Spatial scale influences values and perceptions of green open space.

Abstract

It is important for landscape planners and managers to understand how urban residents value and interact with green open spaces. However, the effect of spatial scale on values and perceptions of green open spaces has to date received little attention. This study explored the influence of spatial scale using Public Participation GIS (PPGIS) methods in the Lower Hunter region of Australia. By asking respondents to assign markers denoting various values and preferences to green spaces displayed on maps of their suburb and municipality, the influence of scale could be assessed experimentally. A greater abundance and diversity of value markers were consistently assigned at the suburb scale, yet this pattern was more pronounced for some values (e.g. physical activity) than others (e.g. nature, cultural significance). The strength of this relationship was related to socio-demographic variables such as education and income. These results have implications for understanding human-environment relationships and the use of PPGIS techniques to inform environmental planning.

Key Words

Green open space; landscape values; human-nature relationships; Public Participation GIS; Spatial Scale

1. Introduction

There is increasing recognition of the importance of incorporating landscapes values into environmental planning and management. One dominant body of literature has framed this challenge in terms of maximising the use and non-use goods and services humans derive from ecosystems (de Groot *et al.* 2010, Díaz *et al.* 2015). Yet other literature has recognised more nuanced understandings of human-environment relationships (Muhar *et al.* 2017). The concept of assigned values (Brown 1984), while proposed more than 20 years ago, is useful in furthering research on human-environment interactions, since it recognises that people value environments for different reasons, many of which may not be commensurable or exchangeable (Bryan *et al.* 2010, Ives and Kendal 2014). This differs from mainstream economic theory, which has underpinned the ecosystem services concept (Flint *et al.* 2013). More recently, scholars have begun to recognise that people interact with, value and benefit from ecosystems via complex multi-directional relationships (Chan *et al.* 2016). One example of this is the embodied ecosystem perspective (Raymond et al. 2017) that brings together the various relations among mind, body, culture and environment. Reasons for incorporating values, perceptions and preferences into environmental planning and management can be both pragmatic (i.e. resulting in improved environmental outcomes) and normative (it is intrinsically important that people's values are accommodated in decision-making) (Reed 2008, Ives and Kendal 2014). Research on landscape values is increasingly designed to inform environmental planning and management (see Kahila-Tani *et al.* 2016). However, to date, evidence for tangible improvement in environmental outcomes remains scant because of difficulties in identifying cause and effect, and the historical disconnect between academia and formal land use planning processes (Brown 2012).

With rapid urbanisation characterising the 21st Century, it is vital that green spaces are planned and managed well to promote ecological sustainability and human health and wellbeing (Ives and Kelly

2016; Sandifer et al. 2015; Swanwick et al. 2003). Urban and suburban green spaces allow for a variety of complex interactions between people and nature (Konijnendijk *et al.* 2013, Andersson *et al.* 2014, Hunter and Luck 2015). In seeking to understand these interactions, some recent studies have focussed on accessibility of green spaces at difference scales (e.g. Van Herzele and Wiedemann 2003, Gupta *et al.* 2016). Research has highlighted that open spaces of different 'functional levels' (e.g. neighbourhood parks, district parks, urban forests) have different qualities and serve different purposes (Van Herzele and Wiedemann 2003). The health and wellbeing benefits of urban green space are well recognised in the literature (Lee and Maheswaran 2011, Konijnendijk *et al.* 2013), but there is also increasing awareness of the importance of interaction with urban nature in shaping positive attitudes and psychological orientations towards nature (Soga *et al.* 2016). For example, the recent concept of 'nature routines' has been used to highlight how regular interaction with natural areas can shape children's development of an affinity for nature (Giusti et al. 2015). In this study, we focus primarily on cognitive dimensions of relationships with urban green spaces: values, preferences and perceptions. However, we recognise that these do not exist in a disembodied state but emerge from a variety of direct and indirect interactions with urban nature (see Raymond et al. 2017).

