes I used to go there, and I used to think, I want to go to the ocean.* [Laughing]*… just to see what's beyond there…*' (male, 35+).

Other biotic and abiotic features on the sea wall contributed to feelings of stress-relief, relaxation and amazement, such as the breeze and the abundance of sea birds (Figure 5.3a):

'*I like the splash of the waves, the water, I like the breeze it's just, you know if you're travelling in a car you don't get that much breeze to inhale and exhale, and feel relieved of stresses and so, so I like that. I like seeing birds, flying*.' (female, 18-35).

Facilitator: What do you like about them?

'*I just, I think they were moving in flocks. Like together, so, I like that. It's just an amazing scene it also adds to the sea wall ocean-y atmospheric ting. It adds to that, birds and breeze so, adds to. It's like everything comes together to form this beautiful scenery*.'

Figure 5.3: Stills from participant's footage: (a) whimbrels (*Numenius phaeopus*) at the sea wall, (b) historic monument at the National Park, (c) litter at the sea wall, (d) interacting with West Indian manatees (*Trichechus manatus*) in the Botanical Gardens

This same individual went onto articulate that the migratory behaviours exhibited by these coastal seabirds, alongside the sensory experience they provided, positively influenced her emotions: '*There's a lot of birds in here. But different timing, there's not a standard timing you would see them. Sometimes they here sometimes they fly to other spots… the sounds they make, and um, the way they move and so on, it just brings* *this wildlife atmosphere around you that makes you want to just, sit and enjoy the fine scenery*.'

Despite very little vegetation at the sea wall, participants described it as '*nature-oriented*', a space to take refuge from city stresses. As such, the presence of wildlife, sounds of waves, and sea breeze were attributed as natural features that contributed to a sense of escape and relaxation:

'*It's very nature-oriented. The breeze, the birds, the ocean. Scenery in general, it just makes you feel relaxed, takes your mind away from the everyday activities.*' (female, 18-35).

Participants discussed the sensory experience of green space, offering an escape from city life, and somewhere to take notice of the surroundings. The mechanical sounds of bush cutters (strimmers) and traffic were described as detracting from this peaceful experience. In contrast, the sound of birdsong was thought to be a stimulus for feelings of calm and serenity:

'*… that's the most beautiful thing about here and it's so unique, you come and enjoy the cool breeze and the plants, and the smell of the plants and the birds chirping… Like this morning we went to the park again and we were sitting on those large tyres and it was so beautiful. The silence and the birds chirping*.' (female, 35+).

Benches offer somewhere to relax, both in the green spaces and at the sea wall, helping one individual escape his daily life:

'*…you just go and you sit in the chair and you just stare into the ocean you know like you just lost in your own world*.' (male, 35-44).

Similarly, features that encouraged visitors, including signage and structured pathways, contributed to a social atmosphere and feelings of safety and relaxation. This was important in quieter locations, such as at the back of the Botanical Gardens:

'*Ever since, before they opened the back there, I never actually went passed, down by the bridge, but since they opened the back there you can drive there, so it's peaceful* *and nice, and so, you kinda get to see it, so I feel like a lot more safer, or maybe because it's peaceful. I feel a lot safer, but, I feel a lot safer now that I've actually just, passed it. And I see people picnicking or whatever, it feels nice, calming vibe*.' (female, 18-35).

However, the overgrown back of the Botanical Gardens was associated with criminal activity and insecurity, particularly at dusk. Participants drew comparisons with the National Park, which is relatively more manicured, consistently referring to light and dark in terms of safety:

'*I would feel more safer in the National Park than the Botanical Gardens because of it having, to me, the entrances are more accessible, and for some reason I feel like it's more transparent, you can see through, other than the Botanical Gardens having a lot of trees so, I feel more safe with it, and a lot of persons, they do*.' (female, 18-35).

The importance of a 'social atmosphere' in Georgetown's green spaces was a recurring narrative, facilitated by the presence of picnic tables and benabs (small wooden shelters), available for hosting social events at no monetary cost. Similarly, the sea wall, running parallel to an accessible main road, is a centre for social gatherings on weekend evenings, serviced by vendors playing music and selling food and drinks. Nearly all participants recalled positive memories from being there, particularly as attendance is free:

'*…it's easily accessible, I don't have to pay a fee to go to the sea wall, it's a quick reservation you know, if you friends link up somewhere, everybody can meet at the sea wall, we have the stands there selling stuff and you can sit there, eat, and have a good conversation*…' (female, 18-35).

Many participants talked about historic monuments and biotic features contributing synergistically to a sense of place (feelings of attachment, belonging, and identity) at all three sites (see Figure 5.3 for film stills):

'*I think the fact that you can find both nature and history in one spot, it makes you whole. Because for me nature is a part of us, because it brings about good feelings,* *such as feeling peaceful, happy, relaxed, stuff like that, and then the history brings in patriotism, feeling proud, feeling proud of your country and all that it will have accomplished back then until now. So both of them is kind of a wholesomeness in some place…*' (female, 18-35).

Many felt that historic monuments were also important for helping younger generations to learn about Guyanese history. As such, the locations around them were seen as a social space that attracted the presence of families and, in turn, contributed to a sense of safety (Figure 5.3b:

'*When my daughter was younger she would take her bicycle and ride around the monument area there so to me it's a nice safe area on the sea wall that the children can socialise and then they have other children going to that same area so that can you know, meet new friends and play and it's away from the road*.' (female, 35+)

Litter at the sea wall was viewed negatively, associated with bad smells and being unsightly (Figure 5.3c. Poor lighting and a lack of security brought about bad memories for some participants, reinforcing the persistent fear of being robbed. These were not only barriers to using the sea wall, but directly prevented participants from perceiving it as beautiful:

'… *because the sea wall is such a long stretch, you still would tend to have a few robberies and such, because I was once robbed out there, and um, I think it was because I was near the part where he was talking about, with the darkness, and stuff like that. So I think they really need to um, just modernise it a bit in terms of lightening, so you can see properly what's going on. Also the garbage at certain parts it's really, really heavy. It's a lot it's dirty. And the smells, it can really take away from the beauty of all that's going on*.' (female, 18-35).

A population of semi-wild West Indian manatees (*Trichechus manatus*) reside in the ponds of both green spaces. Interactions with this species were constantly referred to as an 'exciting' or 'fascinating' experience, associated with meaningful childhood memories (Figure 5.3d). Multiple participants mentioned folklore, which says that the manatees rescue people that fall into the ponds, with some describing how they pushed friends into the water as an experiment to see if this would happen. Another participant recounted the manatee rescuing her daughter:

'*She was about seven. So the edges of the pond it was slippery, so she slipped into the pond, and then, well, we saw, and we were trying to help her but she said she came out on her own. She came up to the edge like. She said that the manatee literally pushed her up to the edge, and then we were able to just pull her*.' (female, 35+).

While attitudes toward manatees were generally positive, one participant, responsible for 30% of all negative content, remarked on his fear:

'*I was actually scared. I was actually very scared to imagine one of them touching me… They're scary*.' (male, 18-35).

The same individual also had a negative attitude toward snakes:

'*They* [the green spaces] *still be too dark, to some points, it's not fully light it's not all around, it's like the snakes they gonna eat somebody else*.'

He continued using references to light and dark in his fears about the sea wall:

'*I'm very afraid of the ocean life. I believe the aqua life is very dark and scary…*'.

He suggested that many of his perceptions were based on stories originating from his family. Surprisingly, this participant also chose to film at the sea wall in the evening, with the intention of securing footage of barn owls, which to him symbolised wisdom and strength.

The one-minute screening discussions enabled a unique shared learning experience, where participants gained new knowledge from one another about spaces in Georgetown. One participant commented that she was now aware of new features in the National Park:

'*…I never knew that there was the map of Guyana, the pond there, I never knew that. I never knew that the trench [canal] that was there, the manatees was actually in there. I never knew caimans were there. I never even saw the bell*.' (female, 18-35).

Noticing these features, and undertaking independent research, transformed how participants viewed the three sites. These effects were apparent where one individual remarked on the historical importance of a flooding event at the sea wall, and how it was managed during Guyana's colonial history, creating a strong sense of place and feelings of fascination:

'*I remember then they had the 2005 flood in Guyana, and all the waters were actually over the wall and it was really panicking especially for persons living on the east coast. So the government had to be working extremely hard with the kokers and everything to get the waters out instead of in, and moving, so, when I remember the flood I try to picture myself back in that era when they had the flood and then the Dutch try to put the concretes and so on, so it has quite an amazing history as to how it established, and I really liked it.*' (female, 18-35).

Participants mentioned how the participatory video process resulted in a positive change in attitude, accentuating their willingness to learn more about and conserve Georgetown's green and coastal blue spaces, as well as visit them more often:

'[the project] *was informative and educational but mostly it brought me closer with nature and its beauty.*' (male, 35+).

Decision-makers also revealed a newfound understanding and intent to respond to the issues presented in the composite film. Suggested changes could, therefore, result in an improvement the public experience:

'*…as Guyana to become a green state, improving these green spaces should be a fundamental priority for government. And improvement not just in the awareness aspect, but improvements to the supporting infrastructure as in lighting, and security*.' (Representative from the Ministry for Public Infrastructure).

Several decision-makers intended to raise awareness of the relationship between nature and wellbeing in Georgetown with colleagues at their respective institutions, to encourage changes from the authorities that manage Georgetown's green and blue spaces:

‘*For my ministry, we probably recommend to them that at their workshops and seminars, we probably dedicate a few minutes to sensitise persons on the benefits of the park and the sea wall and green spaces*.’ (Representative from the Ministry for Natural Resource Management).

In addition, some of the decision-makers stated their intention to integrate new green and blue spaces into Georgetown to reduce inequalities associated with access and, consequently, wellbeing:

‘*Being a part of land policy and planning division we deal with plans that are associated with land and we need to recognize the importance of when we open up land we can set aside land, to be a green space, so that would encourage these types of values or so, in the environment.*’ (Representative from Guyana Lands and Surveys).

While there was some discussion about the need to alter the culture of Guyanese citizens and ‘the way that we think’, several individuals suggested that there should be educational campaigns to raise public awareness of the benefits of green and blue space for wellbeing. This was mentioned in terms of aligning with the Government’s wider sustainable development plans:

‘…*this ties in very well with the Green State Development Strategy… …in 2021 we’re going to have the ban of single use plastics, so I think, for me personally, I have this idea of kind of having awareness sessions right on the sea walls, on weekends, when citizens are out most*…’ (Representative of the Environmental Protection Agency).

5.5 Discussion

Using participatory video enabled participants to capture the visual, auditory, and experiential qualities of their visits to green and blue spaces in Georgetown. Green spaces were perceived as somewhere natural and calming to escape busy city life. This aligns with findings in the global North, where green spaces are generally perceived as natural and contribute to feelings of attention restoration and positive emotion (Hoyle et al., 2019; White et al., 2013). Likewise, the sea wall was described as restorative, despite it being comprised of mostly concrete running parallel to a main road, suggesting that oceanic views disproportionately influenced people's experiences. Findings from Germany contend that people's thoughts and senses in urban blue spaces are primarily driven by the linearity of the waterways, alongside the motion and fluidity of the water itself (Völker and Kistemann, 2015).

Specific features contributed to the restorative quality of Georgetown's green and coastal blue spaces. Participants described how the sea wall evoked feelings of fascination and escape, referencing tides, calm '*glistening*' seas, and crashing waves. This sense of landscape change, often attributed to experiences in natural environments (Bell et al., 2016; Folmer et al., 2018), has been similarly described for coastal blue spaces in the global North (Bell et al., 2015). In Georgetown, the sight and sounds of birds were also related to feelings of fascination, relaxation, and escape. In the UK, birdsong has been found to positively contribute to restorative quality (Hedblom et al., 2017; Ratcliffe et al., 2013), and the quietness offered by urban green spaces also means that birdsong can be heard over the mechanical backdrop (Irvine et al., 2009). Moreover, coastal birds in the global North evoke fascination through unexpected encounters or flocking behaviours (Bell et al., 2017; White et al., 2017). With a high diversity of birds recorded in Georgetown (Hayes et al., 2019), our findings therefore suggest that the ways in which urban green and blue spaces positively affect human wellbeing are consistent across the global North and South, specifically enhanced by features like water and birdlife which stimulate a rich and multi-sensory experience.

Aside from consistent positive sentiment toward birds, a diversity of attitudes was captured when it came to other wildlife taxa. It was apparent that folklore was responsible for much of the negative attitudes expressed towards biodiversity, specifically manatees, snakes, and fish. Negative misconceptions of wildlife can lead to persecution, as seen with the Anaimalai gliding frog (*Rhacophorus pseudomalabaricus*) in India (Kanagavel et al., 2017) and the aye-aye lemur (*Daubentonia madagascariensis*) in Madagascar (Simons and Meyers, 2001), which are considered Critically Endangered and Endangered by the IUCN respectively.

Elsewhere in Guyana, local communities alongside an NGO successfully prevented the continued population decline of *Arapaima* sp., a large freshwater fish surrounded by regional taboo and folklore, by changing the social norms regarding overfishing (Fernandes, 2006). As such, interventions to influence knowledge and attitudes could result in more positive human-wildlife interactions that deliver co-benefits for both human wellbeing and conservation. Indeed, participants with negative attitudes toward wildlife reviewed their own perspectives after interacting with others during the project. Through knowledge sharing, participatory video therefore provided an avenue through which participants could critically reflect on their own cultural values of wildlife.

Across sociodemographic groups, the features of the urban green and coastal blue spaces were closely linked to social cohesion (mutual caring and connectedness which in turn shapes community interactions; Weinstein et al., 2015) and place attachment. For example, vendors, benabs, and tree canopies (and the coastal sea breeze) were necessary in the tropical climate for people to stay longer and gather, therefore leading to the creation of memories. The role of urban green space providing opportunities for social cohesion has been widely documented (see Hartig et al., 2014 for a review), including in India (Gopal and Nagendra, 2014) and Colombia (Ordóñez-Barona and Duinker, 2014), where gatherings are concentrated in green spaces as they offer an escape from the urban heat. In Georgetown's green and blue spaces, feelings of place attachment were furthered by the prominence of several historic monuments reflecting Guyanese political history. Coupled with biotic features, these monuments enabled participants to further their knowledge of, and identify with, both Guyanese history and the natural heritage. Consequently, older participants, particularly those with children, felt that these experiences were important for future generations. International agreements, such as the World Heritage Convention, advocate for the integration of cultural features into recreational spaces for human wellbeing, including in cities specifically (Trzyna et al., 2014).

Concern for personal safety was a dominant narrative, inhibiting positive wellbeing experiences in Georgetown's green and coastal blue spaces. Feeling unsafe in urban green spaces is a recurrent theme in the global North and can prevent people using sites altogether (Cronin-de-Chavez et al., 2019). In Georgetown, overgrown vegetation was described as potentially harbouring criminals or dangerous animals. In particular, the densely vegetated back half of the Botanical Gardens was frequently mentioned. Echoing findings from the UK (Pitt 2019), all our participants said that safety concerns would be eased by enhancing the lighting, safety, and security measures throughout the green and coastal blue spaces, and requested that decision-makers sought to make these improvements.

By using the cameras to actively engage with Georgetown's outdoor spaces *in situ* and acquire new knowledge (e.g. visiting the historic monuments, interacting with wildlife), participants appeared to experience positive wellbeing benefits where they had not done so previously. This message was then conveyed to other participants through the one-minute film screenings and discussions. Moreover, all participants developed their perspectives on Georgetown's green and blue spaces, regardless of their original motivation to take part in the participatory video process. By developing agency, the participants discussed their intentions to share new knowledge and perspectives with family and friends outside the project, visit the green and blue spaces more often, and strive to keep them maintained. Indeed, Truong and Clayton (2020) argue that technology-mediated experiences of nature can be used to encourage engagement, nature connectedness, and pro-environmental behaviours in others. As the participatory video process progressed, the participants focussed increasingly on what messages they wanted decision-makers to hear to inspire action that would improve Georgetown's outdoor spaces.

Participatory video is a dynamic and 'messy' research process (Blazek et al., 2015; Mistry et al., 2014). For instance, involving Guyanese facilitators raises a number of ethical dilemmas, as facilitators are challenged with co-producing research outcomes that satisfy both their foreign academic collaborators and the participants (Mistry et al., 2015). On one hand, their contribution ensured that the project's delivery and outcomes better reflected Guyanese as opposed to Western-imposed perspectives. Indeed, the participants may have felt more comfortable communicating with Guyanese facilitators than foreigners, as shown elsewhere in the Guianas (Tschirhart et al., 2016). On the other hand, facilitators were recruited and trained by the foreign team to deliver the project objectives. If the power had been devolved entirely to a Guyanese research team, the emergent narratives may have differed completely

(Mistry et al., 2015; Tschirhart et al., 2016). Likewise, because a foreign member of the project team was always involved in the research, it is possible that participant responses may have been biased by perceived social desirability. To minimise this dynamic, the participants collected video material in their own time, thus creating authentic data and knowledge for themselves, on their own terms. The facilitators, who are interested in biodiversity and are users of Georgetown's outdoor spaces themselves, were ultimately interested in improvements to green and blue spaces both for conservation and the public. This final point resonates with one of the broader aims of participatory video, which is to give agency and encourage action on the issues that affect those involved in the process, including participants, facilitators, and the wider community (Milne, 2016). While the flexibility and freedom afforded by participatory video directly impacted the research outcomes, it was inclusive to participants needs and willingness to engage in a rich and often complex subject matter, and was well-suited for confronting the traditional barrier between the researcher and the 'researched' (O'Brien and Varley, 2012; Wilson et al., 2018).

