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# The conservation value of urban green space habitats for Australian native bee communities

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ABSTRACT

Networks of urban green space can provide critical resources for wild bees, however it is unclear which attributes of green spaces provide these resources, or how their management can be improved to benefit a diversity of bee species. We examined bee communities in three dominant urban green space habitats: (1) golf courses (2) public parks and (3) front gardens and streetscapes in residential neighbourhoods in Melbourne, Australia and assessed which local and landscape attributes influenced bee communities. There was a greater abundance and richness of bee species in public parks compared to golf courses and residential neighbourhoods, where the latter habitat was dominated by European Honeybees (*Apis mellifera*). The occurrence of *A. mellifera* was positively associated with increases in flowering and native plants. Ground-nesting *Homalictus* species occurred more frequently in older golf courses and public parks surrounded by low impervious surface cover, and with a low diversity of flowering plants. Cavity nesting, floral specialists within the Colletidae family occurred more often in green space habitats with greater native vegetation, and occurred infrequently in residential neighbourhoods. The lack of appropriate nesting habitat and dominance of exotic flowering plants in residential neighbourhoods appeared to positively impact upon the generalist *A. mellifera*, but negatively affected cavity and ground nesting floral specialist bee species (e.g. Halictidae and Colletidae). Our results highlight the need to include urban areas in pollinator conservation initiatives, as providing resources critical to diverse bee communities can assist in maintaining these key pollinators in urban landscapes.


## 1. Introduction

Wild and managed bees are the most economically important pollinators in natural and managed landscapes (Garibaldi et al., 2013; Klein et al., 2007), contributing to the pollination of up to 87% of the world's flowering plants (Ollerton et al., 2011). Consequently, reports of bee declines due to increasing land use change, spread of parasites and pathogens, increased use of pesticides, and climate change are of concern (Potts et al., 2010). Much of our understanding of the impacts of land use change and habitat loss on bee communities has come from studies in forested and agricultural environments (Winfree et al., 2009), whereas the impacts of urbanisation are less well understood. Because the extent of urbanised areas is increasing rapidly (Seto et al., 2013), management of urban bee assemblages will become increasingly important as they play a vital role in the persistence of wild and managed plants in urban areas (Cane et al., 2006; Williams and Winfree, 2013). Many native plant species have gone locally extinct in cities worldwide (Hahs et al., 2009) and altered biotic interactions are one of the proposed drivers of these extinctions (Hahs et al., 2009; Williams et al., 2009). This was highlighted by Pauw (2007; Pauw and Hawkins, 2011), who documented the parallel declines of insect pollinators and associated insect pollinated plants in urban conservation reserves in South Africa. Taken together these studies highlight the importance of understanding the persistence of insect pollinators in cities and the potential

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consequences of pollinator loss on other components of the urban ecosystem.

Most studies of bees in urban landscapes have focussed on bee communities within discrete land uses such as home gardens or remnant habitats (Cane, 2005; Hinners et al., 2012; Matteson and Langellotto, 2010; Matteson et al., 2008, 2012; McIntyre and Hostetler, 2001; Pardee and Philpott, 2014). They suggest that traits, including flight ability, floral specialisation and nest location shape urban bee communities (Cane et al., 2006; Hinners et al., 2012; Pardee and Philpott, 2014). However, there is little consensus regarding how urban bee communities are shaped by habitat attributes, or what management actions could promote urban bee diversity. Some authors report that urban intensity has a negative impact upon bee species richness and abundance (Bates et al., 2011; Fortel et al., 2014), whereas Matteson et al. (2012) found no direct influence of urban development intensity on bee and other insect pollinator communities. Many types of urban habitats appear to support abundant and diverse bee communities, especially residential gardens (Banaszak-Cibicka and Żmihorski, 2012; Fetridge et al., 2008; Matteson et al., 2008). However, the value of residential gardens and other recreational green spaces (e.g. parks and golf courses) for bees is likely to be dependent upon the quality of foraging and nesting habitat (Cane, 2005). While some studies have found that increases in the cover of green spaces such as golf courses and parks are positively associated with bee abundance (Pardee and Philpott, 2014), others show a negative relationship (Tonietto et al., 2011), most likely due to differences in floral quality across different green space types (Matteson et al., 2012) and the floral specialisation of certain bee genera (Cane et al., 2006; McIntyre and Hostetler, 2001).