Accounting for the diverse values, preferences and perceptions that urban residents associate with their green spaces is vital for the planning and management of urban landscapes. Public participation GIS researchers have developed techniques for understanding the diversity of landscape values (e.g., aesthetic, recreation, intrinsic) and activity preferences (e.g., jogging, social interaction, walking) for green open space, and how they vary across user characteristics (Brown et al. 2014), urban form/physical setting characteristics (Wang et al. 2015; Kytta et al. 2016), or a combination of these attributes (Raymond *et al.* 2016). The diversity of residents' preferred activities (e.g., fast walking, jogging, cycling) can vary according to a park's type (e.g., sport park, natural park, school park) and area (Brown et al. 2014; Ives et al. 2017), as well as locational features such as proximity to the park and a sufficient number of parks in the neighbourhood (Wang et al. 2015; Ives et al. 2017). Different types of landscape values and activity preferences can be associated with different user groups and geographic settings (Raymond *et al.* 2016). Even dense urban areas with few green open spaces can be valued for a range of experiential qualities (Kyttä *et al.* 2016). Sometimes these values and preferences are incompatible, leading to the potential for values conflict between different user groups (Brown and Raymond 2014).

Collectively, these empirical works on the non-monetary valuation of green open spaces point to the need to manage for a diversity of value types across a diversity of user groups and physical qualities of place. However, in some instances it may be important to not only manage for values diversity, but also value intensity and rarity (Bryan *et al.* 2010) as a function of distance from one's place of residence. In the economics literature, the travel cost method is regularly used to understand how much individuals are willing to pay to visit areas as a function of distance from their homes. Most studies employ the theoretical framework proposed by Becker (1965) by using a combination of revealed and stated preference data to estimate a value of time which is uniform in all activities and under all circumstances (e.g. Bateman *et al.* 2002), although more recent studies are using socio-demographic data like the wages of travellers to identify the opportunity value of travel time (Fezzi, et al. 2014; Ovaskainen et al. 2012). In contrast, the random utility model does not consider spatial proximity, but assesses the value of a site by calculating the probability of visitation according to how frequently or sequentially sites are visited (Morey et al. 1991) or where sites may be aggregated (Parsons and Needelman 1992).

In the geography literature, Norton and Hannon (1997b) proposed a place-based theory of environmental valuation which suggests that the intensity of environmental valuation is highest in the here and now and is discounted from the home perspective across time and space. Brown et al. (2002) tested this theory across 15 communities in Alaska by inviting a random sample of local residents to identify and map 12 place-based (otherwise termed landscape or social values) on a map of Kenai Peninsula using public participation GIS. General support was found for this place-based theory of valuation: individuals assigned more value dots to places closer to their community place of residence than places further away. When examining specific value types, direct use values (e.g., aesthetic, recreation) were overall found closest to one's community of residence, whereas indirect use values (e.g., intrinsic) were found further away. More recently, Brown et al. (2015) offered a home range theory of values wherein values reflect different currencies or levels of importance to an individual and are dynamic with respect to time and location.

However, more targeted research is needed on how spatial scale influences the distribution and types of values and preferences, particularly in the context of PPGIS studies (Brown and Kyttä 2014). In their review, Matsuoka and Kaplan (2008) call for further examination of scale in relation to the benefits people receive from green space. While the importance of scale in the provision and physical accessibility of green open space has begun to receive attention (e.g. Gupta *et al.* 2016), the effect of scale on public perceptions and values is less clear. PPGIS studies that utilise paper-based maps normally have a single, fixed scale. While digital PPGIS often enables users to zoom between scales when assigning markers, we are aware of only one study that has explicitly explored the effect of spatial scale on the importance of green spaces to urban residents. Bijker and Sijtsma (2017) identified this gap in the literature and examined using an online PPGIS survey how urban residents in the Netherlands, Germany, and Denmark appreciated and used green space at the neighbourhood, region, national and world level. They found that urban residents have a 'portfolio of places' across different scales, with local green spaces rated as slightly less attractive but visited frequently and green spaces at wider spatial scales rated as more attractive but visited less frequently. The present study contributes further empirical evidence to this question, using a different method (paper maps), and in a different study context.

Knowing how residents are likely to value and interact with green spaces within a neighbourhood and across neighbourhood and municipal regions can inform how green space networks are designed and managed. Some types of attributes of green spaces (e.g., spaces for children's nature-based play) may need to be managed at the neighbourhood scale, or municipality scale (e.g., swimming facilities), whereas other features (e.g., long-distance walking trails) may need to be managed at both scales. Understanding the values that people place on such attributes can therefore inform the distribution of management resources across different scales. Such efforts may also shed light on to how drivers of environmental change operate at and across different scales; for example, how changes in landscape might affect ecosystem service provision and their beneficiaries across different scales (Durance *et al.* 2016). There is a general view that larger scales of management provide opportunities for 'joined up thinking' between upstream land managers and downstream beneficiaries (Poppy *et al.* 2014), but we propose that green open space management efforts may need to be varied according to differences in the perceived qualities of places identified at different geographic scales. In this way, green open space management is likely to be nested in a multi-scale spatial hierarchy.