After screening the composite film, decision-makers expressed their intent to deliver action though implementing changes to the upkeep and design of current and future green and blue spaces to improve the wellbeing of Georgetown's residents at large. Propositions included improving security and removing litter, raising awareness amongst the public (and amongst colleagues within the decision-maker's institutions) about the wellbeing benefits these spaces offer, and planning for new green spaces to ensure equitable access across Georgetown. These suggestions were in line with the messages relayed by participants, reiterating how knowledge sharing through creative visual methodologies can lead to successful environmental management, as documented elsewhere in the Guianas (Tschirhart et al., 2016), as well as in the UK (Ranger et al., 2016). As green and blue space users themselves, many decision-makers related anecdotally to the film content, sharing the notion of wellbeing with the voices of participants. As such, the composite film acted as an effective vehicle for both participants and decision-makers to engage with the issues surrounding human wellbeing in urban green and blue spaces, learning through the exchange of ideas, both horizontally (participant to another, decision-maker to another) and vertically (from participant to decision-maker).

Nevertheless, despite some decision-makers stating their intention to deliver upon the film's messages as their public duty, there was still ambiguity in exactly how actions would be taken. Although the decision-makers who attended the composite film screening were largely known to one another, there was little disagreement between their opinions. It was however apparent that a foreign researcher co-leading the workshop may have led to response bias as a consequence of social desirability. Nonetheless, decision-makers agreed between themselves upon the need to raise awareness, increase education, and encourage the public to interact in a deeper way with the city's outdoor spaces (e.g. through media advertisements, birding tours, public 'wellness' programs). Holding additional screenings and discussions of the one-minute films produced by the core groups, involving people from a broader range of sociodemographic backgrounds, could have expanded the breadth of public opinion represented in the project. Future work should focus on engaging individuals who have difficulty accessing green and coastal blue spaces (e.g. people with limited mobility) or are socially excluded groups (Kaley et al., 2019). More research is needed to form a legitimate evidence-base to inform management and policy decisions. Ultimately, decision-makers have to make trade-offs. However, in the face of growing pressures on the psychological health of urban populations and the persistence of biodiversity, changing attitudes in ways that can benefit both people and nature will be advantageous to conservation and human wellbeing.

5.6 Conclusion

Using participatory video, we illustrate how specific characteristics of green and coastal blue spaces benefit the wellbeing of residents, enhancing the multisensory experience, improving accessibility, place attachment, and social cohesion. Our findings were in concert with evidence from the global North, implying that positive nature-wellbeing relationships are cross-cultural. However, locally relevant subtleties were also apparent, such as beliefs about manatee behaviour, and Guyana's complex colonial history enhancing the importance of its historical monuments. We also found that participatory video was an experiential learning process for participants through its dynamic and iterative methodology, which lead to a more authentic and communicable research product that was shared with decision-makers. Both participants and decision-makers were encouraged both to think differently about the urban green and coastal blue space in the city and strive for improvements. Follow-up work will elucidate whether these intentions are translated into informed and sustainable urban planning initiatives that maximise human wellbeing. Guyana, set to undergo a period of rapid economic growth (Panelli, 2019), has the opportunity to develop policies to enhance and restore both new and urban green and blue spaces for the wellbeing of its urban population. By amplifying the public's voices, a participatory video process like the one presented here could be integrated to help design more effective policies that benefit a wider sector of society.

5.7 Acknowledgements

We thank participants and decision-makers for contributing. Thanks to O. Davis, A. Bayney, and Guyana Zoo for coordinating logistics. Drone footage by K. Somarou was used in the composite film. Thanks to S. Bell (University of Exeter), D. Jafferally (Cobra Collective), and C. Willis (Natural England) for useful discussions. The project was supported by grants to JCF from the RGS with IBG (Dudley Stamp Memorial Award), Gilchrist Educational Foundation, the Global Challenges Research Fund (Fortuity Grant), and ESRC (ES/J500148/1) and NERC (NE/L002582/1). ZGD is funded by the European Research Council (ERC) under the European Union's Horizon 2020 Research and Innovation Framework Programme (Consolidator Grant No. 726104). This project received ethical approval from the Faculty of Social Sciences Research Ethics Advisory Group for Human Participants (10 May 2017) (Ref No 0511617) and Environmental Protection Agency of Guyana (ref: 051117BR006).

5.8 Supplementary information

Table S5.1: Table of participant demographics. Sociodemographic of all participants (*n* = 17) who took part in the participatory video project held in Georgetown, Guyana. Core group participants collected the data each week (*n* = 11), whereas the addition wider group participants attended just the film screenings and discussions (*n* = 6)

Participants	Gender	Age	Ethnicity	Religion	Education
Core	F (6)	< 35 (7)	African (4)	Anglican (1)	Primary (1)
	M (5)	> 35 (4)	East Indian (2)	Muslim (1)	Secondary (1)
			Mixed (5)	No religion (2)	Technical/Advanced (2)
				Other (3)	University (7)
				Pentecostal (2)	
				Rastafarian (1)	
				Roman Catholic (1)	
Wider	F (6)	< 35 (5)	African (2)	No religion (4)	University (6)
	M (0)	> 35 (1)	Mixed (1)	Other (1)	
			Chinese (1)	Pentecostal (1)	
			East Indian (2)		

Text Section 5.1: Evaluation survey given to all participants (*n* = 17) upon completing the participatory video project held in Georgetown, Guyana. The questions were all open-ended and the participants responded in writing

1) What did you enjoy about the project?

2) What do you not enjoy about this project / how could it be improved?

3) Do you feel you have a better understanding of the public spaces around Georgetown?

4) Have your attitudes towards these spaces changed? If yes, how?

5) Do you feel like you have a better understanding of the issues faced by other groups of people in these areas, such as gender and age?

6) Is there anything in the public spaces of Georgetown that you would like the managers to think about?

7) Any other comments?

Text Section 5.2: (a) List of decision-maker attendees to the screening of the composite film at the end of the participatory video process held in Gerogetown, Guyana, and (b) the topic guide for post-screening discussion

(a) Attendees

City Council Solid Waste Management (1)

Environmental Protection Agency of Guyana (2)

Government Ministry for Natural Resource Management (1)

Government Ministry for Public Infrastructure (1)

Government Protected Areas Commission (park management) (3)

Guyana Lands and Surveys (1)

Mayor and City Council, Mayor of Georgetown (1)

(b) Topic guide

What are the key messages from the video?

What did you feel watching it?

Do these stories challenge your own personal assumptions of these spaces?

How can residents be better engaged with these spaces?

What are the lessons for decision-makers here?

What is a valuable aim you can contribute?

Text Section 5.3: Consent Form. Questions from the consent form for the participatory video project held in Georgetown, Guyana

1) I confirm I have read the participant information sheet for this study, and have had time to ask questions and receive answers.

2) I understand that taking part in this study is voluntary and that I am free to withdraw at any time without giving any reason.

3) I agree to being videoed, photographed, and recorded on audio.

4) I give permission for anonymised quotes to be used in publications.

5) I give permission for my picture, video and audio to be shared and modified for research purposes (e.g. at a conference presentation or on a research website), but not for commercial purposes.

6) I agree to ask permission from anyone I feature in my film, inform them that it is for research purposes, and ensure they are aware that the film may be shown to a wide variety of audiences, including being posted online.

Chapter 6. Discussion

This interdisciplinary thesis presents novel empirical evidence from the tropical global South regarding how urban green and blue spaces contribute to human psychological wellbeing. This was achieved by combining quantitative, qualitative, and participatory methods from the social sciences, along with techniques from ecology. More specifically, the focus is on biodiversity, exploring the extent to which both public health and conservation challenges can be aligned. Understanding when, why, and how people experience urban green and blue spaces will facilitate effective decision-making, helping to recognise potential trade-offs and identify win-win scenarios relevant to the design and management of cities. Building such an evidence-base is important if urban areas, such as Georgetown in Guyana, are to develop and deliver sustainable urban planning initiatives successfully.

6.1 Contributions to the research field

To my knowledge, this thesis represents the only empirical examination of urban green and blue spaces and human wellbeing in neotropical South America. Throughout the chapters, I uncover both contradictory and complementary findings to those in the global North, likely driven by the immense complexities of the topic, the types of wellbeing measured, the theoretical pathways being tested, the species examined, and the cultural and socioeconomic factors that are tied into how people respond to their environment (Dolan et al., 2016; Markevych et al., 2017; Aerts et al., 2018; Bell et al., 2019). In this section, I highlight some of the contributions the thesis makes to this relatively new and expanding research field.

I quantitatively examine whether biodiversity in urban green and blue spaces enhances or detracts from human wellbeing in **Chapters 3 and 4**, focussing on experiential wellbeing in the moment ('affect'). To do this, I collaborated with another postgraduate student to conduct a bird survey across Georgetown (Hayes et al., 2019). We chose birds because they are a taxa that the public are known to notice visually and audibly (Ratcliffe et al., 2013; Cox et al., 2017b), inexpensive to monitor (Gardner et al., 2008), provide many ecosystem functions (Whelan et al., 2015), and can act as indicators of biodiversity in heterogeneous landscapes like cities (e.g. Eglington et al., 2012; Herrando et al., 2017; MacGregor-Fors and Escobar-Ibáñez, 2017). We recorded over 10% (98) of Guyana's known bird species within the city (Hayes et al., 2019). Indeed, Georgetown is widely recognised as a good birding location, particularly within the Botanical Gardens, with in-country birding tour operators taking tourists there throughout the year. Many studies from the global North have shown that bird species richness, abundance, and sounds are positively associated with human wellbeing (e.g. Bakolis et al., 2018; Cox et al., 2017; Dallimer et al., 2012; Fuller et al., 2007; Hedblom et al., 2017; Luck et al., 2011; Ratcliffe et al., 2013; Wheeler et al., 2015; Wolf et al., 2017). While no associations between objective measures of bird diversity and wellbeing were found in **Chapter 3**, I found positive relationships between perceptions of bird diversity and improved wellbeing in **Chapters 4 and 5**, noting that the sight and sounds of birds (e.g. coastal birdlife, owls, songbirds) were related to feelings of escape, fascination, and relaxation.

No negative associations were uncovered between people and bird diversity in this thesis, in line with those studies from the global North. It is therefore plausible to suggest that increased perceived bird diversity makes a universally positive contribution to human wellbeing across multiple cultural contexts. However, negative attitudes of course do exist towards some species, for example, those with calls perceived as harsh or noisy (e.g. blue jay, *Cyanocitta cristata*; house sparrow, *Passer domesticus*; European starling, *Sturnus vulgaris*) (Belaire et al., 2015), species perceived as a health hazard (e.g. Canada geese *Branta canadensis*) (Conover and Chasko 1985), or species perceived to exhibit destructive and aggressive behaviours (e.g. urban gulls, *Larus* sp.) (Rock 2005). These specific phenotypical or behavioural traits are therefore determinants of how people respond to biodiversity. Elsewhere in South America, bird species with a high-profile at a national-scale include those with large body size, associations with folklore, or distributions that overlap with human populations (Arango et al., 2007; de Azevedo et al., 2012; Correia et al., 2016). In Georgetown, the same traits could explain the positive responses to species of owls in the green and coastal blue spaces. Intriguingly, in a study of human perceptions of birds in urban parks in Santiago, Chile, Celis-Diez et al., (2017) showed that people misidentified some native birds as they were phenotypically similar to those found in Europe, rather than South America. The authors posit that a taxonomic bias of species represented in the media (i.e. television, books, films), alongside decreased visitation to urban parks due to urbanisation (‘extinction of experience’, Miller 2005) was responsible. Identifying which phenotypical or behavioural traits of urban birds are related to people’s knowledge and attitudes merits further investigation.

Throughout the literature there is a study bias towards birds. Aside from birds, other taxa in Georgetown’s green and blue spaces may elicit different wellbeing responses. For instance, many types of herpetofauna (e.g. snakes, frogs, spectacled Caiman *Caiman crocodilus*) were negatively perceived, actively avoided, and connected with folklore, as documented elsewhere in Guyana (Mulder et al., 2016). In Georgetown, visits to urban green and blue spaces (or certain areas within them) may be inhibited by these perceptions, and, could mismatch with what actually exists. As such, a herpetological survey of Georgetown would be beneficial, given that a high diversity and abundance of amphibians and reptiles have been recorded in Guyana in the few surveys that have been conducted (Cole et al., 2013). Indeed, the existing literature on biodiversity-wellbeing rarely explores taxa beyond plants, birds, and pollinators (Lovell et al., 2014; Aerts et al., 2018). Understanding how people perceive biodiversity in their surroundings can better explain how green and blue spaces contribute to human wellbeing, although the relationship is certainly intricately complex and geographically specific. This thesis presents the only examination of the subject in the tropical global South to date. Nonetheless, while I enabled cross-cultural comparisons to be drawn by studying birds, I acknowledge that by not including a broader range of taxa, some of which are more frequently encountered in tropical countries than in the global North, there are questions that remain unanswered.

In the thesis, I demonstrate empirically the importance of perceived restorativeness as a mediating variable between the biodiversity people perceive in their surroundings and the wellbeing they experience (**Chapter 4**). If I had not measured perceived restorativeness in the study and tested it as a mediator, I may have failed to capture the subtle interactions between specific perceived characteristics and human wellbeing in each of the three landcover types typical across Georgetown (green, canal, dense urban). Even dense urban spaces (e.g. commercial streets in the city centre) can be beneficial to human wellbeing when they were perceived as restorative. Indeed, it is known that anywhere perceived as scenic can lead to wellbeing gains (Seresinhe et al., 2019), and that what people perceive in their surroundings often does not align with what objectively exists (Dallimer et al., 2012; Shwartz et al., 2014; Belaire et al., 2015; Pett et al., 2016). To this effect, the Biophilia Hypothesis is replaced by the Topophilia Hypothesis, which posits that people are emotionally affiliated with natural environments as well as non-human nature, and are able to form attachment to places via the mechanisms of biological selection and cultural learning (Beery et al., 2015). Overall, these findings correspond to calls for researchers to consider the mechanisms underlying nature-wellbeing relationships (Hartig et al., 2014; Markevych et al., 2017) and, in line with evidence from the global North (Korpela et al., 2014; Carrus et al., 2015; Marselle et al., 2016), show that urban green and blue space (but also dense urban space) can have restorative value.

People's experiences in urban green and blue spaces are highly multisensory (Franco et al., 2017). In **Chapter 4**, bioacoustic indices developed for ecological monitoring (Bradfer-Lawrence et al., 2019) were used to assess ratios of anthrophonic to biophonic sounds (NDSI), and how they relate to the types of sounds people reported hearing and enjoying. Yet, additional indices also exist, measuring acoustic richness, evenness, Shannon entropy, and complexity (Eldridge et al., 2018; Bradfer-Lawrence et al., 2019). These indices are still in their infancy, and are yet to be finessed for use in urban settings (where the soundscape is highly multifarious) (Fairbrass et al., 2017), with additional bioacoustic indices emerging in their wake (Fairbrass et al., 2019). As such, substantial opportunities are arising to examine how different aspects of the perceived soundscape impact on human wellbeing. In addition to soundscapes, measuring the perceived olfactory, visual, and sensual (i.e. temperature) components of the environment, and how they align with objective measurements, remains a research gap (Erfanian et al., 2019). Indeed participants in **Chapter 5**, described their experiences using all three of these additional senses.

It remains difficult to capture the complex ways that people relate to urban green and blue spaces using quantitative methods alone. Participatory methodologies are being increasingly employed for nature-wellbeing research (e.g. Ives et al., 2017; Jones et al., 2020; Tew et al., 2019), and are particularly useful when triangulated with quantitative approaches. For example, by giving members of the public the autonomy and agency to create their own research data, I consolidated and enriched my findings that the multisensory experience of green and blue spaces enhanced human wellbeing (e.g. sights and sounds of water and birds) (**Chapters 3 and 4**), discovering how place attachment (e.g. memories, history), personal insecurity (e.g. fear of crime), and cultural beliefs (e.g. folklore) were important too (**Chapter 5**). This is particular pertinent given the abundance of 'big-data' approaches to understanding nature-health relationships using national-scale surveys, where locally-specific and context-dependent distinctions can otherwise be overlooked (O'Brien and Varley 2012; Bell et al., 2014; Jones et al., 2020).

6.2 Implications for policy and practice

My research has implications for biodiversity conservation and human wellbeing policy and practice, through both the design and management of cities, as well as public engagement and outreach. While the research is focussed on Guyana, these recommendations can be applied to biodiversity-rich cities elsewhere, particularly in the global South.

This thesis identifies specific features of Georgetown's green spaces could be augmented, restored, and conserved to benefit both people and biodiversity. For instance, trees and vegetation that support high levels of bird diversity can also give shade from the tropical heat and contribute to social cohesion (**Chapter 5**), as well as perceptions of naturalness (**Chapter 4**), thus enhancing their restorative quality. Importantly, the location of these features, the routes that visitors take, and any zonation within the green spaces will dictate the extent to which these interactions take place. For instance, trees and vegetation are also at times associated with criminal activity, dangerous animals, and disease vectors, consistent with findings from the global North (Jorgensen et al., 2002; Sonti et al., 2020). Specifically in Georgetown, the back half of the Botanical Gardens, which comprises a densely overgrown tropical forest fragment, participants called for improvements to the lighting, security measures, and manicuring of the vegetation to reduce personal safety concerns. Given that visitors to Georgetown's green spaces tend to restrict their movements to the footpaths provided, the Protected Areas Commission (PAC) currently installing a platform walkway through the back of the Botanical Gardens, complete with signage and lighting (O. Davies *pers. comm*.), which should encourage people to visit. The area provides natural habitat that supports a wealth of species (e.g. high levels of bird diversity, spectacled caiman *Caiman crocodilus*, released exotic pets). This implies that win-wins concomitant with trade-offs are both necessary to ensure that conservation and human wellbeing needs are met.

