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Research article

Social and environmental factors drive variation in plant and bird communities across urban greenspace in Sydney, Australia

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ABSTRACT

We examined whether environmental or social factors alone, or a combination of social–ecological factors were more effective at explaining patterns in plant and bird assemblages across urban greenspaces. Thirty publicly accessible, passive recreation greenspaces provided by municipal councils (i.e. city parks) were surveyed in a highly urbanised city – Sydney, Australia. Plant communities were influenced most by topography and park management approach, and to a lesser extent by land-use history. Greenspaces with greater topographic variation and that were co-managed with local citizen groups hosted higher plant species richness and abundance. Bird species richness within greenspaces increased with increasing distance from the central business district and decreasing distance from freshwater. Bird abundance was best explained by a combination of social–ecological factors, with abundance increasing with increasing site (greenspace) age, increasing percent concrete groundcover of a site and increasing proximity to the central business district. We identified a group of 'rare city parks', dissimilar in ecological composition that hosted more complex and species rich plant communities compared to 'common city parks'. We suggest this difference is likely because rare city parks received management and maintenance input from local citizen groups, whereas common city parks were managed and maintained exclusively by local councils. How different social factors, such as management approach and ongoing maintenance, are linked to the ecology of urban greenspaces are key areas for future investigation to help create sustainable urban landscapes that provide maximum benefits to urban residents.

1. Introduction

Increased attention has been paid to the drivers of urban biodiversity in recent years (see for example, Farinha-Marques et al., 2011; Karuppannan et al., 2014; Matthies et al., 2015; McKinney, 2008; Nielsen et al., 2014). A critical feature of urban environments that supports relatively high levels of biodiversity is urban greenspace (UGS) (McKinney, 2006), defined as open, unsealed, urban land and its associated vegetative cover (see Hunter and Luck, 2015 and references therein).

Ecological variation may occur between different types of UGS, and individual sites of the same type of UGS. For example, residential neighbourhoods (Kinzig et al., 2005) and allotment gardens (i.e. urban agriculture) (Andersson et al., 2007) may host higher species richness and/or abundance of varying taxa compared to council managed city parks. Despite being a similar type of UGS, Dallimer et al. (2012) reported that publicly accessible recreation greenspaces, many of which were publicly owned and managed, varied widely in ecological diversity between sites in one city – Sheffield, UK.

Environmental or social factors operating at different scales (e.g. vegetation cover in the surrounding neighbourhood, UGS size, neighbourhood income, or UGS age) may influence ecological variation across UGS sites. For example, mean household income can be related to bird, but not plant species richness in council managed city parks, where sites in higher income areas have more bird species (Kinzig et al., 2005). Greenspace age may positively correlate with bird species richness (Fernández-Juricic, 2000), but not plant richness (Nielsen et al., 2014), whereas increased dwelling (Gavier-Pizarro et al., 2010) and population (Pautasso and McKinney, 2007) density have been strongly related to increased plant species richness across broader UGS scales (e.g. urban

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counties). Dwelling density may be positively or negatively correlated with bird richness depending on the species of interest (Hodgson et al., 2007; Pidgeon et al., 2007) or season (Carbó-Ramírez and Zuria, 2011), and may increase the functional similarity of bird communities across neighbourhoods (Luck and Smallbone, 2011). While the influence of social factors on the biodiversity of specific types of UGS (e.g. city parks) is not well studied, research so far suggests that the social variables linked to variation in urban biodiversity more generally may not necessarily be the same as the social variables linked to biodiversity variation across specific UGS sites.

Regarding environmental factors, UGS size is often positively correlated with bird species richness (Carbó-Ramírez and Zuria, 2011; Fernández-Juricic, 2004; Nielsen et al., 2014), and occasionally positively correlated with vascular plant species richness (Bräuniger et al., 2010; Matthies et al., 2015). Increased topographic variation across UGS sites may also be related to higher plant species richness (Cornelis and Hermy, 2004). At a broader scale, the amount of vegetation surrounding an individual UGS site (i.e. within the 'urban matrix'), such as street trees and domestic gardens, may influence bird occurrence in that site (Dauber et al., 2003). For example, Nielsen et al. (2014) found that bird species richness decreased with increasing isolation of greenspace in the urban matrix (i.e. less surrounding vegetation). However, Strohbach et al. (2009) argued that more vegetation in the urban matrix will not necessarily translate to increased bird species richness in specific UGS sites.