In this study, our primary research question is how spatial scale affects the intensity, type and diversity of values, preferences and negative perceptions of green open spaces. Secondary to this is the question of whether the influence of spatial scale differs according to socio-demographic factors. We employ a novel study design using Public Participation GIS methods to answer these questions. This article builds upon the findings of Ives et al. (2017), which focussed on how environmental characteristics and landscape structure influenced the values and preferences local residents had for neighbourhood open spaces. The present study utilises the same dataset but emphasises differences in data collected at two different spatial scales. We consider these findings in the context of theories of landscape values and human-environment interactions as a way of improving environmental planning and management practice.

2. Methods

2.1 Survey design and administration

Four suburbs were selected for analysis, nested within two Local Government Areas (LGAs) in the Lower Hunter Valley, in southeastern Australia. One thousand residents were mailed survey packets after expressing their willingness to participate during an initial screening process of telephone calls to phone numbers within an existing database. Age bias was minimised by asking respondents to indicate their age and ensuring that >20 % of respondents were aged 18-35 and >20% 35-55. The two suburbs within the Lake Macquarie LGA were Charlestown and Toronto, and those within the Port Stephens LGA were Nelson Bay and Raymond Terrace (Fig. 1). These were selected because they are experiencing significant urban development and have a range of different green open spaces. Four hundred and eighteen responses were returned from a potential 972 after accounting for packets that were returned to sender, resulting in a response rate of 43%.

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The survey instrument contained a paper map of the resident's suburb (scale = 1:13,500) and the broader LGA area (scale = 1:116,000). Respondents were able to assign markers to either map, thereby enabling any preference for one scale over another to be observed for each participant. The region of the LGA scale map that was covered by the finer scale suburb map was coloured to force respondents to assign marker dots to the fine scale map (see Figure 2). The maps displayed official municipal green spaces, significant roads and walkways and extant tree cover. In addition to the paper map, the survey packet included a separate 'interactive' map legend, comprised of descriptions of park values preferred activities and negative perceptions that corresponded to numbered marker dots for participants to stick to the map (red, 6 mm diameter, six per marker attribute). Participants were instructed to stick the marker dots denoting specific values, important activities or negative perceptions to any location on either of the maps where they felt it appropriate. Participants could assign as many or as few marker dots as they wished (up to the maximum of six per attribute type), and were not restricted to placing dots in formally identified open spaces. The survey booklet also included questions on socio-demographics such as gender, age, education, occupation, income and housing status of respondents, and space for participants to respond openly about their satisfaction with open space in their area.

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We distinguish between values, activity preferences and negative perceptions of green spaces. We consider these to be distinct but related constructs existing in the cognitive realm. The landscape values we investigated are ‘assigned values’, which “emerge from the interaction between a subject and an object” (Brown 1984) and are commonly the focus of PPGIS studies (Brown 2004). Participants were asked to assign markers to the map that, “show the places you value for the following reasons”:

- Aesthetic / Scenic (e.g. places that are visually attractive)
- Activity / Physical Exercise (e.g. places you value because they provide opportunities for physical activity)
- Native Plants and Animals (e.g. places you value for the protection of native plants and animals)
- Nature (e.g. places to experience the natural world)
- Cultural Significance (e.g. opportunities to express and appreciate culture or cultural practices such as art, music, history or indigenous traditions)
- Health/Therapeutic (e.g. places you value for mental or physical restoration)

- Social Interaction (e.g. opportunities for you to interact with other people)

Activity preference items were designed to reveal places that were important for different embodied interactions with urban parks (as opposed to values which did not necessitate direct engagement). Participants were asked to assign markers to the map that, "show the green open spaces that are important to you for the following activities":

- Casual recreation (e.g. relaxed walking, kite flying, throwing Frisbee, walking the dog etc.)
- Exercise for fitness (e.g. jogging, cycling, brisk walking, formal exercise activities or group sports.)
- Social activities (e.g. picnics, barbecues etc.)
- Children's play (e.g. areas for children to explore, have fun etc.)
- Nature appreciation (e.g. activities such as bird watching, bush walking, photography etc.)