To identify exactly how human wellbeing can be optimised, decision-makers (as well as members of the public) might consider the autoecology of specific species when contemplating design and management plans. For instance, an understanding of the nesting or feeding behaviours of specific bird species that people respond to (i.e. coastal birdlife, owls, songbirds) could help elucidate which species of tree or vegetation should be restored, conserved, or enhanced. As an illustrative example, many songbirds are insectivorous (e.g. kiskadee, *Pitangus sp*.; yellow-chinned spinetail, *Certhiaxis cinnamomus*; house wren, *Troglodytes aedon*) and seek arthropods in fruiting and flowering trees, as well as along waterways (Hayes et al., 2019). Likewise, consideration needs to be given towards maximising co-benefits for biodiversity and ecosystem services more widely where they might potentially exist, such as certain species of trees and vegetation effectively obstructing noise pollution (Pathak et al., 2008; Maleki and Hosseini 2011), absorbing air pollution and lowering air temperatures (Jim and Chen 2008; Vailshery et al., 2013).

Urban blue spaces (e.g. waterways, lakes, ponds) are increasingly being shown to make positive contributions to human wellbeing (Gascón et al., 2017; Grellier et al., 2017; Britton et al., 2018). Similarly, Georgetown's waterways provide a food resource for human residents (i.e. fishing, snails) (**Chapter 2**), and a restorative experience enhanced by enjoyable sounds (such as birdsong), high perceived biodiversity, and feelings of safety (**Chapter 4 and 5**). Encouraging visitation to the waterways by maintaining and improving pedestrian and cycle infrastructure could enhance their restorative quality by reducing the need for vehicles and the associated mechanical sounds. Given that these waterways also act as important habitat corridors for birds traversing through densely urbanised areas (Hayes et al., 2019), conserving the ecological features that characterise the waterways (i.e. tree-line, vegetation, flowing water) could provide co-benefits for both people and biodiversity. For example, overgrown vegetation and invasive weeds obstruct the flow of water, the maintenance of which is costly due to the fast-growing tropical vegetation. However, facilitating the connectivity of these waterways so the manatees can consume the vegetation offers a nature-based solution (Haigh 1991; Adimey et al., 2012). This may in turn raise the profile of the manatee as an emblematic species for Georgetown, which already benefits tourism and attracts people to interact with wildlife in the city.

Georgetown's coastal blue space (i.e. sea wall) affords protection against flooding for Guyana's coastal inhabitants, and participants discussed their memories of past floods contributing to a sense of place in **Chapter 5**. However, as breaches become more regular (the most serious recent flooding event occurring in Spring 2020) (News Room GY 2020), authorities will need to make considerable investments into its fortification to secure the protection of those living along the Atlantic Coast. Simultaneously, urban planners could incorporate characteristics of this space that encourage visitation (i.e. improving accessibility, benches, sense of safety), to benefit human wellbeing through the restorative experience it offers (i.e. oceanic views and sounds, coastal birdlife, sense of landscape change), as well as being a space for physical activity. Likewise, Georgetown's green spaces provide catchment for water during periods of heavy rain and flooding. As such, both green and blue space are integral to climate change resilience. There are, however, ongoing discussions about re-locating Guyana's capital city inland, given the longer term threats of extreme weather events impacting on coastal inhabitants, despite the substantial socio-economic, environmental, and logistical challenges such a move would pose (Earle 2013). Under such circumstances, decision-makers may give due consideration to thoroughly incorporating urban green and blue spaces into the new urban fabric. Nonetheless, securing the long-term safety of Georgetown and its inhabitants remains imperative, as the city is set to become a port town for the petroleum industry.

Georgetown's crime rates are high compared with Guyana on the whole, with most incidents occurring along the country's coastline (Cummings et al., 2018) and within Indigenous territories (Cummings et al., 2019), although crime in Georgetown's urban green or blue spaces has never been examined. It is perhaps not surprising that personal safety was a dominant and recurring theme throughout this thesis, with participants concerned by poor lighting, few security staff, lack of surveillance, and memories or stories about past criminal incidents. These patterns are synonymous with other South American cities, where fear of crime is a consistent barrier to urban green space use, and attests to the fact that urban crime in the global South is a deep societal issue associated with high levels of inequality, illegal activity, and gang violence (Wright Wendel et al., 2012; Rigolon et al., 2018; Moran et al., 2020). Nonetheless, Georgetown's urban planners and park managers could make changes (e.g. improve lighting, security presence) to reduce the safety concerns that inhibit visitation and social cohesion, preventing a restorative experience.

A number of disadvantages could result from enhancing urban green/blue space in tropical biodiversity-rich countries (Gearey et al., 2018). For example, in Spring 2020, Georgetown's National Park was closed due to an infestation of bees (Stabroek News 2020). Pests such as mosquitoes proliferate in areas containing stagnate or shallow water (such as waterways and ponds in urban green spaces), and may also be vectors of disease, several of which are of serious concern in Guyana (e.g. Zika, dengue, Chagas, chikungunya, malaria). The Ministry of Public Health runs a Vector Control Unit that intermittently 'fogs' localised areas of Georgetown, using Malathion (organophosphate) mixed with diesel fuel (to enable dispersal) to kill adult mosquitoes. Fogging activity rises during the rainy season and disease outbreaks. The negative effects of organophosphate chemicals on human health (e.g. poisoning, cancer, evolution of pesticide-resistance) and biodiversity (e.g. indiscriminate impacts on non-target species) has long been known (Carson 1962), although fogging activities in Georgetown continue. Residents are also encouraged to overturn containers of stagnant water and sleep under mosquito nets at night. In our research, pest species like mosquitoes were not mentioned in relation to green or blue spaces. Aerts et al., (2018) highlight that biodiversity can in fact help combat pest species like mosquitoes and subsequent disease outbreaks, thereby contributing to human wellbeing indirectly. This theory, known as the 'dilution effect', states that higher host species richness lowers disease transmission and prevalence if the vectors feed on multiple host species (Bradley and Altizer 2007). For example, Swaddle and Calos (2008) show that incidence of West Nile Virus in the USA was lower in areas of higher (host) bird diversity. However, the opposite was found by Levine et al., (2017). Indeed, species of songbird (passiformes) that are hosts of zoonotic diseases are found in greater abundance in urban areas due to their tolerance to human disturbance (Gibb et al., 2020). The existing evidence is contradictory as the relationships between host, vector, and habitat are extremely complex and rarely surveyed in their entirety (Huang et al., 2016). Disentangling the interplay between zoonotic host species of songbird, human health and wellbeing in Georgetown warrants further investigation, given the range of serious diseases in the city and the wealth of bird diversity in particular.

As Georgetown expands, several considerations need to be taken into account when retrofitting or establishing new green and blue spaces for both biodiversity conservation and human wellbeing, given the findings from this thesis. To reduce health inequalities, access to green spaces must be equally distributed (Mitchell et al., 2015; Sugiyama et al., 2016), and unused informal green spaces across the city could be conserved and enhanced into local community gardens or recreational spaces. Ensuring connectivity between green spaces, while extending the city's waterways, could benefit urban biodiversity and the users of these spaces (Grafius et al., 2017; Hayes et al., 2019). PAC could initiate the creation of new urban parks within their jurisdiction to ensure their status as protected areas, given that designation status (and the conservation of biodiversity it affords) has been associated with greater psychological benefits for visitors in the global North (Wyles et al., 2019). Further work is needed to uncover the role of green and blue space size for visitation and for biodiversity, as well as monitor how patterns of visitor use change over different times of the day (MacKerron and Mourato 2013; Seresinhe et al., 2019). Nevertheless, it is likely that mixed provision of green and blue space sizes and types (i.e. urban park, coastal blue space, waterway) will promote better wellbeing outcomes across different communities and, concurrently, provide a heterogeneous mosaic of habitats that will diversify available ecological niches and resources for urban biodiversity (McKinney 2008; Beninde et al., 2015). Decision-makers will also need to account for the tropical climate, people's physical capacity to visit, and the proximity of new green and blue spaces to people's homes and places of work or education. The provision of private green spaces (i.e. backyards) should be incorporated into new residential areas as they provide features and activities not available in public green and blue spaces, such as growing produce and fruiting trees (**Chapter 2**). In turn, these activities are valuable for people's cultural identity (Hunte et al., 2019) and abundance of insectivorous bird species (Hayes et al., 2019).

Ensuring that scientific evidence is integrated effectively into urban planning and management is crucial. By involving a variety of stakeholders (members of the public, students studying in Georgetown, national government, urban planners, green space managers, conservation NGOs the city Mayor) throughout the research process, I was able to enhance its policy-relevance. The findings from this thesis are directly relevant to the Protected Areas Act of the Guyanese Government to ‘recognise the intrinsic values of biological diversity and its components’, and to ‘conserve biodiversity, ecosystem services, and ecosystems’ (Protected Areas Commission Guyana, 2016), and provides information to inform the delivery of the ‘Three Parks Initiative’, which could improve the restorative quality of Georgetown’s green spaces. Unfortunately, transformation of Georgetown’s urban blue spaces falls outside of any current policy initiatives. As different voices were accounted for through multiple quantitative, qualitative, and participatory methodologies, any resultant interventions are likely to be more equitable and socially-just, thus benefitting a wider section of society. Nonetheless, while this will help to raise awareness of the issues, the actual implementation of policies on the ground will require further guidance and strong-will from all stakeholders (MacGregor-Fors et al., 2020).

Using the detail from this thesis about visit patterns, biodiversity, history, folklore, and culture, public health and educational campaigns could be targeted at the non-users of Georgetown’s urban green and blue spaces to improve the health and wellbeing of the population at large. While these actions were championed by decision-makers in **Chapter 5** (i.e. maintaining specific features, undertaking public engagement activities *in situ*, instigation of wellness programmes), there is scope to suggest that birding tours to the Botanical Gardens could be prescribed. The notion of social prescribing (or ‘green’ prescribing, when in relation to nature) is gaining traction in some parts of the world (Twohig-Bennett and Jones 2015; Van den Berg 2017; Shanahan et al., 2019; Robinson et al., 2020), and it is plausible that improved knowledge and identification skills about local birdlife could influence people’s ability to perceive species richness and subsequently affect their wellbeing (Dallimer et al., 2012; Celis-Diez et al., 2017). Guyana might seek to consider how its urban green and blue spaces can be used in tandem with other treatments for psychological health issues, and woven into existing and future mental health resources and support networks. While the WHO-5 mental wellbeing scale examined in **Chapter 2** is indicative of suicide-risk (Sisask et al., 2008), there was no evidence to suggest that using the city’s green and blue spaces had a positive effect on this measure. Yet, further investigation into how urban green and blue space could relate to suicide prevention is required, given evidence from the global North suggests that exposure to urban green space can potentially reduce suicide mortality (Helbich, et al., 2018; Shen and Lung, 2018), as well as reduced antidepressant prescription rates (Helbich, et al., 2018; Taylor et al., 2015).

The findings from this thesis tentatively imply that a greater awareness and knowledge about Georgetown’s green and blue spaces can improve human wellbeing, exemplified by participants who were more attuned with the natural environment (greater nature-relatedness, perceived high species richness and naturalness in the surroundings, and had positive past experiences). Given the mismatch between the objective and perceived measures of biodiversity, Dallimer et al., (2012) argue that through meaningful public engagement that increases people’s awareness of the natural features in their surroundings, win-win scenarios for both people and biodiversity can be ‘unlocked’. As such, I delivered a series of outreach activities to increase public awareness about biodiversity in Georgetown’s urban green and blue spaces, and the health and wellbeing benefits that can be gained from interacting with nature. In collaboration with Conservation International, PAC and two postgraduate students, we first designed a bird guide for Guyanese school-aged children (Figure 6.1) and some new public signage (Figure 6.2), giving information about the species found in the city. We then held a public event in the Botanical Gardens on Easter Sunday (2019), which is the busiest day of the year for the park (Figure 6.1).

Figure 6.1: An outreach event held in the Botanical Gardens on Easter Sunday promoting nature and wellbeing in Georgetown. Panels depict photographs from the event, including (a) a graffiti board produce by children about nature and their wellbeing, (b) members of the public engaging in the activities, (c) a bird guide produced for school-aged children, and (d) free badges for visitors depicting bird species (blood coloured woodpecker, *Veniliornis sanguineus*; wattled jacana, *Jacana jacana*; scarlet ibis, *Eudocimus ruber*) from each of Georgetown's public spaces (green, waterway, and coastal blue spaces, respectively), along with one of three pledges: 'to take pride in my city', 'to learn a new bird each week', 'to visit the park once more this week'

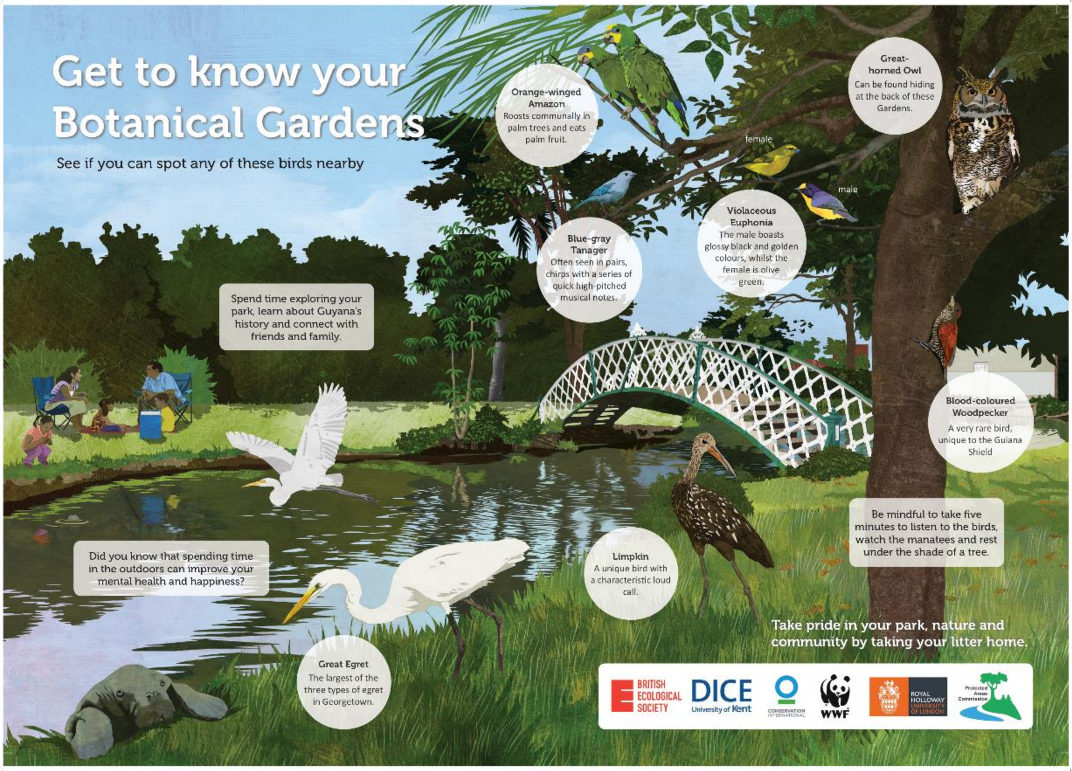


Figure 6.2: Permanent signage erected in Georgetown at the Botanical Gardens and sea wall, giving information about the species that can be found there, and how interacting with nature can improve human wellbeing

During the event we ran a range of activities. This involved a participatory bird survey, a self-guided tour of the Botanical Gardens using a mobile phone application ('Action Bound') with points and prizes (that required participants to take sound recordings, photographs and answer questions about the gardens), a graffiti board about nature and wellbeing for children, and an informal public participatory GIS (PPGIS) activity to stimulate discussion about the cultural ecosystem services provided within the Botanical Gardens. The latter activity was loosely structured around Natural England's 'Econets' project (Natural England 2015), where park visitors indicate the areas where they experience each of six cultural ecosystem service benefits (sense of local identity or history, amenity or leisure, escape or tranquillity, aesthetic or beauty, appreciation of wildlife or perceived naturalness, and air quality or flood prevention). A more thorough and in-depth PPGIS investigation could reveal valuable information about specific green and blue space locations across the city the contributions they make to people's wellbeing, which could then inform the tailored management and planning of public spaces (Natural England 2015; Ives et al., 2018; Jones et al., 2020). Moreover, further work is required to explore the scope for (and measure the effectiveness of) integrating an understanding of nature and wellbeing into the school curriculum. To date, there is very little research on this within South America (Proctor et al., 2019).

Whether people will change their behaviour on the basis of new information about the health and wellbeing benefits of urban green and blue space, and whether it actually results in enhanced wellbeing, will require monitoring over time. Indeed, increased awareness and positive changes in attitudes toward the environment do not necessarily lead to actual behavioural change (Waylen et al., 2009), given that human behaviours are also influenced by subjective norms, morals, personal identities and other factors specific to the cultural context within which they are being described (Clayton and Myers 2009; Gatersleben et al., 2014). While social norming could help influence personal identities to encourage increased visitation, establishing a culture of regular use will take time, and fluctuate according to individuals shifting priorities, circumstances, and orientations (Bell et al., 2014, 2019). Gobster et al., (2007) argue that interventions to alter human interactions with and perceptions of the natural environment can be ‘ethically questionable’ in some circumstances (e.g. if interventions are threatening or emphasise fear). However, identifying instances where aesthetically pleasing and ecologically beneficial landscapes exist is a starting point to align these sometimes competing goals.

6.3 Conclusions

In the coming years, Guyana will face substantial economic, social, and environmental challenges as a result of its vast petroleum discoveries. Yet, the appropriate legislation, physical infrastructure, and skilled workforce to handle these changes is still incomplete (Panelli 2019; Elias-Roberts 2020). In December 2018, a vote of no confidence in the government was followed by nearly 21 months of political instability, which culminated in August 2020 with the legal admittance of the People’s Progressive Party. Several serious corruption charges are currently held against its leader, the newly elected President (Panelli 2019). Nonetheless, the new government will imminently begin to establish how the flow of petroleum-based capital moves throughout Guyana. Only careful and cautious leadership from this new government will determine the success of Guyana’s transition through the Green State Development Strategy (GSDS), and ensure that the ‘Resource Curse’ is avoided (Azubike 2020). It is hoped that Guyana can establish itself as an important model country for sustainable economic growth and biodiversity conservation worldwide (Holland 2018).

