Landscape and Urban Planning 151 (2016) 79–88

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Research paper

To what extent does vegetation composition and structure influence beetle communities and species richness in private gardens in New Zealand?

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HIGHLIGHTS

- Over a short trapping period, 164 beetle species were collected in a NZ city.
- Beetle communities are dominated by native species.
- Beetle species richness in gardens is higher than in many less modified habitats.
- Garden vegetation only weakly explained beetle communities and diversity.

ARTICLE INFO

Article history:
Received 27 December 2014
Received in revised form 19 October 2015
Accepted 12 February 2016

Keywords:
Coleoptera
Invertebrate
Native
Exotic
Non-native
New Zealand

ABSTRACT

Private gardens comprise a large proportion of urban green space and can contain diverse and structurally complex vegetation, typically dominated by exotic species, but potentially providing resources for a diverse invertebrate fauna. We determined how much beetle diversity and community structure were influenced by vegetation composition and structure, native vegetation, garden land covers, and proximity and extent of neighbourhood green spaces in 55 gardens in Dunedin, New Zealand. We recorded 164 species from 29 families after 10 days of pitfall trapping; 68% native, 15% exotic. Beetle diversity exceeded that reported in other less modified New Zealand habitats, possibly due to high habitat heterogeneity at the scale of the garden but also the variety of habitats present at a larger scale but separated by relatively short distances within this small city and across a short altitudinal gradient, from sea level to sub-alpine environments. Number of shrubs (2–5 m), woody plant density, and area of lawn and hedge influenced beetle richness, diversity and community structure, but explained <30% of variation between gardens. We found no effect of mean diversity of herbaceous vegetation in bed use, mowing and composting on diversity or community structure. Proximity to green space, woody plant diversity and vegetation structural complexity influenced beetle community composition, but correlations were weak. Although only 17% of all woody plants were native, most beetle species were native. With the exception of gardens that had very little vegetation, landscaping choices appeared to have little effect on beetle diversity and assemblage composition.

1. Introduction

Urbanisation tends to have detrimental impacts on invertebrate diversity, with species responding negatively to habitat loss and fragmentation, changes in the abiotic environment, pollution, high levels of human disturbance and loss of host plants (Jones & Leather, 2012; McDonnell & Hahs, 2008; McKinney, 2008). Beetles (Insecta, Coleoptera), which have received more attention in cities than most other groups, tend to decline in diversity across the

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http://dx.doi.org/10.1016/j.landurbplan.2016.02.013
0169-2046/

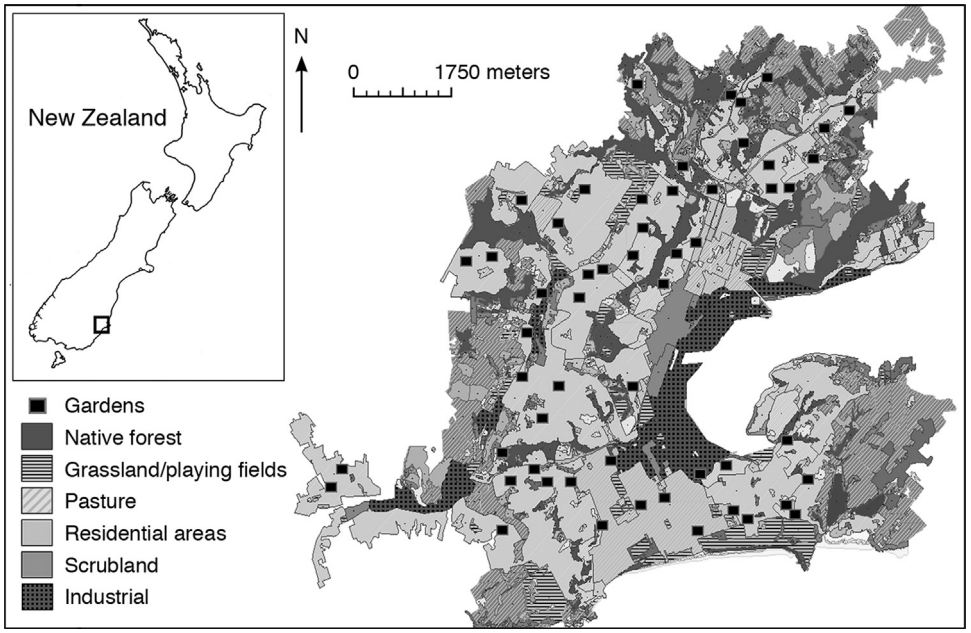

Fig. 1. Map of Dunedin city showing the distribution of sampled gardens in relation to the main habitat types.