Items about the negative perceptions of green open spaces revealed places that participants associated with various unfavourable qualities. Participants were asked to assign markers to the map that, "show the green open spaces you feel have the following negative qualities":

- Unappealing (e.g. neglected, damaged, unaesthetic, ugly)
- Scary/Unsafe (e.g. dangerous or threatening)
- Noisy (i.e. disturbingly loud or noisy)
- Unpleasant (unpleasant or exposed to the elements, i.e. too hot, too windy, no shade or shelter etc.)

These items were adapted from existing typologies of landscape values used in previous PPGIS studies (Tyrväinen et al. 2007; Brown et al. 2002). These typologies were further refined following interviews with key stakeholders such as government, industry and Non-Governmental

Organisation representatives from the Hunter Valley area, meetings with local government staff, and focus groups with community members from both municipalities.

A series of incentives and reminders were employed to enhance response rates, based on the principles of the tailored design method (Dillman 2007). This included a gift of six packaged postal stamps, an opportunity to win a $100 AUD shopping voucher. Two reminder postcards were also mailed to survey recipients at two-week intervals and an additional complete survey packet was sent to non respondents after this time. The survey design and administration procedure was reviewed and approved by [*identity hidden for peer review*] University's ethics board (project 06/13).

2.2 Data analysis

Returned maps were scanned and the marker dots were digitised. Counts of respondent's value markers on both maps were collated and were analysed statistically using R (R Core Team 2015). A Chi-Square test was used to assess an overall difference in marker dot abundance between the suburb and LGA scale maps, with data aggregated for all respondents. The number of respondents assigning attribute markers to the maps was calculated to ascertain whether a propensity to map at a particular scale was observable. In addition, the mean number of markers assigned per respondent was also calculated. Differences in marker abundance between specific value types were assessed using Wilcoxon signed-rank tests, which allowed data from every respondent to be included, thus increasing statistical power.

The diversity of marker dots at both scales for each individual was calculated using the 'diversity' function in the 'vegan' package in R. Specifically, the Shannon diversity metric was used because it accounts for both the number of unique attributes (in this case value types) and their relative abundances (or evenness). Differences in value diversity between the two map scales was also analysed via a Wilcoxon signed-rank test.

Finally, to analyse the effect of socio-demographics on the difference between value marker abundance at the two spatial scales, Spearman rank correlation and Mann-Whitney U tests were conducted in R, depending on the independent variable of interest. The proportional difference for attribute k was calculated as $\frac{\sum_i Sub_{ik} - \sum_j LGA_{jk}}{\sum_j LGA_{jk}}$, where $\sum_i Sub_{ik}$ represents the number of dots for attribute k at the suburb scale and $\sum_j LGA_{jk}$ represents the number of dots for attribute k at the LGA scale. Tests were also performed with the difference between Shannon diversity scores as the dependent variable. The socio-demographic variables that were analysed were age, gender, income, education level, and the number of years respondents had lived in the Local Government Area.

3. Results

Respondents mapped a total of 9290 marker dots at the suburb scale and 4027 markers at the LGA scale. The average number of markers assigned per respondent was 31.86 markers across both maps. Yet more markers were assigned at the suburb scale (Table 1), with an average of 22.22 placed on the suburb map and 9.64 on the LGA map. The effect of map scale on marker abundance was found to be statistically significant when all value markers were considered together (χ^2 = 403.78, d.f. = 15, $P < 0.0001$). There were also more respondents who failed to assign any markers to the LGA scale map than the suburb scale (Table 1). These results suggest that people have a greater propensity to map at the local scale in addition to assigning more markers overall. The trend of greater numbers of marker dots at the suburb scale than the LGA scale was consistent across all 4 suburbs (Charlestown: χ^2 = 242.77, d.f. = 15, $P < 0.0001$; Toronto: χ^2 = 111.77, d.f. = 15, $P < 0.0001$; Nelson Bay: χ^2 = 164.03, d.f. = 15, $P < 0.0001$; Raymond Terrace: χ^2 = 257.82, d.f. = 15, $P < 0.0001$).