While populations expand, the climate changes, and urbanisation accelerates, biodiversity will continue to decline with concomitant impacts on human wellbeing. As such, scientists, decision-makers, public health professionals and members of the public should seize this opportune moment to green (and blue) the cities, encouraging biodiversity and people to co-exist and co-benefit from one another (Botzat et al., 2016; van den Bosch and Nieuwenhuijsen 2016). This thesis exemplifies how empirical scientific evidence from multiple disciplines can be used to inform policy and practice that benefits biodiversity and human wellbeing harmoniously, while demonstrating how understanding the local context is imperative to designing needs-enhancing interventions that reach all sectors of society. Guyana, and Georgetown particularly, are about to undergo a period of immense change, so this a timely junction at which to integrate sustainable land-use planning interventions into the current and future urban fabric of Georgetown. The findings in my thesis are also applicable to other tropical cities across the global South, where urban areas are expanding rapidly but biodiversity is not prioritised in urban planning and management decision-making. Meanwhile, decision-makers globally are starting to consider strategies for societal and economic progress that advance people's quality of life rather than GDP, in light of the multidimensionality of human wellbeing (Stiglitz et al., 2010; Karma-Ura et al., 2012; OECD 2015). Given the challenges we face in the 21st century, it is vital that biodiversity conservation is seen as part of a toolkit in the design and management of cities that are as positive as possible for the people that inhabit them (Giles-Corti et al., 2016; Hartig and Kahn 2016).

References

Abbot A. 2012. Urban Decay. Nature **490**:162–164.

Adams WM. 2014. The value of Valuing Nature. Science **346**:549–551.

Adimey N, Mignucci-Giannoni A, Auil-Gomez NE, Da Silva V. M., De Carvalho Alvite C., Morales-Vela B, De Lima RP, Rosas FC. 2012. Manatee rescue, rehabilitation, and release efforts as a tool for species conservation. Page in E. Hines and J. E. Reynolds III, editors. Sirenian Conservation: Issues and strategies in developing countries. University Press of Florida, Gainesville. Available from https://muse.jhu.edu/chapter/571263.

Aerts R, Honnay O, Van Nieuwenhuyse A. 2018. Biodiversity and human health: mechanisms and evidence of the positive health effects of diversity in nature and green spaces. British Medical Bulletin:1–18. doi: 10.1093/bmb/ldy021/5051732.

Akpinar-Elci M, Rose S, Kekeh M. 2018. Well-being and mental health impact of household flooding in Guyana, the Caribbean. Marine Technology Society Journal **52**:18–22.

Akpinar A. 2016. How is quality of urban green spaces associated with physical activity and health? Urban Forestry and Urban Greening **16**:76–83.

Alcock I, White MP, Pahl S, Duarte-davidson R, Fleming LE. 2020. Associations between pro-environmental behaviour and neighbourhood nature, nature visit frequency and nature appreciation: Evidence from a nationally representative survey in England. Environment International **136**:105441. doi:10.1016/j.envint.2019.105441.

Alder D, Kuijk M Van. 2009. A baseline assessment of forest carbon in Guyana. Guyana Forestry Commission, Revision 1.1. Georgetown, Guyana.

Alkire S, Kanagaratnam U, Suppa N. 2019. Global multidimensional poverty index (MPI). The Global Multidimensional Poverty Index. Oxford, UK.

Ambrey CL, Shahni TJ. 2017. Greenspace and wellbeing in Tehran: A relationship conditional on a neighbourhood's crime rate? Urban Forestry & Urban Greening. doi:10.1016/j.ufug.2017.08.003

Andrade-Núñez MJ, Aide TM. 2018. Built-up expansion between 2001 and 2011 in South America continues well beyond the cities. Environmental Research Letters **13**. doi:10.1088/1748-9326/aad2e3.

Angel S, Parent J, Civco DL, Blei A, Potere D. 2011. The dimensions of global urban expansion: Estimates and projections for all countries, 2000-2050. Progress in Planning **75**:53–107.

Antonelli A, Zizka A, Carvalho FA, Scharn R, Bacon CD, Silvestro D, Condamine FL. 2018. Amazonia is the primary source of Neotropical biodiversity. Proceedings of the National Academy of Sciences of the United States of America **115**:6034–6039.

Arango X, Rozzi R, Massardo F, Anderson CB, Ibarra T. 2007. Descubrimiento e implementación del pájaro carpintero gigante (Campephilus magellanicus) como especie carismática: Una aproximación biocultural para la conservación en la Reserva de Biosfera Cabo de Hornos. Magallania **35**:71–88.

Aronson MFJ, Lepczyk CA, Evans KL, Goddard MA, Lerman SB, MacIvor JS, Nilon CH, Vargo T. 2017. Biodiversity in the city: key challenges for urban green space management. Frontiers in Ecology and the Environment **15**:189–196.

Arora PG, Persaud S. 2019. Suicide among Guyanese youth: Barriers to mental health help-seeking and recommendations for suicide prevention. International Journal of School & Educational Psychology **0**:1–13. Routledge. doi:10.1080/21683603.2019.1578313.

Asan O, Montague E. 2014. Using video-based observation research methods in primary care health encounters to evaluate complex interactions. Informatics in Primary Care **21**:161–170.

Astell-Burt T, Mitchell RJ, Hartig T. 2014. The association between green space and mental health varies across the lifecourse. A longitudinal study. Journal of epidemiology and community health **68**:578–83.

Ayala-Azcárraga C, Diaz D, Zambrano L. 2019. Characteristics of urban parks and their relation to user well-being. Landscape and Urban Planning **189**:27–35.

Azubike VC. 2020. Critical government and national oil company role in their petroleum resource development: lessons for Guyana petroleum sector. Commonwealth Law Bulletin **0**:1–22. Routledge. doi:10.1080/03050718.2020.1782238.

Bakolis I, Hammoud R, Smythe M, Gibbons J, Davidson N, Tognin S, Mechelli A. 2018. Urban Mind: Using smartphone technologies to investigate the impact of nature on mental well-being in real time. BioScience:1–12.

Baldock KCR, Goddard MA, Hicks DM, Kunin WE, Mitschunas N, Osgathorpe LM, Potts SG, Robertson KM, Scott AV, Stone GN, Vaughan IP, Memmott J. 2015. Where is the UK's pollinator biodiversity? The importance of urban areas for flower-visiting insects. Proceedings of the Royal Society B: Biological Sciences **282**:20142849.

Baldock KCR, Goddard MA, Hicks DM, Kunin WE, Mitschunas N, Morse H, Osfathorpe LM, Potts SG, Robertson KM, Scott AV, Staniczenko PPA, Stone GN, Vaughan IP, Memmott J. 2019. A systems approach reveals urban pollinator hotspots and conservation opportunities. Nature Ecology and Evolution **3**:363–373.

Barlow J, França F, Gardner TA, Hicks CC, Lennox GD, Berenguer E, Castello L, Economo EP, Ferreira J, Guénard B, Gontijo Leal C, Isaac V, Lees AC, Parr CL, Wilson SK, Yooung PJ, Graham NAJ. 2018. The future of hyperdiverse tropical ecosystems. Nature **559**:517–526.

Bartoń K. 2018. MuMIn: Multi-model inference. R package. Available from https://cran.r-project.org/web/packages/MuMIn/MuMIn.pdf.

Bates D, Maechler M, Bolker B, Walker S. 2015. Fitting linear mixed-effects models using lme4. Journal of Statistical Software **67**.

Beery TH, Jönsson KI, Elmberg J. 2015. From environmental connectedness to sustainable futures: topophilia and human affiliation with nature. Sustainability **7**:8837–8854.

Belaire JA, Westphal LM, Whelan CJ, Minor ES. 2015. Urban residents' perceptions of birds in the neighborhood: Biodiversity, cultural ecosystem services, and disservices. The Condor: Ornithological Applications **117**:192–202.

Bell SL, Leyshon C, Foley R, Kearns RA. 2019. The "healthy dose" of nature: A cautionary tale. Geography Compass **13**:1–14.

Bell SL, Phoenix C, Lovell R, Wheeler BW. 2014. Green space, health and wellbeing: Making space for individual agency. Health and Place **30**:287–292.

Bell SL, Phoenix C, Lovell R, Wheeler BW. 2015. Seeking everyday wellbeing: The coast as a therapeutic landscape. Social Science and Medicine **142**:56–67.

Bell SL, Weston MA, Lovell R, Wheeler BW. 2017. Everyday green space and experienced well-being: the significance of wildlife encounters. Landscape Research **43**:8–19.

Bell SL, Wheeler BW, Phoenix C. 2016. Using geonarratives to explore the diverse temporalities of therapeutic landscapes: perspectives from "green" and "blue" settings. Annals of the American Association of Geographers **4452**:1–16. doi:10.1080/24694452.2016.1218269.

Beninde J, Veith M, Hochkirch A. 2015. Biodiversity in cities needs space: a meta-analysis of factors determining intra-urban biodiversity variation. Ecology Letters **18**:581–592.

Bennett NJ, Roth R, Klain SC, Chan K, Christie P, Clark DA, Cullman G, Curran D, Durbin TJ, Epstein G, Greenberg A, Nelson MP, Sandlos J, Stedman RA, Teel TL, Thomas R, Veríssimo

D, Wyborn C. 2016. Conservation social science: Understanding and integrating human dimensions to improve conservation. Biological Conservation **205**:93–108.

Bicknell JE, Collins MB, Pickles RSA, McCann NP, Bernard CR, Fernandes DJ, Miller MGR, James SM, Williams AU, Struebig MJ, Davies ZG, Smith RJ. 2017. Designing protected area networks that translate international conservation commitments into national action. Biological Conservation **214**:168–175.

Bies AJ, Blanc-Goldhammer DR, Boydston CR, Taylor RP, Sereno ME. 2016. Aesthetic responses to exact fractals driven by physical complexity. Frontiers in Human Neuroscience **10**. doi:10.3389/fnhum.2016.00210.

Bixler RD, Floyd MF. 1997. Nature is scary, disgusting, and uncomfortable. Environment And Behavior **29**:443–467.

Blazek M, Smith FM, Lemesova M, Hricova P. 2015. Ethics of care across professional and everyday positionalities: The (un)expected impacts of participatory video with young female carers in Slovakia. Geoforum **61**:45–55.

Bonta M. 2008. Valorizing the relationships between people and birds: Experiences and lessons from Honduras. Ornitologia Neotropical **19**:595–604.

Bosurgi R, Horton R. 2017. The Lancet Planetary Health: a new journal for a new discipline - a call for papers. The Lancet **389**:139.

Botzat A, Fischer LK, Kowarik I. 2016. Unexploited opportunities in understanding liveable and biodiverse cities. A review on urban biodiversity perception and valuation. Global Environmental Change **39**:220–233.

Bovolo CI, Wagner T, Parkin G, Hein-Griggs D, Pereira R, Jones R. 2018. The Guiana Shield rainforests-overlooked guardians of South American climate. Environmental Research Letters **13**. doi:10.1088/1748-9326/aacf60.

Boyd F, White MP, Bell SL, Burt J. 2018. Who doesn’t visit natural environments for recreation and why: A population representative analysis of spatial, individual and temporal factors among adults in England. Landscape and Urban Planning **175**:102–113.

Bradfer-Lawrence T, Bunnefeld N, Gardner N, Willis SG, Dent DH. 2020. Rapid assessment of avian species richness and abundance using acoustic indices. Ecological Indicators **115**:106400. doi:10.1016/j.ecolind.2020.106400.

Bradfer-Lawrence T, Gardner N, Bunnefeld L, Bunnefeld N, Willis SG, Dent DH. 2019. Guidelines for the use of acoustic indices in environmental research. Methods in Ecology and Evolution **10**:1796–1807.

Bradley CA, Altizer S. 2007. Urbanization and the ecology of wildlife diseases. Trends in Ecology and Evolution **22**:95–102.

Bradley EH, Curry LA, Devers KJ. 2007. Qualitative data analysis for health services research: Developing taxonomy, themes, and theory. Health Research and Educational Trust **42**:1758–1772.

Bratman GN, Anderson CB, Berman MG, Cochran B, de Vries S, Flanders J, Folke C, Frumkin H, Gross JJ, Hartig T, Kahn PH, Kuo M, Lawler JJ, Levin PS, Lindahl T, Meyer-Lindenberg A, Mitchell RJ, Ouyang Z, Roe J, Scarlett L, Smith J R, van den Bosch MA, Wheeler BW, White MP, Zheng H, Daily GC. 2019. Nature and mental health: An ecosystem service perspective. Science Advances **5**:eaax0903. doi:10.1126/sciadv.aax0903.

Britton E, Kindermann G, Domegan C, Carlin C. 2018. Blue care: a systematic review of blue space interventions for health and wellbeing. Health Promotion International:1–20. doi:10.1093/heapro/day103/5252008.

Brock M, Perino G, Sugden R. 2017. The Warden Attitude: An investigation of the value of interaction with everyday wildlife. Environmental and Resource Economics **67**:127–155.

Bryce R, Irvine KN, Church A, Fish R, Ranger S, Kenter JO. 2016. Subjective well-being indicators for large-scale assessment of cultural ecosystem services. Ecosystem Services **21**:258–269.

Buchholz S, Blick T, Hannig K, Kowarik I, Lemke A, Otte V, Scharon J, Schönhofer A, Teige T, von der Lippe M, Seitz B. 2016. Biological richness of a large urban cemetery in Berlin. Results of a multi-taxon approach. Biodiversity Data Journal **4**:e7057. Available from http://bdj.pensoft.net/articles.php?id=7057.

Bureau of Statistics. 2012. Guyana Population & Housing Census 2012. Preliminary Report. Georgetown, Guyana. Available from http://sp.lyellcollection.org/content/250/1/35.short.

Burnham KP, Anderson DR, Huyvaert KP. 2011. AIC model selection and multimodel inference in behavioral ecology: Some background, observations, and comparisons. Behavioral Ecology and Sociobiology **65**:23–35.

Cai T, Steinfield C, Chiwasa H, Ganunga T. 2019. Understanding Malawian farmers' slow adoption of composting: Stories about composting using a participatory video approach. Land Degradation and Development **30**:1336–1344.

Campbell LK, Svendsen ES, Roman LA. 2016. Knowledge co-production at the research–practice interface: embedded case studies from urban forestry. Environmental Management **57**:1262–1280. Springer US.

Capolongo S, Rebecchi A, Buffoli M, Appolloni L, Signorelli C, Fara GM, D'Alessandro D. 2020. COVID-19 and cities: From urban health strategies to the pandemic challenge. a decalogue of public health opportunities. Acta Biomedica **91**:13–22.

Cardinale BJ, Duffy JE, Gonzalez A, Hooper DU, Perrings C, Venail P, Narwani A, Mace GM, Tilman D, Wardle DA, Kinzig AP. 2012. Biodiversity loss and its impact on humanity. Nature **486**:59–67.

Carrus G, Scopelliti M, Lafortezza R, Colangelo G, Ferrini F, Salbitano F, Agrimi M, Portoghesi L, Semenzato P, Sanesi G. 2015. Go greener, feel better? The positive effects of biodiversity on the well-being of individuals visiting urban and peri-urban green areas. Landscape and Urban Planning **134**:221–228.

Carruthers-Jones J, Eldridge A, Guyot P, Hassall C, Holmes G. 2019. The call of the wild: investigating the potential for ecoacoustic methods in mapping wilderness areas. Science of the Total Environment **695**:133797. doi:10.1016/j.scitotenv.2019.133797.

Carson R. 1962. Silent Spring. Houghton Miffin Harcourt, Boston.

Ceballos G, Ehrlich PR, Dirzo R. 2017. Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. Proceedings of the National Academy of Sciences **114**:E6089–E6096.

Celis-Diez J, Muñoz C, Abades S, Marquet P, Armesto J. 2017. Biocultural homogenization in urban settings: public knowledge of birds in City Parks of Santiago, Chile. Sustainability **9**. doi:10.3390/su9040485.

Chang C chen, Cheng GJY, Nghiem TP Le, Song XP, Oh RRY, Richards DR, Carrasco LR. 2020. Social media, nature, and life satisfaction: global evidence of the biophilia hypothesis. Scientific Reports **10**:1–9. doi:10.1038/s41598-020-60902-w.

Chida Y, Steptoe A. 2008. Positive psychological well-being and mortality: A quantitative review of prospective observational studies. Psychosomatic Medicine **70**:741–756.

Christie P, Campbell LM, Armada N. 2014. Stewardship in tropical small-scale fisheries: Community and national perspectives. Pages 332–345 in S. M. Garcia, J. Rice, and A. Charles, editors. Governance of Marine Fisheries and Biodiversity Conservation: Interaction and coevolution First Edit. John Wiley & Sons.

Clayton S, Colléony A, Conversy P, Maclouf E, Martin L, Torres AC, Truong MXA, Prévot AC. 2017. Transformation of experience: Toward a new relationship with nature. Conservation

Letters **10**:645–651.

Clayton S, Myers G. 2009. Conservation psychology: Understanding and promoting human care for nature. John Wiley & Sons, New Jersey.

Clucas B, Rabotyagov S, Marzluff JM. 2015. How much is that birdie in my backyard? A cross-continental economic valuation of native urban songbirds. Urban Ecosystems **18**:251–266.

Coldwell DF, Evans KL. 2018. Visits to urban green-space and the countryside associate with different components of mental well-being and are better predictors than perceived or actual local urbanisation intensity. Landscape and Urban Planning **175**:114–122.

Cole CJ, Townsend CR, Reynolds RP, MacCulloch RD, Lathrop A. 2013. Amphibians and reptiles of Guyana, South America: Illustrated keys, annotated species accounts, and a biogeographic synopsis. Proceedings of the Biological Society of Washington **125**:317–578.

Cole HVS, Lamarca MG, Connolly JJT, Anguelovski I. 2017. Are green cities healthy and equitable? Unpacking the relationship between health, green space and gentrification. Journal of Epidemiology and Community Health **71**:1118–1121.