gradient of increasing urbanisation, as forest specialist species are lost (Magura, Lövei, & Tóthmérész, 2010; Niemelä and Kotze, 2009; Sadler, Small, Fiszpan, Telfer, & Niemelä, 2006; Tóthmérész, Máthé, Balázs, & Magura, 2011; Vergnes, Pellissier, Lemperiere, Rollard, & Clergeau, 2014; but see Elek & Lövei, 2007). Nevertheless, urban landscapes are also characterised by high heterogeneity, and invertebrate diversity has been shown to be positively related to habitat heterogeneity (Tews et al., 2004). Urbanisation has created a variety of open habitats such as those covered by lawns, bare soil, moss and gravel, resulting in an increase in open habitat specialist, generalist, and opportunist species (Gagné & Fahrig, 2011; Jones & Leather, 2012; Madre, Vergnes, Machon, & Clergeau, 2013; Tóthmérész et al., 2011; Vergnes et al., 2014). Private gardens (i.e., those owned by householders) make up a large proportion of the suburban landscape and also the total city-wide green space (Loram, Thompson, Warren, & Gaston, 2008; Mathieu, Freeman, & Aryal, 2007), and usually contain a variety of landforms, from open habitats to densely vegetated beds, as well as a diverse mix of native and introduced plant communities (Godefroid & Koedam, 2007; Loram, Tratalos, Warren, & Gaston, 2007; Meurk et al., 2009; Thompson et al., 2003). The high habitat heterogeneity found in gardens in the UK is associated with higher moth species richness (Bates et al., 2014) and suggests a potential to support significant beetle diversity as well.

Much of the variation in abundance and diversity of urban beetle communities is explained by vegetation structure and composition (Jaganmohan, Vailshery, & Nagnedra, 2013; Magura, Lövei, & Tóthmérész, 2008; Niemelä & Spence, 1994; Small, Sadler, & Telfer, 2003; Small, Sadler, & Telfer, 2006; Smith, Gaston, Warren, & Thompson, 2006a, 2006b), with the implication that habitats that contain rich communities of plants may also provide resources for a diverse beetle fauna (Godefroid & Koedam, 2007; Loram et al., 2008; Mathieu et al., 2007; Thompson et al., 2003). Brose (2003) tested two hypotheses of bottom-up control predicting carabid diversity and concluded that the structural heterogeneity of vegetation was more important than taxonomic diversity in influencing beetle species richness. Plant richness in urban areas is usually characterised by many exotic species (Smith et al., 2006a, 2006b; van Heezik, Freeman, Porter, & Dickinson, 2014). The extent to which native invertebrates can use exotic vegetation is not well understood. Some evidence suggests that native invertebrate species can be negatively affected by exotic plant taxa (Burghardt, Tallamy, & Shriver, 2008;Crisp, Dickinson, & Gibbs, 1998; Derraik, Rufaut, Closs, & Dickinson, 2005;Helden, Stamp, & Leather, 2012; Kuschel, 1990; Pardee and Philpott, 2014; Simao, Flory, & Rudgers, 2010). Burghardt et al. (2008) found fewer Lepidoptera associated with exotic plant-dominated gardens in the USA, but in Davis, California, many native butterfly species breed mostly or entirely on exotic plants, in particular on naturalised weeds (Shapiro, 2002). In New Zealand evidence suggests the proportion of exotic invertebrates can increase when there is a high proportion of exotic vegetation, but not always (Harris & Burns, 2000; Harris, Toft, Dugdale, Williams, & Rees, 2004; Pawson, Brockerhoff, & Meenken, 2008).

The proportion of exotic vegetation in New Zealand gardens is very high relative to that reported in other countries: in the UK 30% of the garden flora and about one third of the 50 most frequently occurring species were native (Knapp et al., 2012; Loram et al., 2008; Smith, Gaston, Warren, & Thompson, 2006b; Thompson et al., 2003), but New Zealand gardens typically contain twice as many exotic as native woody plant species, and a number of gardens have no native woody plants at all (van Heezik et al., 2014). Presence of herbaceous native plant species in garden beds is also very low (van Heezik et al., 2014), and in lawns it is only 13% of total plant species richness (Stewart et al., 2009). Moreover, while gardens provide many habitats for invertebrates they are also sites of frequent and regular disturbance in the form of weeding and cultivation, mowing and pruning, and the application of fertiliser, insecticides and herbicides.

Few studies have examined the role private gardens play in supporting beetle diversity (but see Bang & Faeth, 2011; Jaganmohan et al., 2013; Smith et al., 2006a, 2006b; Vergnes, Le Viol, & Clergeau, 2012). On the one hand, the diversity of habitats in gardens implies high beetle diversity, but the predominance of exotic vegetation and vulnerability of species to fragmentation, and the absence of ecological corridors for dispersal (Vergnes et al., 2012) argue against a diverse beetle community. Very little is known about beetles in New Zealand gardens, or the extent to which the high proportion of exotic vegetation (by which we mean plants which