At smaller scales, vegetation characteristics within individual UGS sites – such as plant species richness and structural heterogeneity – may be important in increasing bird species richness (Fernández-Juricic, 2004; Husté et al., 2006; Murgui, 2007). For example, bird species richness in UGS may be positively influenced by increasing woody plant species richness and/or shrub and tree cover (Fernández-Juricic, 2004; Nielsen et al., 2014); although Fontana et al. (2011) found that bird species richness was more strongly influenced by tree abundance.

Furthering knowledge on how social and environmental factors influence variation in bird and plant communities across UGS requires acknowledging that not all UGS is the same. Past research has tended to ignore the important, site-specific differences in UGS history, management and use, assigning sites with vastly different management objectives and uses to a single, but often amorphous category 'urban greenspace'. In Hunter and Luck (2015), we show that greenspace qualities such as ownership and management may vary substantially and this can have important implications for understanding variation in greenspace ecology (e.g. species richness). Given this, it is crucial to employ a more comprehensive and transparent approach to defining the type of UGS under investigation, and to account for underlying variation in the research design. In Australia's urban centres, UGS provided by city councils (i.e. local government authorities) can be roughly categorised into (i) formal recreation greenspace, (ii) conservation greenspace, and, (iii) passive recreation greenspace (Supplementary material – S.1).

Conservation greenspaces are designated to protect native ecosystems, ecological communities or species; consequently they are often biologically diverse. Formal recreation greenspaces are designated for organised sporting activities (e.g. football), resulting in monocultures of mown turf and relatively low levels of biodiversity. Hence, the drivers of ecological variation in conservation and recreation greenspaces are strongly linked to management (Hunter and Luck, 2015). Given this, we excluded formal recreation and conservation greenspaces from our study because they have entrenched and overriding management approaches that lead to predictable ecological outcomes.

Instead, we focus here on a globally common, specific type of UGS – passive recreation greenspace (i.e. city parks) – for which there is limited knowledge of the social and environmental factors influencing variation in biodiversity across sites. Passive recreation greenspaces are mandated and designated by local government authorities worldwide specifically for use by local residents for passive recreation (e.g. picnicking, walking). They are a key location within urban environments where city dwellers are able to readily interact with nature (Dunn et al., 2006). Yet, there is limited knowledge of the magnitude of variation in the ecological characteristics of passive recreation greenspaces, or what factors might drive this variation. Improving understanding of these factors is vital given that the composition and structure of plant and animal taxa in city parks may have measurable impacts on a greenspace users' wellbeing (Carrus et al., 2015; Dallimer et al., 2012; Dunn et al., 2006; Fuller et al., 2007). We focussed on passive recreation greenspaces because they are widely used and there is much greater scope to modify management and planning to improve both human encounters with nature and the ecological values of the greenspace.

Descriptive nomenclature such as 'park', 'reserve' or 'garden' may be used when naming passive recreation greenspaces. Naming conventions reflect cultural or historical trends which could indicate a site's ecological characteristics, but it cannot be assumed a priori that, for example, gardens are more biodiverse than parks or reserves. Further, the biodiversity of 'botanic gardens' (which may be designated as passive recreation greenspaces) comparatively to other city parks is relatively un-documented (Maunder et al., 2001; Ward et al., 2010). Here, we use the term 'city parks' to refer to passive recreation greenspaces irrespective of whether councils formally named them 'reserves', 'parks' 'gardens' or 'botanic gardens' (Supplementary material – S.2). Using the typology of UGS qualities presented by Hunter and Luck (2015), city parks possess the following social qualities: publicly accessible; managed by city council; situated on public land; and formally designated on town plans for passive recreation (Supplementary material – S.3).

We investigated the extent to which a suite of social and environmental variables can explain variation in the bird and plant communities of city parks. By focussing on one type of greenspace, we reduced the likelihood of confounding research findings which may occur if a broader range of UGS types are included (Hunter and Luck, 2015). The following research questions were addressed:

1) How do city park sites vary in ecological characteristics?
2) What social and environmental factors are related to differences in plant and bird communities across city park sites?

2. Methods

2.1. Site selection

A stratified, random approach was used to select 30 city park sites in Sydney, Australia (Fig. 1). Using orthocorrected aerial maps, the amount of canopy cover per site (estimated ocularly and confirmed by two researchers) was estimated and used to stratify sites into four categories (0–24%; 25–49%; 50–74%; 75–100% canopy cover – Supplementary material – S.4). Canopy cover was used because we expected this variable would capture the full range of ecological variation among sites. Sites were then randomly chosen within these canopy cover categories and included in our study based on the aforementioned social qualities of city parks (see Introduction). Additional site selection criteria included no significant water views, located a minimum of 1 km apart (to maintain spatial independence) and ranging between 0.5 and 5 ha in size (Supplementary material – S.3). This resulted in between six