Colléony A, Prévot A-C, Saint Jalme M, Clayton S. 2017. What kind of landscape management can counteract the extinction of experience? Landscape and Urban Planning **159**:23–31.

Commonwealth Secreteriat. 2015. Migration and Development: Perspectives from Small States. London, UK.

Conover MR, Chasko GG. 1985. Nuisance Canada goose problems in the Eastern United States. Wildlife Society Bulletin **13**:228–233.

Cooper N, Brady E, Steen H, Bryce R. 2016. Aesthetic and spiritual values of ecosystems: recognising the ontological and axiological plurality of cultural ecosystem “services.” Ecosystem Services:218–229.

Correia RA, Jepson PR, Malhado ACM, Ladle RJ. 2016. Familiarity breeds content: Assessing bird species popularity with culturomics. PeerJ **2016**:1–15.

Costanza R, Kubiszewski I, Giovannini E, Lovins H, McGlade J, Pickett KE, Ragnarsdóttir KV, Roberts D, De Vogli R, Wilkinson R. 2014. Time to leave GDP behind. Nature **505**:283–285.

Cox DTC, Shanahan DF, Hudson HL, Fuller RA, Anderson K, Hancock S, Gaston KJ. 2017a. Doses of nearby nature simultaneously associated with multiple health benefits. International Journal of Environmental Research and Public Health **14**:172.

Cox DTC, Shanahan DF, Hudson HL, Fuller RA, Gaston KJ. 2018. The impact of urbanisation on nature dose and the implications for human health. Landscape and Urban Planning **179**:72–80.

Cox DTC, Shanahan DF, Hudson HL, Plummer KE, Siriwardena GM, Fuller RA, Anderson K, Hancock S, Gaston KJ. 2017b. Doses of neighborhood nature: The benefits for mental health of living with nature. BioScience **67**:147–155.

Cracknell D, White MP, Pahl S, Depledge MH. 2017. A preliminary investigation into the restorative potential of public aquaria exhibits: a UK student-based study. Landscape Research **42**:18–32.

Cracknell D, White MP, Pahl S, Nichols WJ, Depledge MH. 2016. Marine biota and psychological well-being: a preliminary examination of dose–response effects in an aquarium setting. Environment and Behavior **48**:1242–1269.

Cronbach LJ. 1951. Coefficient alpha and the internal structure of tests. Psychometrika **16**:297–334.

Cronin-de-chavez A, Islam S, McEachan RRC. 2019. Not a level playing field: a qualitative study exploring structural, community and individual determinants of greenspace use amongst low-income multi-ethnic families. Health and Place **56**:118–126.

Cummings AR, Markandey N, Das H, Arredondo C, Wehenkel A, Tiemann BL, Lee G. 2019. The spill over of crime from urban centers: An account of the changing spatial distribution of violent crime in Guyana. ISPRS International Journal of Geo-Information **8**:481.

Cummings AR, Piquero AR, Accetturo PW. 2018. Insights into the nature and spatial distribution of Guyanese crime. Deviant Behavior **39**:20–34.

Dallimer M, Davies ZG, Irvine KN, Maltby LM, Warren PH, Gaston KJ, Armsworth PR. 2014. What personal and environmental factors determine frequency of urban greenspace use? International Journal of Environmental Research and Public Health **11**:7977–7992.

Dallimer M, Irvine KN, Skinner AMJ, Davies ZG, Rouquette JR, Maltby LM, Warren PH, Armsworth PR, Gaston KJ. 2012a. Biodiversity and the feel-good factor: Understanding associations between self-reported human well-being and species richness. BioScience **62**:47–55.

Dallimer M, Rouquette JR, Skinner AMJ, Armsworth PR, Maltby LM, Warren PH, Gaston KJ. 2012b. Contrasting patterns in species richness of birds, butterflies and plants along riparian corridors in an urban landscape. Diversity and Distributions **18**:742–753.

de Azevedo CS, Silva KS, Ferraz JB, Tinoco HP, Young RJ, Rodrigues M. 2012. Does people's knowledge about an endangered bird species differ between rural and urban communities? The case of the greater rhea (Rhea americana, rheidae) in Minas Gerais, Brazil. Revista Brasileira de Ornitologia **20**:8–18.

de Bell S, White MP, Gri A, Darlow A, Taylor T, Wheeler BW, Lovell R. 2020. Spending time in the garden is positively associated with health and wellbeing: Results from a national survey in England. Landscape and Urban Planning **200**:103836. doi:10.1016/j.landurbplan.2020.103836.

de Oliveira FL, Mell I. 2019. Planning cities with nature: Theories, strategies, and methods. Switzerland.

de Vries S, ten Have M, van Dorsselaer S, van Wezep M, Hermans T, de Graaf R. 2016. Local availability of green and blue space and prevalence of common mental disorders in the Netherlands. British Journal of Psychiatry Open **2**:366–372.

Dean AJ, Barnett AG, Wilson KA, Turrell G. 2019. Beyond the ‘ extinction of experience ’ – novel pathways between nature experience and support for nature conservation. Global Environmental Change **55**:48–57.

Dearborn DC, Kark S. 2010. Motivations for conserving urban biodiversity. Conservation Biology **24**:432–440.

Dibble ED, Thomaz SM. 2009. Use of fractal dimension to assess habitat complexity and its influence on dominant invertebrates inhabiting tropical and temperate macrophytes. Journal of Freshwater Ecology **24**:93–102.

Diener E, Chan MY. 2011. Happy people live longer: Subjective well-being contributes to health and longevity. Applied Psychology: Health and Well-Being **3**:1–43.

Diener E, Oishi S, Tay L. 2018. Advances in subjective well-being research. Nature Human Behaviour **2**:253–260.

Dinnie E, Brown KM, Morris S. 2013. Community, cooperation and conflict: Negotiating the social well-being benefits of urban greenspace experiences. Landscape and Urban Planning **112**:1–9. doi:10.1016/j.landurbplan.2012.12.012.

Dirzo R, Young HS, Galetti M, Ceballos G, Isaac NJB, Collen B. 2014. Defaunation in the Anthropocene. Science **345**:401–406.

Dolan P, Kudrna L, Stone A. 2016. The measure matters: An investigation of evaluative and experience-based measures of wellbeing in time use data. Social Indicators Research:1–17. Springer Netherlands.

Dolan P, Metcalfe R. 2012. Measuring Subjective Wellbeing: Recommendations on Measures for use by National Governments. Journal of Social Policy **41**:409–427.

Douglas I. 2016. The challenge of urban poverty for the use of green infrastructure on floodplains and wetlands to reduce flood impacts in intertropical Africa. Landscape and Urban Planning. doi:10.1016/j.landurbplan.2016.09.025.

Dunn OJ. 1964. Multiple comparisons using rank sums. Technometrics **6**:241–252.

Earle J. 2013, May 17. Guyana must invest against sea level rise - expert. Thomson Reuters Foundation. Georgetown, Guyana. Available from https://news.trust.org/item/20130516135027-p82uh/.

eBird. 2017. eBird: An online database of bird distribution and abundance [web application]. eBird, Cornell Lab of Ornithology, Ithaca, New York. Available from http://www.ebird.org (accessed July 8, 2020).

Edwards R, Wu SC, Mensah J. 2005. City profile: Georgetown, Guyana. Cities **22**:446–454.

Eglington SM, Noble DG, Fuller RJ. 2012. A meta-analysis of spatial relationships in species richness across taxa: Birds as indicators of wider biodiversity in temperate regions. Journal for Nature Conservation **20**:301–309. Eldridge A, Guyot P, Moscoso P, Johnston A, Eyre-walker Y. 2018. Sounding out ecoacoustic metrics: avian species richness is predicted by acoustic indices in temperate but not tropical habitats. Ecological Indicators **94**:939–952.

Elias-Roberts A. 2020. Balancing environmental protection and offshore petroleum developments in Guyana. Global Energy Law and Sustainability **1**:1–27.

Elmqvist T, Fragkias J, Goodness J, Guneralp B, Marcotullio PJ, McDonald RI, Parnell S, Schequenius M, Sendstad M, Seto KC, Wilkinson C. 2013. Urbanization, biodiversity, and ecosystem services: challenges and opportunities. Springer, Dordrecht Heidelberg New York London.

Engemann K, Pedersen CB, Arge L, Tsirogiannis C, Mortensen PB, Svenning J-C. 2019. Residential green space in childhood is associated with lower risk of psychiatric disorders from adolescence into adulthood. Proceedings of the National Academy of Sciences:201807504. doi:10.1073/pnas.1807504116.

Erfanian M, Mitchell AJ, Kang J, Aletta F. 2019. The psychophysiological implications of soundscape: A systematic review of empirical literature and a research agenda. International Journal of Environmental Research and Public Health **16**:1–20.

Evensen KH, Raanaas RK, Fyhri A. 2016. Soundscape and perceived suitability for recreation in an urban designated quiet zone. Urban Forestry and Urban Greening **20**:243–248.

Fagerland MW, Hosmer DW. 2016. Tests for goodness of fit in ordinal logistic regression models. Journal of Statistical Computation and Simulation **86**:3398–3418.

Fairbrass AJ, Firman M, Williams C, Brostow GJ, Titheridge H, Jones KE. 2019. CityNet—Deep learning tools for urban ecoacoustic assessment. Methods in Ecology and Evolution **10**:186–197.

Fairbrass AJ, Peter R, Carol W, Helena T, Jones KE. 2017. Biases of acoustic indices measuring biodiversity in urban areas. Ecological Indicators **83**:169–177.

Feld CK, Segurado P, Gutiérrez-Cánovas C. 2016. Analysing the impact of multiple stressors in aquatic biomonitoring data: A ‘cookbook’ with applications in R. Science of the Total Environment **573**:1320–1339.

Fernandes DJ. 2006. “More eyes watching...” Community-based management of the Arapaima (Arapaima gigas) in Central Guyana. Page Eleventh biennial conference of the International Association for the Study of Common Property (IASCP). Georgetown, Guyana.

Finlay J, Franke T, McKay H, Sims-Gould J. 2015. Therapeutic landscapes and wellbeing in later life: Impacts of blue and green spaces for older adults. Health and Place **34**:97–106.

Fish R, Church A, Winter M. 2016. Conceptualising cultural ecosystem services: a novel framework for research and critical engagement. Ecosystem Services **21**:208–217.

Folmer A, Haartsen T, Huigen PPP. 2018. How ordinary wildlife makes local green places special. Landscape Research **6397**:1–11. doi:10.1080/01426397.2018.1457142

Fontana S, Sattler T, Bontadina F, Moretti M. 2011. How to manage the urban green to improve bird diversity and community structure. Landscape and Urban Planning **101**:278–285.

Francis J, Wood LJ, Knuiman M, Giles-Corti B. 2012. Quality or quantity? Exploring the relationship between public open space attributes and mental health in perth, western australia. social science and medicine **74**:1570–1577.

Francis RA, Chadwick MA. 2015. Invasions : non-native and invasive species in cities. Geography **100**:2015.

Franco LS, Shanahan DF, Fuller RA. 2017. A review of the benefits of nature experiences: More than meets the eye. International Journal of Environmental Research and Public Health **14**. doi:10.3390/ijerph14080864.

Fuller RA, Irvine KN, Devine-Wright P, Warren PH, Gaston KJ. 2007. Psychological benefits of greenspace increase with biodiversity. Biology Letters **3**:390–394.

Gallardo B. 2014. Europes top 10 invasive species: Relative importance of climatic, habitat and socio-economic factors. Ethology Ecology and Evolution **26**:130–151.

Gardner T A, Barlow J, Araujo IS, Ávila-Pires C, Bonaldo AB, Costa JE, Esposito MC, Ferreira L V., Hawes J, Hernandez MIM, Hoogmoed MS, Leite RN, Lo-Man-Hung NF, Malcolm JR, Martins MB, Mestre LAM, Miranda-Santos R, Overal WL, Parry L, Peters SL, Ribeiro MA, Da Silva MNF, Da Silva Motta C, Peres CA. 2008. The cost-effectiveness of biodiversity surveys in tropical forests. Ecology Letters **11**:139–150.

Garrett JK, White P, Huang J, Ng S, Hui Z, Leung C, Tse LA, Fung F, Elliott LR, Depledge MH, Wong MCS. 2019. Urban blue space and health and wellbeing in Hong Kong: Results from a survey of older adults. Health and Place **55**:100–110.

Gascón M, Zijlemaa W, Verta C, Whited M, Nieuwenhuijsen MJ. 2017. Blue spaces, human health and well-being: a systematic review. International Journal of Hygiene and Environmental Health **220**:1207–1221.

Gatersleben B, Murtagh N, Abrahamse W. 2014. Values, identity and pro-environmental behaviour. Contemporary Social Science **9**:374–392.

Gearey M, Robertson L, Anderson J, Barros P, Cracknell D. 2018. Re-naturing the city for health and wellbeing: green/blue urban spaces as sites of renewal and contestation. Pages 153–168 in F. L. de Oliveira and I. Mell, editors. Planning cities with nature: Theories, strategies, and methods. Springer International, Switzerland.

Gibb R, Redding DW, Chin KQ, Donnelly CA, Blackburn TM, Newbold T, Jones KE. 2020. Zoonotic host diversity increases in human-dominated ecosystems. Nature. doi:10.1038/s41586-020-2562-8.

Giles-Corti B, Vernez-Moudon A, Reis R, Turrell G, Dannenberg AL, Badland H, Foster S, Lowe M, Sallis JF, Stevenson M, Owen N. 2016. City planning and population health: A global challenge. The Lancet **388**:2912–2924.

Gobster PH, Nassauer JI, Daniel TC, Fry G. 2007. The shared landscape: what does aesthetics have to do with ecology? Landscape Ecology **22**:959–972.

Goddard MA, Dougill AJ, Benton TG. 2010. Scaling up from gardens: biodiversity conservation in urban environments. Trends in Ecology & Evolution **25**:90–98.

Gopal D, Nagendra H. 2014. Vegetation in Bangalore's slums: Boosting livelihoods, well-being and social capital. Sustainability (Switzerland) **6**:2459–2473.

Gopal D, von der Lippe M, Kowarik I. 2019. Sacred sites, biodiversity and urbanization in an Indian megacity. Urban Ecosystems **22**:161–172.

Grafius DR, Najihah A, Nor M, Corstanje R, Harris JA, Grafius DR. 2017. Ecological connectivity networks in rapidly expanding cities. Heliyon:e00325. doi:10.1016/j.heliyon.2017.e00325.

Graham C, Comim F, Anand P. 2018. The Global Analysis of Wellbeing Report. Oxford, UK. Available from http://globalwellbeingreport.org/wp-content/uploads/2018/02/WellBeingGlobalReport.pdf%0Ahttp://eprints.lse.ac.uk/90234/1/Anand__global-analysis-of-wellbeing.pdf.

Grellier J, White MP, Albin M, Bell S, Elliott LR, Gascón M, Gualdi S, Mancini L, Nieuwenhuijsen MJ, Sarigiannis DA, van den Bosch MA, Wolf T, Wuijts S, Fleming E. 2017. BlueHealth: A study programme protocol for mapping and quantifying the potential benefits to public health and well-being from Europe's blue spaces. BMJ Open **7**:1–10.

Griggs D. 2013. Sustainable developmnet goals for people and planet. Nature **495**:305–307.

Guenat S, Dougill AJ, Kunin WE, Dallimer M. 2019. Untangling the motivations of different stakeholders for urban greenspace conservation in sub-Saharan Africa. Ecosystem Services **36**:100904. doi:10.1016/j.ecoser.2019.100904.

Güneralp B, Seto KC. 2013. Futures of global urban expansion: uncertainties and implications for biodiversity conservation. Environmental Research Letters **8**:014025.

Haase D, Kabisch S, Haase A, Andersson E, Banzhaf E, Baró F, Brenck M, Fischer LK, Frantzeskaki N, Kabisch N, Krellenberg K, Kremer P, Kronenberg J, Larondelle N, Mathey J, Pauleit S, Ring I, Rink D, Schwarz N, Wolff M 2017. Greening cities – To be socially inclusive? About the alleged paradox of society and ecology in cities. Habitat International **64**:41–48.

Hägerhäll CM, Laike T, Küller M, Marcheschi E, Boydston C, Taylor RP. 2015. Human physiological benefits of viewing nature: EEG responses to exact and statistical fractal patterns. Nonlinear Dynamics, Psychology, and Life Sciences **19**:1–12.

Haigh MD. 1991. The use of manatees for the control of aquatic weeds in Guyana. Irrigation and Drainage Systems **5**:339–349.

Harrison XA, Donaldson L, Correa-cano ME, Evans J, Fisher DN, Goodwin CED, Robinson BS, Hodgson DJ, Inger R. 2018. A brief introduction to mixed effects modelling and multi-model inference in ecology. PeerJ:6:e4794.

Hartig T, Kahn PHJ. 2016. Living in cities, naturally. Science **352**:938–940.

Hartig T, Korpela KM, Evans GW, Gärling T. 1997. A measure of restorative quality in environments. Scandinavian Housing and Planning Research **14**:175–194.

Hartig T, Mitchell RJ, de Vries S, Frumkin H. 2014. Nature and health. Annual review of public health **35**:21.2-22.22.

Hausmann A, Slotow R, Burns JK, Di Minin E. 2016. The ecosystem service of sense of place: Benefits for human well-being and biodiversity conservation. Environmental Conservation **43**:117–127.

Hayes AF. 2009. Beyond Baron and Kenny: Statistical mediation analysis in the new millennium. Communication Monographs **764**:408–420.

Hayes AF, Preacher KJ. 2014. Statistical mediation analysis with a multicategorical independent variable. British Journal of Mathematical and Statistical Psychology **67**:451–470.

Hayes WM, Fisher JC, Pierre MA, Bicknell JE, Davies ZG. 2019. Bird communities across varying landcover types in a Neotropical city. Biotropica **00**:1–14.