For every value type, more marker dots were assigned by respondents at the suburb scale than the LGA scale (Table 1). This is demonstrated visually in Figures 3 and 4. Wilcoxon tests of differences in marker abundance between individual value types were all found to be significant, although the effect size was greater for some values (e.g. Activity/Physical Exercise) than others (e.g. Cultural Significance) (see Table 1 for statistics). For each attribute, the total number of respondents who assigned markers at the suburb scale was greater than those who assigned markers at the LGA scale (Table 1). The Shannon diversity of value types was found to be greater at the suburb scale than the LGA scale (Wilcoxon signed-rank test: V = 8373, P <0.0001).

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Correlation and Mann-Whitney U tests of the influence of socio-demographic variables on the difference in (i) the abundance of all value marker types and (ii) the Shannon diversity of value markers between suburb and LGA scale maps revealed some significant results. Details of these significant results are shown in Table 2. Some key results include females assigning more markers the local suburb scale over the LGA scale for health/therapeutic values (mean deviation marker abundance for males: LGA = 0.52, suburb = 1.06; mean abundance for females LGA = 0.50, suburb = 1.53) and scary/unsafe perceptions (mean marker abundance for males: LGA = 0.20, suburb = 0.46; mean abundance for females LGA = 0.05, suburb = 0.52), more highly educated residents favouring the regional/LGA scale than less educated residents, and those who have spent longer in the region more likely to assign markers for social activities and exercise for fitness at the regional scale.

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Qualitative responses also highlighted the importance of the local scale. Three key themes emerged from participants' responses: concern over future development impinging upon local green space, accessibility constraints, and a desire for facilities and management of local green spaces to be improved. Thirty-six participants directly mentioned concerns about the loss of open spaces and ecological habitat due to development. For example: "retaining bushland is extremely valuable for future generations and for children to enjoy the range of experiences for free play, exploration and appreciation". Many of the concerns about the proximity of local green space and residents' ability to access it were in the context of parents with young children. Finally, comments about facilities included issues such as installation and maintenance of toilets, structures, trees for shade and drinking fountain facilities – all matters that are particularly pertinent at the local scale.

4. Discussion

This study has shown that the diversity and abundance of values and activity preferences for green open space is greater at the suburb (local) scale than at the LGA (regional) scale. This is one of the first studies to demonstrate the significant effect of scale using PPGIS techniques, and highlights the importance of considering scale in the design of PPGIS studies. The importance of the local scale is particularly so for values and activities that were most closely related to exercise, health, and social interaction. These functions of open spaces are intrinsically of highest importance within people's home range. Additionally, relatively large differences were also observed for negative perceptions of open spaces, specifically their perception as being scary or unsafe, unpleasant, or noisy. However, there was a difference between the proportional difference between scales and the overall abundance of marker dots. Generally, those values and important activities related to active use of green spaces received very high abundances of markers, despite their dominance at the local scale. This differs from negative perceptions, which, although vastly more significant at the local scale, received relatively few markers overall.

Socio-demographic factors were shown to exert some influence on the degree to which respondents favoured one spatial scale over another. Many of these relationships are intuitive. For example, the preference older people displayed for health/therapeutic values in their local region could reflect their relative lack of mobility and increasing health concerns with age. It is also widely recognised that safety concerns related to green spaces are more salient for females than males (e.g. Jorgensen et al. 2007), and it makes sense that these concerns are most relevant in the vicinity one may encounter regularly. In contrast, people of higher education and income levels and those who had lived longer in the region were more likely to associate certain attributes at the regional (LGA) scale than the local scale (Table 2), although the local scale remained more important overall. This suggests that people are more likely to value green spaces beyond their local area when they are more familiar with the region and have the capacity to experience them. These results align closely with those from a recent PPGIS study in Helsinki, which found that more educated, wealthier and older residents tended to value areas outside of the city more so than younger, less educated residents (Raymond *et al.* 2016). Interestingly, females were found to value green open spaces for health and casual recreation at the local scale more than males, which is contrary to the results identified by Brown et al. (2015).