A common strategy used to conserve bees in agricultural landscapes is the preservation of networks of remnant or 'wild' habitat (Ricketts et al., 2008; Steffan-Dewenter et al., 2002). However, in most urban landscapes, few patches of remnant habitat remain, and they are often small and fragmented. As an alternative, networks of urban green spaces could be managed to provide bee habitat in otherwise resource-poor environments. These networks may include natural, planted and managed vegetation in public and private spaces such as residential gardens and recreation fields (Tzoulas et al., 2007).

There is currently a lack of consensus about which attributes of green spaces support bee communities, or whether patterns observed to date are consistent in different parts of the world. To assess the potential contribution of networks of green spaces to urban bee conservation efforts, we examined (1) bee community composition in a range of urban green space habitats and (2) how local and landscape variables influenced bees with differing floral and nesting requirements, in Melbourne, Australia.

## 2. Materials and methods

### 2.1. Study area and experimental design

Melbourne is Australia's second most populated city with approximately 4 million human inhabitants. Melbourne spans several bioregions, so to minimise soil type, rainfall and vegetation variation we restricted the study to the south-eastern suburbs within the Gippsland Plain bioregion. This area is characterised by sandy soils, dominated by grassy woodland and heathland vegetation communities. Urbanisation began in the early 1900's, but this region continues to experience rapid urban expansion as 85,000 new houses are to be built between 2005 and 2030 (Victorian Department of Sustainability and Environment, 2005). Suburbs built in the early 1900's, closer to Melbourne's city centre, contain more trees and are characterised by larger residential gardens (Hall, 2010) than those in the outer suburbs. In recent decades, urban development styles have changed to smaller single detached dwelling residential blocks with larger building footprints, and much less garden area (Hall, 2010). Hence, the arrangement and extent of urban green spaces vary considerably between suburbs.

We sampled 130 20 m $\times$ 30 m (600 $m^2$) plots across 39 green space sites located in 13 suburbs of different development age (1890–2000 s), which varied in the cover of woody vegetation and impervious surfaces (Fig. 1). The decade each suburb was established was determined by examining historical aerial imagery, and consulting municipal land release and construction records. We sampled bees in three dominant green space habitats: (1) golf courses (13 golf courses: 52 plots) (2) public parks (13 public parks: 26 plots) and (3) residential neighbourhoods (13 neighbourhoods: 52 plots comprised of front gardens and streetscapes). We did not sample remnant or agricultural habitats as these land covers are not dominant in the study area, and remnant habitat cannot be re-instated in urban landscapes. In addition, the diversity of vegetation communities present in different remnants made it difficult to establish a consistent reference bee community. Instead, we sampled the dominant urban green space habitats in our study area, as these have significant opportunities for habitat improvement through changes to vegetation management. Within each suburb, the selected suite of three green space habitats (residential neighbourhoods, public park and golf course) were on average greater than one km apart.

Within golf courses and public parks, we established 78 plots randomly (52 and 26 plots respectively) within the 'out of play', wooded areas. In residential neighbourhoods, we established the remaining 52 plots by randomly selecting four streets within each residential neighbourhood, and mailing invitations to households on those streets to take part in the study. Plots were usually greater than 100 m apart within each green space (residential neighbourhood, public park and golf course). To adequately represent residential neighbourhoods these plots consisted of the front garden, the pavement and road verge (if present) out to a midway point of the road directly in front of the property. The width and depth of each front garden primarily dictated the size of each plot in the residential neighbourhoods as we could only sample properties for which we had permission.

### 2.2. Bee sampling

Within each plot we used two standard methods to sample the bee species present, both of which have been recognised for their ability to representatively sample bee species across varied habitats (Westphal et al., 2008). We placed six coloured pan traps (two yellow, two blue and two white; 15 cm diameter) randomly on the ground throughout each plot for a 24 h period, leading to the deployment of 1560 coloured pan traps throughout the study. Pan traps were 1/3 filled with water containing a few drops of detergent to break the surface tension and cause trapped insects to sink to the bottom. On the same day, we collected bees from flowers within each plot through 200 sweeps of a sweep net allocated evenly across all vegetation present within the plot boundary to a height of 2 m, leading to a total of 390 h of sweep net sampling. We limited our bee surveys to warm sunny days (average temperature 24.7 °C) with low wind speeds and little to no rain. We sampled all plots twice in austral spring and twice in summer during 2012, totalling four bee data collection periods over two seasons. Bees were stored in 70% ethanol, and returned to the laboratory for sorting and subsequent identification to species where possible, and otherwise to morphospecies. We air-dried and pinned representative specimens from each species for taxonomic verification.