Haynes K, Tanner TM. 2015. Empowering young people and strengthening resilience: youth-centred participatory video as a tool for climate change adaptation and disaster risk reduction. Children's Geographies **13**:357–371. Taylor & Francis.

Hedblom M, Heyman E, Antonsson H, Gunnarsson B. 2014. Bird song diversity influences young people’s appreciation of urban landscapes. Urban Forestry and Urban Greening **13**:469–474.

Hedblom M, Knez I, Gunnarsson B. 2017. Bird diversity improves the well-being of city residents. Pages 287–386 in E. Murgui and M. Hedblom, editors. Ecology and Conservation of birds in Urban Environments. Springer Nature, Cham, Switzerland. doi:10.1007/978-3-319-43314-1_19.

Helbich M, de Beurs D, Kwan MP, O’Connor RC, Groenewegen PP. 2018a. Natural environments and suicide mortality in the Netherlands: A cross-sectional, ecological study. The Lancet Planetary Health **2**:e134–e139.

Helbich M, Klein N, Roberts H, Hagedoorn P, Groenewegen PP. 2018b. More green space is related to less antidepressant prescription rates in the Netherlands: A Bayesian geoadditive quantile regression approach. Environmental Research **166**:290–297.

Helliwell JF, Layard R, Sachs J. 2016. World Happiness Report Update. New York.

Helliwell JF, Layard R, Sachs J, De Neve J-E. 2020. World Happiness Report. New York, NY.

Herrando S, Brotons L, Anton M, Franch M, Quesada J, Ferrer X. 2017. Indicators of the effects of the urban greening on birds: the case of Barcelona. Pages 449–463 in E. Murgui and M. Hedblom, editors. Ecology and conservation of birds in urban environments. Springer, Cham, Switzerland.

Higgins, Sahran L, Hassall C, Thomas F, Goldsmith B, Brooks SJ, Harlow J, Stone D, Völker S, White PCL. 2019. Urban freshwaters, biodiversity, and human health and well-being: setting an interdisciplinary research agenda. WIREs Water:1–13.

High C, Singh N, Petheram L, Nemes G. 2012. Defining participatory video from practice. Pages 35–48 in E. J. Milne, C. Mitchell, and N. de Lange, editors. Handbook of Participatory Video. Altamira Press, Lanham, Maryland.

Holland A. 2018. Guyana: Building sustainable security. Page American security project. Available from www.AmericanSecurityProject.org.

Hong A, Sallis JF, King AC, Conway TL, Saelens B, Cain KL, Fox EH, Frank LD. 2018. Linking green space to neighborhood social capital in older adults: The role of perceived safety. Social Science & Medicine. doi:10.1016/j.socscimed.2018.04.051.

Hossain MM, Sultana A, Ma P, Fan Q, Sharma R, Purohit N, Sharmin DF. 2020. Effects of natural environment on mental health: an umbrella review of systematic reviews and meta-analyses. PsyArXiv. doi: 10.31234/osf.io/4r3mh.

Hoyle H, Jorgensen A, Hitchmough JD. 2019. What determines how we see nature? Perceptions of naturalness in designed urban green spaces. People and Nature:1–14.

Hoyle H, Norton B, Dunnett N, Richards JP, Russell JM, Warren P. 2018. Plant species or flower colour diversity? Identifying the drivers of public and invertebrate response to designed annual meadows. Landscape and Urban Planning **180**:103–113.

Huang ZYX, Van Langevelde F, Estrada-Peña A, Suzán G, De Boer WF. 2016. The diversity-disease relationship: Evidence for and criticisms of the dilution effect. Parasitology **143**:1075–1086.

Hunte N, Roopsind A, Ansari AA, Trevor Caughlin T. 2019. Colonial history impacts urban tree species distribution in a tropical city. Urban Forestry and Urban Greening **41**:313–322.

Ibrahim R, Clayden A, Cameron R. 2020. Tropical urban parks in Kuala Lumpur, Malaysia: Challenging the attitudes of park management teams towards a more environmentally sustainable approach. Urban Forestry and Urban Greening **49**:126605. doi:10.1016/j.ufug.2020.126605.

Irvine KN, Devine-Wright P, Payne SR, Fuller RA, Painter B, Gaston KJ. 2009. Green space, soundscape and urban sustainability: an interdisciplinary, empirical study. Local Environment

14:155–172. doi:10.1080/13549830802522061.

Irvine KN, Warber SL, Devine-Wright P, Gaston KJ. 2013. Understanding urban green space as a health resource: A qualitative comparison of visit motivation and derived effects among park users in Sheffield, UK. International Journal of Environmental Research and Public Health **10**:417–442.

Ives C D, Lentini PE, Threlfall CG, Ikin K, Shanahan DF, Garrard GE, Bekessy SA, Fuller RA, Mumaw L, Rayner L, Rowe R, Valentine LE, Kendal D. 2016. Cities are hotspots for threatened species. Global Ecology and Biogeography **25**:117–126.

Ives C D, Giusti M, Fischer J, Abson DJ, Klaniecki K, Dorninger C, Laudan J, Barthel S, Abernethy P, Martín-López B, Raymond CM, Kendal D, von Wehrden H 2017a. Human–nature connection: a multidisciplinary review. Current Opinion in Environmental Sustainability **26–27**:106–113.

Ives CD, Oke C, Hehir A, Gordon A, Wang Y, Bekessy SA. 2017b. Capturing residents' values for urban green space: Mapping, analysis and guidance for practice. Landscape and Urban Planning **161**:32–43.

Ives CD, Gordon A, Oke C, Raymond CM, Hehir A, Bekessy SA. 2018. Spatial scale influences how people value and perceive green open space. Journal of Environmental Planning and Management **61**:2133–2150.

Jansson M, Fors H, Lindgren T, Wiström B. 2013. Perceived personal safety in relation to urban woodland vegetation – a review. Urban Forestry & urban Greening **12**:127–133.

Jenkins CN, Pimm SL, Joppa LN. 2013. Global patterns of terrestrial vertebrate diversity and conservation. Proceedings of the National Academy of Sciences of the United States of America **110**:E2603–E2610.

Jim CY, Chen WY. 2008. Assessing the ecosystem service of air pollutant removal by urban trees in Guangzhou (China). Journal of Environmental Management **88**:665–676.

Jones L, Holland RA, Ball J, Sykes T, Taylor G, Ingwall-King L, Snaddon JL, S.-H. Peh K. 2020. A place-based participatory mapping approach for assessing cultural ecosystem services in urban green space. People and Nature **2**:123–137.

Jorgensen A, Hitchmough J, Calvert T. 2002. Woodland spaces and edges: their impact on perception of safety and preference. Landscape and Urban Planning **60**:135–150.

Jorgensen A, Hitchmough J, Dunnett N. 2007. Woodland as a setting for housing-appreciation and fear and the contribution to residential satisfaction and place identity in Warrington New Town, UK. Landscape and Urban Planning **79**:273–287.

Joye Y, de Block A. 2011. "Nature and I are two": A critical examination of the biophilia hypothesis. Environmental Values **20**:189–215.

Joye Y, Steg L, Ünal AB, Pals R. 2016. When complex is easy on the mind: Internal repetition of visual information in complex objects is a source of perceptual fluency. Journal of Experimental Psychology: Human Perception and Performance **42**:103–114.

Kaley A, Hatton C, Milligan C. 2019. More than words: the use of video in ethnographic research with people with intellectual disabilities. Qualitative Health Research **29**:931–943.

Kanagavel A, Parvathy S, Nirmal N, Divakar N, Raghavan R. 2017. Do frogs really eat cardamom? Understanding the myth of crop damage by amphibians in the Western Ghats, India. Ambio. Springer Netherlands. Available from http://link.springer.com/10.1007/s13280-017-0908-8.

Kaplan R, Kaplan S. 1989. The experience of nature: A psychological perspective. Page Cambridge University Press. Cambridge University Press, Cambridge, UK.

Kaplan S. 1995. The restorative benefits of nature: Toward an integrative framework. Journal of Environmental Psychology **15**:169–182.

Karma-Ura D, Alkire S, Zangmo T. 2012. A short guide to the Gross National Happiness (GNH) Index. Thimphu, Bhutan. Available from www.grossnationalhappiness.com.

Kellert SR, Wilson E. 1993. The Biophilia Hypothesis. Island Press, Washington, DC.

Keniger LE, Gaston KJ, Irvine KN, Fuller RA. 2013. What are the benefits of interacting with nature? International Journal of Environmental Research and Public Health **10**:913–935.

Kindon S. 2003. Participatory video in geographic research: A feminist practice of looking? Area **35**:142–153.

Kleiber C, Zeileis A. 2016. Visualizing count data regressions using rootograms. Working papers in economics and statistics. Innsbruck, Austria.

Kondo MC, Han SH, Donovan GH, MacDonald JM. 2017. The association between urban trees and crime: Evidence from the spread of the emerald ash borer in Cincinnati. Landscape and Urban Planning **157**:193–199.

Korpela KM, Borodulin K, Neuvonen M, Paronen O, Tyrväinen L. 2014. Analyzing the mediators between nature-based outdoor recreation and emotional well-being. Journal of Environmental Psychology **37**:1–7. doi:10.1016/j.jenvp.2013.11.003.

Kruize H, van der Vliet N, Staatsen B, Bell R, Chiabai A, Muiños G, Higgins S, Quiroga S, Martinez-Juarez P, Yngwe MA, Tsichlas F, Karnaki P, Lima ML, de Jalón SG, Khan M, Morris G, Stegeman I. 2019. Urban green space: creating a triple win for environmental sustainability, health, and health equity through behavior change. International Journal of Environmental Research and Public Health **16**. doi:10.3390/ijerph16224403.

Laatikainen TE, Broberg A, Kyttä M. 2016. The physical environment of positive places: Exploring differences between age groups. Preventive Medicine. doi:10.1016/j.ypmed.2016.11.015.

Lafortezza R, Carrus G, Sanesi G, Davies C. 2009. Benefits and well-being perceived by people visiting green spaces in periods of heat stress. Urban Forestry and Urban Greening **8**:97–108.

Larson LR, Keith SJ, Fernandez M, Hallo JC, Shafer CS, Jennings V. 2016. Ecosystem services and urban greenways: What's the public's perspective? Ecosystem Services **22**:111–116.

Lee J, Tsunetsugu Y, Takayama N, Park BJ, Li Q, Song C, Komatsu M, Ikei H, Tyrväinen L, Kagawa T, Miyazaki Y. 2014. Influence of forest therapy on cardiovascular relaxation in young adults. Evidence-based Complementary and Alternative Medicine. doi:10.1155/2014/834360.

Levine RS, Hedeen DL, Hedeen MW, Hamer GL, Mead DG, Kitron UD. 2017. Avian species diversity and transmission of West Nile virus in Atlanta, Georgia. Parasites and Vectors **10**:1–12.

Liddicoat C, Bi P, Waycott M, Glover J, Lowe AJ, Weinstein P. 2018. Landscape biodiversity correlates with respiratory health in Australia. Journal of Environmental Management **206**:113–122.

Lin BB, Fuller RA, Bush R, Gaston KJ, Shanahan DF. 2014. Opportunity or orientation? Who uses urban parks and why. PLoS ONE **9**:e87422.

Liu Z, He C, Wu J. 2016. The relationship between habitat loss and fragmentation during urbanization: An empirical evaluation from 16 world cities. PLoS ONE **11**:e0154613.

Lovell R, Wheeler BW, Higgins, Sahran L, Irvine KN, Depledge MH. 2014. A systematic review of the health and well-being benefits of biodiverse environments. J Toxicol Environ Health B **17**:1–20.

Luck GW, Davidson P, Boxall D, Smallbone L. 2011. Relations between Urban Bird and Plant Communities and Human Well-Being and Connection to Nature. Conservation Biology **25**:816–826.

Luederitz C, Brink E, Gralla F, Hermelingmeier V, Meyer M, Niven L, Panzer L, Partelow S, Rau A L, Sasaki R, Abson DJ, Lang DJ, Wamsler C, von Wehrden H. 2015. A review of urban ecosystem services: Six key challenges for future research. Ecosystem Services **14**:98–112.

MacGregor-Fors I, Escobar-Ibáñez JF. 2017. Avian ecology in Latin American cityscapes. In MacGregor-Fors I, Escobar-Ibáñez JF, editors. Avian ecology in Latin American cityscapes. Springer, Cham, Switzerland.

MacGregor-Fors I, Gómez-Martínez MA, García-Arroyo M, Chávez-Zichinelli CA. 2020. A dead letter? Urban conservation, management, and planning strategies from the Mexican urban bird literature. Urban Ecosystems. doi:10.1007/s11252-020-00970-y.

Machado RB, Aguiar L, Jones G. 2017. Do acoustic indices reflect the characteristics of bird communities in the savannas of Central Brazil? Landscape and Urban Planning **162**:36–43.

Mackenzie CS, Karaoylas EC, Starzyk KB. 2018. Lifespan differences in a self determination theory model of eudaimonia: a cross-sectional survey of younger, middle-aged, and older adults. Journal of Happiness Studies **19**:2465–2487.

MacKerron G, Mourato S. 2013. Happiness is greater in natural environments. Global Environmental Change **23**:992–1000.

Mahipaul G. 2016, November 30. Government must be given credit for the D'Urban Park Project. Kaiteur News. Georgetown, Guyana, Guyana. Available from https://www.kaieteurnewsonline.com/2016/11/30/government-must-be-given-credit-for-the-durban-park-project/.

Maleki K, Hosseini S. 2011. Investigation of the effect of leaves, branches and canopies of trees on noise pollution reduction. Annals of Environmental Science **5**:13–21.

Markevych I, Schoierer J, Hartig T, Chudnovsky A, Hystad P, Dzhambov AM, de Vries S, Triguero-Mas M, Brauer M, Nieuwenhuijsen MJ, Lupp G, Richardson EA, Astell-Burt T, Dimitrova D, Feng X, Sadeh M, Standl M, Heinrich J, Fuertes E. 2017. Exploring pathways linking greenspace to health: Theoretical and methodological guidance. Environmental Research **158**:301–317.

Marselle MR, Irvine KN, Lorenzo-Arribas A, Warber SL. 2015. Moving beyond green: Exploring the relationship of environment type and indicators of perceived environmental quality on emotional well-being following group walks. International Journal of Environmental Research and Public Health **12**:106–130.

Marselle MR, Irvine KN, Lorenzo-Arribas A, Warber SL. 2016. Does perceived restorativeness mediate the effects of perceived biodiversity and perceived naturalness on emotional well-being following group walks in nature? Journal of Environmental Psychology **46**:217–232.

Marteau TM, Bekker H. 1992. The development of a six-item short-form of the state scale of the Spielberger State—Trait Anxiety Inventory (STAI). British Journal of Clinical Psychology **31**:301–306.

Martin L, White MP, Hunt A, Richardson M, Pahl S, Burt J. 2020. Nature contact, nature connectedness and associations with health, wellbeing and pro-environmental behaviours. Journal of Environmental Psychology **68**:101389.

Martyn P, Brymer E. 2014. The relationship between nature relatedness and anxiety. Journal of Health Psychology **21**:1436–1445.

Maund PR, Irvine KN, Reeves J, Strong E, Cromie R, Dallimer M, Davies ZG. 2019. Wetlands for wellbeing: piloting a nature-based health intervention for the management of anxiety and depression **16**:4413.

Mayer FS, Frantz CM. 2004. The connectedness to nature scale: A measure of individuals' feeling in community with nature. Journal of Environmental Psychology **24**:503–515.

McDonald RI, Colbert ML, Hamann M, Simkin R, Walsh B. 2018. Nature in the Urban Century. Arlington, VA.

Mcdougall CW, Quilliam RS, Hanley N, Oliver DM. 2020. Freshwater blue space and population health: An emerging research agenda. Science of the Total Environment **737**:140196. doi:10.1016/j.scitotenv.2020.140196.

McKinney ML. 2008. Effects of urbanization on species richness: A review of plants and animals. Urban Ecosystems **11**:161–176.

McMahan EA, Estes D. 2015. The effect of contact with natural environments on positive and negative affect: A meta-analysis. The Journal of Positive Psychology **10**. doi:10.1080/17439760.2014.994224.

Mikołajczak K, Barlow J, Lees AC, Schultz PW, Pato C, Parry L. 2019. Loving Amazonian nature? Extending the study of psychological nature connection to rural areas in the Global South. PsyArXiv:1–18.

Millenium Ecosystem Assessment. 2003. Ecosystems and Human Well-being: A Framework for Assessment. Washington, DC.

Miller JR. 2005. Biodiversity conservation and the extinction of experience. Trends in Ecology and Evolution **20**:430–434.

Milne EJ. 2016. Critiquing participatory video: experiences from around the world. Area **48**:401–404.

Ministry of Health Guyana. 2013. Health Vision 2020; Health for all in Guyana; A National Health Strategy for Guyana:83–84. Available from http://www.paho.org/guy/index.php?option=com_docman&view=download&category_slug=health-systems-and-services&alias=123-guy-healthvision-2013-2020&Itemid=291.

Mistry J, Berardi A. 2012. The challenges and opportunities of participatory video in geographical research: Exploring collaboration with indigenous communities in the North Rupununi, Guyana. Area **44**:110–116.

Mistry J, Berardi A, Bignante E, Tschirhart CC. 2015. Between a rock and a hard place: Ethical dilemmas of local community facilitators doing participatory research projects. Geoforum **61**:27–35.

Mistry J, Berardi A, Tschirhart C, Bignante E, Haynes L, Benjamin R, Albert G, Xavier R, Jafferally D, de Ville G. 2014. Indigenous identity and environmental governance in Guyana, South America. Cultural Geographies **22**:689 –712.

Mitchell RJ, Richardson EA, Shortt NK, Pearce JR. 2015. Neighborhood environments and socioeconomic inequalities in mental well-being. American Journal of Preventive Medicine **49**:80–84.