Compared to Bijker and Sijtsma (2017), this study identified a much stronger effect of spatial scale on the assignment of values for natural areas. However, we consider the two studies to be complementary, since our research focussed on urban and suburban areas and measured importance by the abundance of markers and did not allow respondents to assign a value to each marker. The greater abundance of value and activity marker dots at the local scale in this study provides further supporting evidence for both the home range theory of values (Brown et al. 2015) and the theory of geographic discounting (Norton and Hannon 1997) by identifying the types of values which are most salient at different geographic scales. The local scale was more important for use or interactive values and activities associated with green open spaces (such as health or recreation values), and less important for intangible values such as aesthetics or cultural value. Negative perceptions are also are important locally, given they impinge upon the value or utility of a space much more than if this was a place far away. Sotoudehnia & Comber (2011) found that cleanliness and safety were two of the top three factors influencing green space use in Leicester, UK; qualities that are particularly pertinent locally. Previous studies suggest that respondents with higher levels of formal education map values (e.g. aesthetic) at different intensities to respondents with lower levels of formal education (Brown and Reed 2009), and that those with higher levels of education and income assign values further away from their place of residence (Raymond *et al.* 2016). However, this study adds to the PPGIS literature by showing that people's value 'home range' is likely to differ according to the type of values in question, the geographic scale at which those values are assigned, and the socio-demographic characteristics of the respondent.

This study provides interesting insights into how people relate to nature. Understanding the complexity of human values for nature is vital for effective environmental management outcomes (Ives and Kendal 2014, Muhar *et al.* 2017). First, the variety of values and activities assigned by residents to green open spaces highlights the need to manage for a range of values and user groups (Raymond et al. 2016; Brown et al. 2014). It appears that urban green spaces are important to residents for a variety of instrumental and non-instrumental values, as has been shown elsewhere (Tyrväinen et al. 2007). We concur with Bijker and Sijtsma (2017) who suggested that people require a 'portfolio of places' across different scales that are characterised by different but complementary qualities and functions. Second, the influence of spatial scale emphasises that these values are highly reliant on familiarity and access, and is not only related to one's place identity or place dependence (Brown and Raymond 2007). The recent concept of 'nature routines' (Giusti et al. 2015) may also provide guidance in understanding these patterns. According to Giusti et al. (2015), the everyday activities individuals undertake in natural areas help to shape one's values and support connections to nature. It is plausible that the emphasis of positive values at the local scale is a function of these common activities like walking the dog or meeting friends for coffee in the park. Third, the disproportional importance of values at the local scale was seen even for negative perceptions. Although perceived negative qualities received fewer marker dots overall, it highlights that people's interactions with urban green areas are complex and there exists some degree of value ambivalence in the community (c.f. Jorgensen and Tylecote 2007; Manzo 2005). Finally, exploring the assignment of nature and biodiversity values for green spaces provides some insight into the relationship between biodiversity conservation and more traditional functions of urban parks. In line with other values, nature and biodiversity values were also more strongly represented at the local scale compared to the regional scale. This is an interesting result because in the study region, species' populations of greatest conservation concern were present at the regional scale much more than the local scale (Whitehead et al. 2014; Lechner et al. 2015). One possible conclusion from this is that people's direct experience of nature might be important for promoting conservation concern and action, irrespective of the scientifically-verified levels of biodiversity present (c.f. Dallimer *et al.* 2012).

This study showed clearly that the abundance and composition of marker dots differed according to map spatial scale, yet discerning exactly which mechanisms contributed to this result is difficult because of the study design. The methodological approach of this study (paper-based PPGIS mapping) and its location (Hunter Valley, Australia) means it is not possible to fully disentangle the effect of spatial scale on *mapped* landscape values and activity preferences from the ways people

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actually value and interact with urban parks. Indeed, these results could feasibly be the result of (i) greater priority given to the values depicted in the survey at local scales, (ii) specific green spaces available at the regional (LGA) scale failing to have the characteristics that support such values, or (iii) specific green spaces at local scales being more accessible than those at regional scales. A further limitation of this study is that it is not possible to extrapolate these findings to all urban regions. To overcome these limitations, we call for future research to disentangle these factors by enquiring into them directly, for example by asking about perceived qualities of green spaces and their accessibility. Additional studies using these methods in different regions (particularly in different cultural contexts) would also help to understand the generalisability of our results.