Moran M, Rodríguez DA, Cotinez-O'Ryan A, Miranda JJ. 2020. Park use, park proximity, and neighborhood characteristics: Evidence from 11 cities in Latin America. Cities **105**:102817. doi:10.1016/j.cities.2020.102817.

Moscoso P, Peck M, Eldridge A. 2018. Emotional associations with soundscape reflect human-environment relationships. Journal of Ecoacoustics **1**.

Mulder MB, Schacht R, Caro T, Schacht J, Caro B. 2016. Knowledge and attitudes of children of the Rupununi: Implications for conservation in Guyana. Biological Conservation **142**:879–997.

Mycoo MA. 2014. Autonomous household responses and urban governance capacity building for climate change adaptation: Georgetown, Guyana. Urban Climate **9**:134–154.

Mycoo MA. 2017. A Caribbean New Urban Agenda post-Habitat III: Closing the gaps. Habitat International **69**:68–77. Nath TK, Zhe Han SS, Lechner AM. 2018. Urban green space and well-being in Kuala Lumpur, Malaysia. Urban Forestry and Urban Greening **36**:34–41. doi:10.1016/j.ufug.2018.09.013.

Natural England. 2015. Econets, landscape and people: integrating people's values and cultural ecosystem services into the design of ecological networks and other landscape change proposals. (No. NECR180). Natural England Enquiry Service.

Neumann B, Vafeidis AT, Zimmermann J, Nicholls RJ. 2015. Future coastal population growth and exposure to sea-level rise and coastal flooding - a global assessment. PLoS ONE **3**:e0118571.

Neuteleers S, Deliège G. 2019. Does nature experience matter? Why not to care too much about the link between nature experience and valuing nature. Biological Conservation **231**:49–50.

Newbold T, Hudson LN, Hill SLL, Contu S, Lysenko I, Senior R A, Börger L, Bennett DJ, Choimes A, Collen B, Day J, De Palma A, Díaz S, Echeverria-Londoño S, Edgar MJ, Feldman A, Garon M, Harrison MLK, Alhusseini T, Ingram DJ, Itescu Y, Kattge J, Kemp V, Kirkpatrick L, Kleyer M, Correia DLP, Martin CD, Meiri S, Novosolov M, Pan Y, Phillips HRP, Purves DW, Robinson A, Simpson J, Tuck SL, Weiher E, White HJ, Ewers RM, Mace GM, Scharlemann JP W, Purvis A. 2015. Global effects of land use on local terrestrial biodiversity. Nature **520**:45–50.

News Room GY. 2020, May 12. Sections of Georgetown flooded. News Room GY. Georgetown, Guyana. Available from https://newsroom.gy/2020/05/12/sections-of-georgetown-flooded/.

Nicolas G, Dudley-Grant GR, Maxie-Moreman A, Liddell-Quintyn E, Baussan J, Janac N, McKenny M. 2020. Psychotherapy with Caribbean Women: Examples from USVI, Haiti, and Guyana. Women and Therapy **0**:1–20. Routledge. doi:10.1080/02703149.2020.1775993.

Nisbet EK, Zelenski JM. 2013. The NR-6: A new brief measure of nature relatedness. Frontiers in Psychology **4**. doi:10.3389/fpsyg.2013.00813.

Nisbet EK, Zelenski JM, Murphy S a. 2009. The Nature Relatedness Scale - Linking individuals' connection with nature to environmental concern and behavior. Environment And Behavior **27**:1–26. doi:10.1177/0013916506295574.

Nisbet EK, Zelenski JM, Murphy SA. 2011. Happiness is in our nature: Exploring nature relatedness as a contributor to subjective qell-being. Journal of Happiness Studies **12**:303–322.

Nutsford D, Pearson AL, Kingham S, Reitsma F. 2016. Residential exposure to visible blue space (but not green space) associated with lower psychological distress in a capital city. Health and Place **39**:70–78.

O'Brien L, Varley P. 2012. Use of ethnographic approaches to the study of health experiences in relation to natural landscapes. Perspectives in Public Health **132**:305–312.

O'Neill DW, Fanning AL, Lamb WF, Steinberger JK. 2018. A good life for all within planetary boundaries. Nature Sustainability **1**:88–95.

O'Sullivan OS, Holt AR, Warren PH, Evans KL. 2017. Optimising UK urban road verge contributions to biodiversity and ecosystem services with cost-effective management. Journal of Environmental Management **191**:162–171.

Ode Sang Å, Knez I, Gunnarsson B, Hedblom M. 2016. The effects of naturalness, gender, and age on how urban green space is perceived and used. Urban Forestry and Urban Greening **18**:268–276.

OECD. 2013. OECD Guidelines on Measuring Subjective Well-being. Available from http://www.oecd-ilibrary.org/economics/oecd-guidelines-on-measuring-subjective-well-being_9789264191655-en.

OECD. 2015. How's life? 2015: Measuring Well-being. Page How's Life? 2015: Measuring well-being. Paris.

Oksanen J, Blanchet FG, Kindt R, Legen- P, Minchin PR, Hara RBO, Simpson GL, Soly- P, Stevens MHH, Wagner H. 2018. Package ' vegan ' version 2.5-2.

ONS. 2016. Personal well-being in the UK: Quality and Methodology Information. Cardiff, UK. Available from https://www.ons.gov.uk/.

Ordóñez-Barona C, Duinker PN. 2014. Urban forest values of the citizenry in three colombian cities. Society & Natural Resources **27**:834–849.

Palliwoda J, Kowarik I, von der Lippe M. 2017. Human-biodiversity interactions in urban parks: The species level matters. Landscape and Urban Planning **157**:394–406.

Panelli LF. 2019. Is Guyana a new oil El Dorado? The Journal of World Energy Law & Business **12**:365–368.

Parliament of Guyana. 2010. National mangrove management action plan for 2010 to 2012. Georgetown, Guyana. Available: http://parliament.gov.gy/documents/documents-laid/4002-the_national_mangrove_management_action_plan_for_2010_to_2012.pdf

Parnell S, Simon D, Vogel C. 2007. Global environmental change: Conceptualising the growing challenge for cities in poor countries. Area **39**:357–369.

Parra DC, Gomez LF, Fleischer NL, David Pinzon J. 2010. Built environment characteristics and perceived active park use among older adults: Results from a multilevel study in Bogotá. Health and Place **16**:1174–1181.

Parris KM, Amati M, Bekessy SA, Dagenais D, Fryd O, Hahs A K, Hes D, Imberger SJ, Livesley SJ, Marshall AJ, Rhodes JR, Threlfall CG, Tingley R, van der Ree R, Walsh CJ, Wilkerson ML, Williams NSG. 2018. The seven lamps of planning for biodiversity in the city. Cities:0–1. doi:10.1016/j.cities.2018.06.007.

Pasanen TP, White MP, Garrett JK, Wheeler BW, Fleming LE. 2019. Neighbourhood bluespaces and positive health and wellbeing: The mediating role of different types of physical activity. Environment International **131**:105016. doi:10.1016/j.envint.2019.105016.

Pathak V, Tripathi BD, Mishra VK. 2008. Dynamics of traffic noise in a tropical city Varanasi and its abatement through vegetation. Environmental Monitoring and Assessment **146**:67–75.

Pauchard A, Aguayo M, Pena E, Urrutia R. 2006. Multiple effects of urbanization on the biodiversity of developing countries: The case of a fast-growing metropolitan area (Concepcion, Chile). Biological Conservation **127**:272–281.

Pauchard A, Barbosa O. 2013. Chapter 28: Regional assessment of Latin America: rapid urban development and social economic inequality threaten biodiversity hotspots. Pages 589–608 in T. Elmqvist, editor. Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities. Santiago, Chile.

Payne SR, Bruce N. 2019. Exploring the relationship between urban quiet areas and perceived restorative benefits. International Journal of Environmental Research and Public Health **16**:1611.

Peen J, Schoevers RA, Beekman AT, Dekker J. 2010. The current status of urban-rural differences in psychiatric disorders. Acta Psychiatrica Scandinavica **121**:84–93.

Pett TJ, Shwartz A, Irvine KN, Dallimer M, Davies ZG. 2016. Unpacking the people–biodiversity paradox: A conceptual framework. BioScience:biw036.

Pijanowski BC, Villanueva-Rivera LJ, Dumyahn SL, Farina A, Krause BL, Napoletano BM, Gage SH, Pieretti N. 2011. Soundscape ccology: The science of sound in the landscape. BioScience **61**:203–216.

Pimm SL, Jenkins CN, Abell R, Brooks TM, Gittleman JL, Joppa LN, Raven PH, Roberts CM, Sexton JO. 2014. The biodiversity of species and their rates of extinction, distribution, and protection. Science **344**. doi:10.1126/science.1246752.

Pitt H. 2019. What prevents people accessing urban bluespaces? A qualitative study. Urban Forestry and Urban Greening **39**:89–97.

Preacher KJ, Hayes AF. 2008. Contemporary approaches to assessing mediation in communication research. Pages 13–54 in A. F. Hayes, M. D. Slater, and L. B. Snyder, editors. The SAGE sourcebook of advanced data analysis methods for communication research. Sage Publications, Thousand Oaks.

Pretty J, Barton J, Pervez Bharucha Z, Bragg R, Pencheon D, Wood C, Depledge MH. 2016. Improving health and well-being independently of GDP: dividends of greener and prosocial economies. International Journal of Environmental Health Research **26**:11–36.

Prévot AC, Cheval H, Raymond R, Cosquer A. 2018. Routine experiences of nature in cities can increase personal commitment toward biodiversity conservation. Biological Conservation **226**:1–8. doi:10.1016/j.biocon.2018.07.008.

Proctor R, Guell C, Wyatt K, Williams A. 2019. What is the evidence base for integrating health and environmental agendas in the school context to improve healthy and environmentally aware behaviours? A systematic scoping review of global evidence. Health and Place **64**:A9102356. doi:10.1016/j.healthplace.2020.102356.

Proshansky HM, Fabian AK, Kaminoff R. 1983. Place-identity: Physical world socialization of the self. Journal of Environmental Psychology **3**:57–83.

Protected Areas Commission Guyana. 2016. Strategic Plan 2016-2020. Georgetown, Guyana.

R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Rands MRW, Adams WM, Bennun L, Butchart SHM, Clements A, Coomes D, Entwistle A, Hodge I, Kapos V, Scharlemann JPW, Sutherland WJ, Vira B. 2010. Biodiversity conservation: Challenges beyond 2010. Science **329**:1298–1303.

Ranger S, Kenter JO, Bryce R, Cumming G, Dapling T, Lawes E, Richardson PB. 2016. Forming shared values in conservation management: An interpretive-deliberative-democratic approach to including community voices. Ecosystem Services **21**:344–357.

Ratcliffe E, Gatersleben B, Sowden PT. 2013. Bird sounds and their contributions to perceived attention restoration and stress recovery. Journal of Environmental Psychology **36**:221–228.

Ratcliffe E, Gatersleben B, Sowden PT. 2018. Predicting the perceived restorative potential of bird sounds through acoustics and aesthetics. Environment And Behavior. doi:10.1177/0013916518806952.

Reis E, López-Iborra GM, Pinheiro RT. 2012. Changes in bird species richness through different levels of urbanization: Implications for biodiversity conservation and garden design in Central Brazil. Landscape and Urban Planning **107**:31–42.

Reynaud P., Thioulouse J. 2000. Identification of birds as biological markers along a neotropical urban–rural gradient (Cayenne, French Guiana), using co-inertia analysis. Journal of Environmental Management **59**:121–140.

Richards DR, Passy P, Oh RRY. 2017. Impacts of population density and wealth on the quantity and structure of urban green space in tropical Southeast Asia. Landscape and Urban Planning **157**:553–560.

Rigolon A, Browning M, Lee K, Shin S. 2018. Access to urban green space in cities of the Global South: a systematic literature review. Urban Science **2**:67. doi:10.3390/urbansci2030067.

Roberts D. 2009. The development impact of remittances on Guyana's economy. Social and Economic Studies **58**:199–225.

Robinson JM, Jorgensen A, Cameron R, Brindley P. 2020. Let nature be thy medicine: A socioecological exploration of green prescribing in the UK. International Journal of Environmental Research and Public Health **17**:3460. doi:10.3390/ijerph17103460.

Robson C, McCartan K. 2016. Real World Research 4th Edition. John Wiley & Sons.

Rock P. 2005. Urban gulls. British Birds **98**:338–355.

Rogerson M, Barton J, Bragg R, Pretty J. 2017. The health and wellbeing impacts of volunteering with The Wildlife Trusts. Colchester. Available from https://t.co/cKHqgKXI72.

Rose D, Evans MC, Jarvis R. 2020. Effective engagement of conservation scientists with decision-makers. Pages 162–182 in WJ. Sunderland, PN. Brotherton, ZG. Davies, N. Ockendon, N. Pettorelli, JA. Vickery, editors. Conservation Research, Policy, and Practice. Cambridge University Press, Cambridge, UK, UK.

Sandifer PA, Sutton-Grier AE, Ward BP. 2015. Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation. Ecosystem Services **12**:1–15.

Satterthwaite D. 2016. A new urban agenda? Environment and Urbanization **28**:3–12.

Saunders CD, Brook AT, Eugene Myers O. 2006. Using psychology to save biodiversity and human well-being. Conservation Biology **20**:702–705.

Saw LE, Lim FKS, Carrasco LR. 2015. The relationship between natural park usage and happiness does not hold in a tropical city-state. PLoS ONE **10**:e0133781.

Schafer RM 1977. The tuning of the world. Knopf, New York.

Schlegel B, Steenbergen M. 2018. Package "brant": Test for parallel regression assumption. R package. Available from https://benjaminschlegel.ch/r/brant/.

Schuttler SG, Stevenson K, Kays R, Dunn RR. 2019. Children's attitudes towards animals are similar across suburban, exurban, and rural areas. PeerJ **7**:e7328.

Schwarz N, Moretti M, Bugalho MN, Davies ZG, Haase D, Hack J, Hof A, Melero Y, Pett TJ, Knapp S. 2017. Understanding biodiversity-ecosystem service relationships in urban areas: A comprehensive literature review. Ecosystem Services **27**:161–171.

Seddon N, Mace GM, Naeem S, Tobias JA, Pigot AL, Cavanagh R, Mouillot D, Vause J, Walpole M. 2016. Biodiversity in the anthropocene: Prospects and policy. Proceedings of the Royal Society B: Biological Sciences **283**:1–9.

Selinske MJ, Garrard GE, Bekessy SA, Gordon A, Kusmanoff AM, Fidler F. 2018. Revisiting the promise of conservation psychology. Conservation Biology **32**:1464–1468.

Seresinhe CI, Preis T, MacKerron G, Moat HS. 2019. Happiness is greater in more scenic locations. Scientific Reports **9**:4498. doi:10.1038/s41598-019-40854-6.

Seto KC, Guneralp B, Hutyra LR. 2012. Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. Proceedings of the National Academy of Sciences **109**:16083–16088.

Shanahan DF, Astell-Burt T, Barber EA, Brymer EA, Cox DTC, Dean J, Depledge M, Fuller RA, Hartig T, Irvine KN, Jones A, Kikillus H, Lovell R, Mitchell R, Niemelä J, Nieuwenhuijsen M, Pretty J, Townsend M, van Heezik Y, Warber S, Gaston K. 2019. Nature–based interventions for improving health and wellbeing: The purpose, the people and the outcomes. Sports **7**:141. doi:10.3390/sports7060141.

Shanahan DF, Bush R, Gaston KJ, Lin BB, Dean JH, Barber E, Fuller RA. 2016. Health benefits from nature experiences depend on dose. Scientific Reports **6**:28551. doi:10.1038/srep28551.

Shanahan DF, Cox DTC, Fuller RA, Hancock S, Lin BB, Anderson K, Bush R, Gaston KJ. 2017. Variation in experiences of nature across gradients of tree cover in compact and sprawling cities. Landscape and Urban Planning **157**:231–238.

Shanahan DF, Lin BB, Bush R, Gaston KJ, Dean JH, Barber E, Fuller RA. 2015. Toward improved public health outcomes from urban nature. Am J Public Health **105**:470–477.

Shen YS, Lung SCC. 2018. Identifying critical green structure characteristics for reducing the suicide rate. Urban Forestry and Urban Greening **34**:147–153..

Shwartz A, Turbé A, Julliard R, Simon L, Prévot AC. 2014a. Outstanding challenges for urban conservation research and action. Global Environmental Change **28**:39–49.

Shwartz A, Turbé A, Simon L, Julliard R. 2014b. Enhancing urban biodiversity and its influence on city-dwellers: An experiment. Biological Conservation **171**:82–90.

Silva CP, García CE, Estay SA, Barbosa O. 2015. Bird richness and abundance in response to urban form in a Latin American city: Valdivia, Chile as a case study. PLoS ONE **10**:e0138120.

Silvennoinen S, Taka M, Yli-pelkonen V, Koivusalo H, Ollikaine M, Setala H. 2017. Monetary value of urban green space as an ecosystem service provider: A case study of urban runoff management in Finland. Ecosystem Services **28**:17–27.

Simons EL, Meyers DM. 2001. Folklore and beliefs about the Aye aye (Daubentonia madagascariensis). Lemur News **6**:11–16.

Sisask M, Värnik A, Kõlves K, Konstabel K, Wasserman D, Varnik A, Kolves K, Konstabel K, Wasserman D. 2008. Subjective psychological well-being (WHO-5) in assessment of the severity of suicide attempt. Nordic Journal of Psychiatry **62**:431–435.

Soga M, Gaston KJ. 2016. Extinction of experience: The loss of human-nature interactions. Frontiers in Ecology and the Environment **14**:94–101.

Song X, Hansen MC, Stehman S V, Potapov P V, Tyukavina A, Vermote EF, Townshend JR. 2018. Global land change 1982-2016. Nature **560**:639–643.

Sonti NF, Campbell LK, Svendsen ES, Johnson ML, Novem Auyeung DS. 2020. Fear and fascination: Use and perceptions of New York City's forests, wetlands, and landscaped park areas. Urban Forestry and Urban Greening **49**:126601. doi:10.1016/j.ufug.2020.126601.

Southon GE, Jorgensen A, Dunnett N, Hoyle H, Evans KL. 2017. Biodiverse perennial meadows have aesthetic value and increase residents' perceptions of site quality in urban green-space. Landscape and Urban Planning **158**:105–118.

Spehar B, Clifford CWG, Newell BR, Taylor RP. 2003. Universal aesthetic of fractals. Computers and Graphics (Pergamon) **27**:813–820.

Stabroek News. 2020, February. Bee invasion forces closure of National Park. Stabroek News. Georgetown, Guyana. Available from https://www.stabroeknews.com/2020/02/02/news/guyana/bee-invasion-forces-closure-of-national-park/.

Steffen W, Broadgate W, Deutsch L, Gaffney O, Ludwig C. 2015. The trajectory of the anthropocene: The great acceleration. Anthropocene Review **2**:81–98.

Steptoe A, Deaton A, Stone AA. 2015. Subjective wellbeing, health, and ageing. The Lancet **385**:640–648.

Sterling EJ, Betley E, Sigouin A, Gomez A, Toomey A, Cullman G, Malone C, Pekor A, Arengo F, Blair M, Filardi C, Landrigan K, Porzecanski AL. 2017. Assessing the evidence for stakeholder engagement in biodiversity conservation. Biological Conservation **209**:159–171.

Stevens P. 2018. Fractal dimension links responses to a visual scene to its biodiversity. Ecopsychology **10**:89–96.

Stiglitz JE, Sen A, Fitoussi J-P. 2010. Report by the vommission on the measurement of economic performance and social progress. Commission on the Measurement of Economic Performance and Social Progress. Paris. Available from http://www.ssrn.com/abstract=1714428.

Sugiyama T, Villanueva K, Knuiman M, Francis J, Foster S, Wood LJ, Giles-Corti B. 2016. Can neighborhood green space mitigate health inequalities? A study of socio-economic status and mental health. Health and Place **38**:16–21.

Swaddle JP, Calos SE. 2008. Increased avian diversity is associated with lower incidence of human West Nile infection: Observation of the dilution effect. PLoS ONE **3**. doi:10.1371/journal.pone.0002488

Tabrizian P, Baran PK, Smith WR, Meentemeyer RK. 2018. Exploring perceived restoration potential of urban green enclosure through immersive virtual environments. Journal of Environmental Psychology **55**:99–109.

Taylor MS, Wheeler BW, White MP, Economou T, Osborne NJ. 2015. Research note: Urban street tree density and antidepressant prescription rates-A cross-sectional study in London, UK. Landscape and Urban Planning **136**:174–179.

TEEB. 2011. TEEB - The Economics of Ecosystems and Biodiversity. Page TEEB Manual for Cities: Ecosystem Services in Urban Management. Available from http://www.teebweb.org/.

Tew ER, Simmons BI, Sutherland WJ. 2019. Quantifying cultural ecosystem services: Disentangling the effects of management from landscape features. People and Nature **1**:70–86.

Theodorou P, Radzevi R, Lentendu G, Kahnt B, Husemann M, Bleidorn C, Settele J, Schweiger O, Grosse I, Wubet T, Murray TE, Paxton RJ. 2020. Urban areas as hotspots for bees and pollination but not a panacea for all insects. Nature Communications **11**:576. doi:10.1038/s41467-020-14496-6.

Thompson JA, Gaskin SJ, Agbor M. 2017. Embodied intersections: Gender, water and sanitation in Cameroon. Agenda **31**:140–155.

Tilman D, Clark M, Williams DR, Kimmel K, Polasky S, Packer C. 2017. Future threats to biodiversity and pathways to their prevention. Nature **546**:73–81.

Tingley D, Yamamoto T, Hirose K, Keele L, Imai K. 2014. Mediation: R package for causal mediation analysis. Journal of Statistical Software **59**:1–38.

Topp CW, Østergaard SD, Søndergaard S, Bech P. 2015. The WHO-5 well-being index: A systematic review of the literature. Psychotherapy and Psychosomatics **84**:167–176.

Tremblay C, Harris L. 2018. Critical video engagements: Empathy, subjectivity and changing narratives of water resources through participatory video. Geoforum **90**:174–182.

Truong MXA, Clayton S. 2020. Technologically transformed experiences of nature: A challenge for environmental conservation? Biological Conservation **244**:108532. doi:10.1016/j.biocon.2020.108532.

Trzyna T, Edmiston JT, Hyman G, Mcneely JA, da Cunha e Menezes P, Myrdal B, Phillips A. 2014. Urban Protected Areas: Profiles and best practice guidelines. Gland, Switzerland. Available from http://cmsdata.iucn.org/downloads/bpg_urban_protected_areas.pdf.

Tschirhart C, Mistry K, Berardi A, Bignante E, Simpson M, Haynes L, Benjamin R, Albert G, Xavier R, Robertson B, Davis O, Verwer C, de Ville G, Jafferally D. 2016. Learning from one another: Evaluating the impact of horizontal knowledge exchange for environmental management and governance. Ecology and Society **21**:41. doi:10.5751/ES-08495-210241.

Twohig-Bennett C, Jones A. 2015. The health benefits of the great outdoors: a systematic review of greenspace exposure and health outcomes. Environmental Research **166**:628–637.

Ulrich RS. 1983. Aesthetic and affective response to natural environment. Pages 85–125 in I. Altman and J. Wohlwill, editors. Human behavior and environment, Vol 6. Behavior and natural environment. Plenum, New York.

Ulrich RS, Simons RF, Losito BD, Fiorito E, Miles MA, Zelson M. 1991. Stress recovery during exposure to natural and urban environments. Journal of Environmental Psychology **11**:201–230.

UN-Habitat. 2016. Urbanization and development: emerging futures. Page UN Habitat World Cities Report 2016. Nairobi, Kenya. Available from http://wcr.unhabitat.org/main-report/.

UN Environment Programme. 2017. Framework of the Guyana Green State Development Strategy and financing mechanisms. Georgetown, Guyana. Available from https://doe.gov.gy/published/document/5af72c1734a1b326d4e01968.

UN Development Programme. 2019. Beyond income, beyond averages, beyond today: Inequalities in human development in the 21st century. Page Human Development Report 2019. United

Nations, New York, NY.

United Nations. 2016. United Nations Conference on housing and sustainable urban development (Habitat III). Page Item 10 of the provisional agenda. A/CONF.226/4. Quito, Ecuador.

United Nations. 2018. World urbanization prospects: The 2018 revision. Page Demographic Research. New York: United Nations. Available from https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf.

United Nations. 2019. World population prospects 2019. New York. Available from http://www.ncbi.nlm.nih.gov/pubmed/12283219.

Vailshery LS, Jaganmohan M, Nagendra H. 2013. Effect of street trees on microclimate and air pollution in a tropical city. Urban Forestry and Urban Greening **12**:408–415.

Van den Berg AE. 2017. From green space to green prescriptions: challenges and opportunities for research and practice. Frontiers in Psychology **8**:8–11.

van den Berg MM, Poppel M Van, Smith G, Triguero-mas M, Andrusaityte S, Kamp I Van, Mechelen W Van, Gidlow CJ, Nieuwenhuijsen MJ, Gra R. 2017. Does time spent on visits to green space mediate the associations between the level of residential greenness and mental health? Urban Forestry & Urban Greening. doi:10.1016/j.ufug.2017.04.010.

van den Bosch MA, Ode Sang Å. 2017. Urban natural environments as nature-based solutions for improved public health – A systematic review of reviews. Environmental Research **158**:373–384.

van den Bosch MA, Nieuwenhuijsen MJ. 2016. No time to lose – Green the cities now. Environment International. Elsevier Ltd. Available from http://linkinghub.elsevier.com/retrieve/pii/S0160412016308996.

Villanueva-Rivera LJ, Pijanowski BC. 2018. Soundecology: soundscape ecology. R package.

Völker S, Kistemann T. 2015. Developing the urban blue: Comparative health responses to blue and green urban open spaces in Germany. Health and Place **35**:196–205.

Wang X, Rodiek S, Wu C, Chen Y, Li Y. 2016. Stress recovery and restorative effects of viewing different urban park scenes in Shanghai, China. Urban Forestry and Urban Greening **15**:112–122.

Ward K, Lauf S, Kleinschmit B, Endlicher W. 2016. Heat waves and urban heat islands in Europe: A review of relevant drivers. Science of the Total Environment **569**–**570**:527–539.

Watson D, Clark LA, Tellegen A. 1988. Development and validation of brief measures of positive and negative affect: The PANAS scales. Journal of Personality and Social Psychology **54**:1063–1070.

Waylen KA, McGowan PJK, Pawi Study Group, Milner-Gulland EJ. 2009. Ecotourism positively affects awareness and attitudes but not conservation behaviours: A case study at Grande Riviere, Trinidad. Oryx **43**:343–351.

Weimann H, Rylander L, van den Bosch MA, Albin M, Skärbäck E, Grahn P, Björk J. 2017. Perception of safety is a prerequisite for the association between neighbourhood green qualities and physical activity: Results from a cross-sectional study in Sweden. Health and Place **45**:124–130. 1.

Weinstein N, Balmford A, Dehaan CR, Gladwell V, Bradbury RB, Amano T. 2015. Seeing community for the trees: the links among contact with natural environments, community cohesion, and crime. BioScience **65**:1141–1153.

Wheeler BW, Lovell R, Higgins, Sahran L, White MP, Alcock I, Osborne NJ, Husk K, Sabel CE, Depledge MH. 2015. Beyond greenspace: an ecological study of population general health and indicators of natural environment type and quality. International journal of health geographics **14**:17. doi:10.1186/s12942-015-0009-5.

Whelan CJ, Şekercioğlu ÇH, Wenny DG. 2015. Why birds matter: From economic ornithology to ecosystem services. Journal of Ornithology **156**:227–238.

White MP, Alcock I, Grellier J, Wheeler BW, Hartig T, Warber SL, Bone A, Depledge MH, Fleming LE. 2019. Spending at least 120 minutes a week in nature is associated with good health and wellbeing. Scientific Reports **9**:7730. doi:10.1038/s41598-019-44097-3.

White MP, Pahl S, Ashbullby KJ, Herbert S, Depledge MH. 2013. Feelings of restoration from recent nature visits. Journal of Environmental Psychology **35**:40–51.

White MP, Pahl S, Wheeler BW, Depledge MH, Fleming LE. 2017a. Natural environments and subjective wellbeing: Different types of exposure are associated with different aspects of wellbeing. Health and Place **45**:77–84.

White MP, Smith A, Humphryes K, Pahl S, Snelling D, Depledge M. 2010. Blue space: The importance of water for preference, affect, and restorativeness ratings of natural and built scenes. Journal of Environmental Psychology **30**:482–493.

White MP, Weeks A, Hooper T, Bleakley L, Cracknell D, Lovell R, Jefferson RL. 2017b. Marine wildlife as an important component of coastal visits: The role of perceived biodiversity and species behaviour. Marine Policy **78**:80–89.

Wilson E, Kenny A, Dickson-Swift V. 2018. Ethical challenges in community-based participatory research: a scoping review. Qualitative Health Research **28**:189–199.

Wolch JR, Byrne J, Newell JP. 2014. Urban green space, public health, and environmental justice: The challenge of making cities "just green enough." Landscape and Urban Planning **125**:234–244.

Wolf LJ, zu Ermgassen S, Balmford A, White MP, Weinstein N. 2017. Is variety the spice of life? An experimental investigation into the fffects of species richness on self-reported mental well-being. Plos One **12**:e0170225. doi:10.1371/journal.pone.0170225.

Wood E, Harsant A, Dallimer M, de Chavez AC, McEachan RRC, Hassall C. 2018. Not all green space is created equal: Biodiversity predicts psychological restorative benefits from urban green space. Frontiers in Psychology **9**:2320.

World Bank. 2020. World Development Indicators. Available from https://data.worldbank.org/country/guyana (accessed July 8, 2020).

World Health Organisation & Secretariat of the Convention on Biological Diversity. 2015. Connecting global priorities: biodiversity and human health: a state of knowledge review. Montreal, Canada. Available from https://www.cbd.int/health/SOK-biodiversity-en.pdf.

World Health Organization. 1998. Wellbeing measures in primary health care / The Depcare Project. Page Consensus Meeting. Stockholm.

World Health Organization. 2014. Preventing suicide: A global imperative. Geneva.

World Health Organization. 2016a. Global report on urban health: equitable, healthier cities for sustainable development. Geneva, Switzerland. Available from http://www.who.int/about/licensing/copy-right_form/index.html.

World Health Organization. 2016b. Urban green spaces and health: A review of evidence. Copenhagen.

Wright Wendel HE, Zarger RK, Mihelcic JR. 2012. Accessibility and usability: Green space preferences, perceptions, and barriers in a rapidly urbanizing city in Latin America. Landscape and Urban Planning **107**:272–282.

Wyles KJ, White MP, Hattam C, Pahl S, King H, Austen M. 2019. Are some natural environments more psychologically beneficial than others? The importance of type and quality on connectedness to nature and psychological restoration. Environment And Behavior **51**:111–143.

Young C, Hofmann M, Frey D, Moretti M, Bauer N. 2020. Psychological restoration in urban gardens related to garden type, biodiversity and garden-related stress. Landscape and Urban Planning **198**:103777. doi:10.1016/j.landurbplan.2020.103777.

Yu C-P, Lee H-Y, Luo X-Y. 2018. The effect of virtual reality forest and urban environments on physiological and psychological responses. Urban Forestry & Urban Greening. Elsevier GmbH. Available from https://linkinghub.elsevier.com/retrieve/pii/S1618866718301900.

Zeileis A, Kleiber C, Jackman S. 2008. Regression models for count data in R. Journal of Statistical Software **27**:1–25. Available from http://www.jstatsoft.org/v27/i08/.

Zelenski JM, Nisbet EK. 2014. Happiness and feeling connected: The distinct role of nature relatedness. Environment And Behavior **46**:3–23.

Zhang H, Chen B, Sun Z, Bao Z. 2013. Landscape perception and recreation needs in urban green space in Fuyang, Hangzhou, China. Urban Forestry and Urban Greening **12**:44–52. Elsevier GmbH. doi:10.1016/j.ufug.2012.11.001.

Zhang J, Yu Z, Zhao B, Sun R, Vejre H. 2020. Links between green space and public health: a bibliometric review of global research trends and future prospects from 1901 to 2019. Environmental Research Letters **15**:063001. doi:10.1088/1748-9326/ab7f64.

Zhao J, Tang T, Wang X. 2020. Effects of landscape composition on mosquito population in urban green spaces. Urban Forestry and Urban Greening **49**:126626. doi:10.1016/j.ufug.2020.126626.

Zuur AF, Ieno EN. 2016. A protocol for conducting and presenting results of regression-type analyses. Methods in Ecology and Evolution **7**:636–645.

Appendix: Co-authored publications

Peer-reviewed journal articles supplementary to the research manuscripts presented within the main thesis, to which I contributed throughout my PhD programme. Each publication is broadly relevant to the main themes presented within this thesis. Here I present the abstracts for reference in reverse chronological order, full text copies are available online.

Research article: Bird communities across varying landcover types in a Neotropical city

Biotropica: 2019

Volume: 00; DOI: 10.1111/btp.12729

William M. Hayes, **Jessica C. Fisher**, Meshach A. Pierre, Jack E. Bicknell, Zoe G. Davies

Abstract: Urbanization poses a serious threat to local biodiversity, yet towns and cities with abundant natural features may harbor important species populations and communi- ties. While the contribution of urban greenspaces to conservation has been dem- onstrated by numerous studies within temperate regions, few consider the bird communities associated with different landcovers in Neotropical cities. To begin to fill this knowledge gap, we examined how the avifauna of a wetland city in northern Amazonia varied across six urban landcover types (coastal bluespace; urban blues- pace; managed greenspace; unmanaged greenspace; dense urban; and sparse urban). We measured detections, species richness, and a series of ground cover variables that characterized the heterogeneity of each landcover, at 114 locations across the city. We recorded >10% (98) of Guyana's bird species in Georgetown, including taxa of conservation interest. Avian detections, richness, and community composition dif- fered with landcover type. Indicator species analysis identified 29 species from across dietary guilds, which could be driving community composition. Comparing landcov- ers, species richness was highest in managed greenspaces and lowest in dense urban areas. The canal network had comparable levels of species richness to greenspaces. The waterways are likely to play a key role in enhancing habitat connectivity as they traverse densely urbanized areas. Both species and landcover information should be integrated into urban land-use planning in the rapidly urbanizing Neotropics to maxi- mize the conservation value of cities. This is imperative in the tropics, where anthro- pogenic pressures on species are growing significantly, and action needs to be taken to prevent biodiversity collapse

Book chapter: Biodiversity and Health - Implications for Conservation

Springer Publishing: 2018

Pages: 283-294; DOI: 10.1007/978-3-030-02318-8

Editors: Melissa R. Marselle, Jutta Stadler, Horst Korn, Katherine N. Irvina, Aletta Bonn

Zoe G. Davies, Martin Dallimer, **Jessica C. Fisher**, Richard Fuller

Abstract: The human health and well-being benefits of contact with nature are becoming increasingly recognised and well understood, yet the implications of nature experiences for biodiversity conservation are far less clear. Theoretically, there are two plausible pathways that could lead to positive conservation outcomes. The first is a direct win-win scenario where biodiverse areas of high conservation value are also disproportionately beneficial to human health and well-being, meaning that the two sets of objectives can be simultaneously and directly achieved, as long as such green spaces are safeguarded appropriately. The second is that experiencing nature can stimulate people's interest in biodiversity, concern for its fate, and willingness to take action to protect it, therefore generating conservation gains indirectly. To date, the two pathways have rarely been distinguished and scarcely studied. Here we consider how they may potentially operate in practice, while acknowledging that the mechanisms by which biodiversity might underpin human health and well-being benefits are still being determined.