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This research has a number of implications for urban landscape management, planning and assessment. In addition to the need for urban planners and green space managers to provide a variety of places for residents' requirements and preferences, they must also consider the spatial scale at which different green space functions are most important. Green spaces should be available and accessible in the local vicinity to where people live. This is particularly vital for health/therapeutic, exercise and social interaction values. Thus, we recommend that planners provide facilities that enable these values to be activated near to where people live. However, it is also important for regional green spaces (which are often larger) to be protected and managed carefully. Values and activities related to nature appreciation were not as strongly emphasised at the local scale and nature experiences in extensive, in-tact ecological reserves are likely to differ from and complement those at the local scale. Further, the fact that wealthier and higher educated people tend to have stronger aesthetic values at the regional scale also implies some degree of constraint for other socio-economic groups. We therefore suggest from an environmental justice perspective that local authorities may like to consider ways in which local residents can more easily access the more spectacular or beautiful landscapes that exist outside the local region (c.f. Raymond *et al.* 2016). Initiatives like community shuttle buses could be useful here. Negative perceptions towards green spaces should also continue to be managed carefully, particularly at the local scale, to avoid compromising the more positive benefits green open spaces offer to urban residents.

Finally, for researchers using PPGIS techniques to spatially map landscape values, our results highlight that the spatial scale at which a landscape is represented on a map is likely to influence the results obtained. While the importance of spatial scale for the precision of mapped values has already been identified (Brown and Kyttä 2014), this study shows clearly that it is also likely to influence the *composition* of values mapped by respondents. From these results we draw some practical recommendations for researchers and practitioners utilising PPGIS methods. First, we encourage researchers to undertake community consultation exercises (such as focus groups or public meetings) with people from a broad range of locations. Enquiring specifically into the places that people value at different distances from their place of residence or work will help to reveal the most appropriate scale at which to conduct a PPGIS study for the given topical focus. Second, researchers should consider using methods that allow for varying map scales, such as online mapping applications with 'zoom' functions, but ensure that the scale at which a feature is mapped is recorded. Finally, the scale at which data are collected should relate to the scale of data application. For example, results from a PPGIS study at a regional scale can reasonably inform regional planning (e.g. siting of new nature reserves), but should not be extrapolated to local land use decision-making (e.g. identifying culturally-significant trees).

Moved up [1]: . We note that the methodological approach of this study (paper-based PPGIS mapping) and its location (Hunter Valley, Australia) means it is not possible to fully disentangle the effect of spatial scale on *mapped* landscape values from the ways people actually value and interact with urban parks, nor is it possible to extrapolate these findings to all urban regions.

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5. Conclusion

This study has shown that spatial scale is an important factor that influences the type and quality of relationships people have with their surrounding landscapes. Specifically, the local suburb scale is consistently more important than the regional scale for a broad range of positive values, important activities and perceived negative qualities of urban green spaces. This shows not only that people relate to nature in complex ways, but that these relationships are influenced by the interactions and experiences that occur in people's daily lives. As interactions with nature are increasingly considered to be a crucial part of the sustainable cities of the future (Hartig and Kahn 2016), there is a clear need for a greater understanding of how spatial scale influences people's experiences of and values for urban green areas. We encourage future research on the importance of scale using complementary research techniques (e.g. qualitative research and observational studies), further differentiation of the kinds of green space characteristics that contribute to scalar differences in assigned landscape values, broadening research into different social, cultural and environmental settings, and an exploration of the relationships between different kinds of relationships with these green spaces (e.g. direct interactions, cognitions, emotions). Such knowledge would provide a valuable evidence-base for the planning and management of sustainable cities of the future.

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Tables

Table 1. Wilcoxon rank test statistics for comparisons of marker dot abundance between the LGA and suburb scale maps, ranked according to the proportional difference between the two maps.

Attribute name	**Type**	**Number of respondents assigning markers**		**Mean number of markers per respondent**		**Total assigned markers**			**V**	***P***
		Suburb	**LGA**	**Suburb**	**LGA**	**Suburb**	**LGA**	**Total**		
Unappealing	Negative perception	164 (40.4%)	45 (11.1%)	0.94	0.19	381 (83.0%)	78 (17.0%)	459	1893	<0.001
Exercise for fitness	Activity	314 (77.3%)	134 (33.0%)	2.05	0.51	832 (80.0%)	208 (20%)	1040	4106	<0.001
Scary/unsafe	Negative perception	104 (25.6%)	35 (8.6%)	0.47	0.13	192 (78.7%)	52 (21.3%)	244	781	<0.001
Casual recreation	Activity	323 (80.0%)	167 (41.1%)	2.15	0.64	873 (77.2%)	258 (22.8%)	1131	4146	<0.001
Unpleasant	Negative perception	68 (16.7%)	22 (5.4%)	0.31	0.09	125 (76.7%)	38 (23.3%)	163	600	<0.001
Activity/physical exercise value	Value	339 (83.5%)	193 (47.5%)	2.78	0.89	1130 (75.8%)	360 (24.2%)	1490	6373	<0.001
Noisy	Negative perception	78 (19.2%)	29 (6.9%)	0.32	0.10	130 (75.6%)	42 (24.4%)	172	567	<0.001
Social interaction value	Value	280 (69.0%)	155 (38.2%)	1.82	0.61	738 (74.8%)	248 (25.2%)	986	5840	<0.001
Children's play	Activity	275 (67.7%)	151 (37.2%)	1.70	0.60	689 (73.8%)	245 (26.2%)	934	4543	<0.001
Health/therapeutic value	Value	228 (56.2%)	138 (34.0%)	1.32	0.51	534 (72.2%)	206 (27.8%)	740	5034	<0.001
Social activities	Activity	262 (64.5%)	178 (43.8%)	1.44	0.78	585 (64.9%)	317 (35.1%)	902	12928	<0.001
Native plants and animals	Value	281 (69.2%)	202 (49.8%)	1.78	0.99	721 (64.3%)	400 (35.7%)	1121	11930	<0.001
Aesthetic value	Value	337 (83.0%)	243 (59.9%)	2.52	1.48	1022 (62.9%)	602 (37.1%)	1624	16030	<0.001
Nature appreciation	Activity	240 (59.1%)	171 (42.1%)	1.26	0.82	511 (60.7%)	331 (39.3%)	842	10026	<0.001
Nature value	Value	248 (61.1%)	201 (49.5)	1.36	1.04	554 (56.8%)	422 (43.2%)	976	14819	0.005
Cultural significance value	Value	155 (38.2%)	133 (32.8%)	0.67	0.54	273 (55.4%)	220 (44.6%)	493	7072	0.04
Total markers		**397 (95.0%)**	**325 (77.8%)**	**22.22**	**9.64**	**9290 (69.8%)**	**4027 (30.2%)**	**13317**		

Table 2. Socio-demographic variables that were found to have a statistically significant influence on the difference between value marker abundances between suburb and LGA scale maps.

Socio-demographic variable	**Mapped response variable**	**Statistical test**	**Test statistic**	**P value**	**Interpretation**
Age	Health/Therapeutic value	Spearman rank correlation	Rho = 0.140	0.006	Older people place more health/therapeutic markers at suburb scale
Gender	Health/Therapeutic value	Mann-Whitney U test	U = 20605	0.038	Females place more health/therapeutic markers at suburb scale.
Gender	Scary/Unsafe	Mann-Whitney U test	U = 20818	0.005	Females place more casual recreation markers at suburb scale
Education	Aesthetic value	Spearman rank correlation	Rho = -0.121	0.012	People with higher levels of education place more aesthetic markers at LGA scale
Education	Casual recreation activities	Spearman rank correlation	Rho = -0.113	0.028	People with higher levels of education place more casual recreation markers at LGA scale
Education	Social activities	Spearman rank correlation	Rho = -0.155	0.002	People with higher levels of education place more social activity markers at LGA scale
Income	Aesthetic value	Spearman rank correlation	Rho = -0.135	0.011	People with higher income place more aesthetic markers at LGA scale
Years in LGA	Social activities	Spearman rank correlation	Rho = -0.110	0.033	People who have resided in the area for longer place more social activity markers at LGA scale
Years in LGA	Exercise for fitness activities	Spearman rank correlation	Rho = -0.106	0.038	People who have resided in the area for longer place more exercise for fitness markers at LGA scale

Figure Captions

Figure 1. Map of the study area.

Figure 2: Sample map as presented to residents of the suburb Charlestown

Figure 3. Barplot of the abundance of value markers at the suburb and LGA scales.

Figure 4. Barplot of the proportional difference between marker dots assigned at the suburb and LGA scales.