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# The importance of urban backgardens on plant and invertebrate recruitment: a field microcosm experiment

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**Abstract** Private backgardens in cities have the capacity to enhance ecological function and connectivity. The importance of increased habitat availability was tested experimentally using microcosms with soil or with soil and vegetation added into Toronto backgardens. Local attributes of the backgardens were recorded, and within the microcosms, recruitment of seeds, plants, and winged and wingless invertebrates were recorded. Natural recruitment by all organisms was significant into the microcosms in the 20 backgardens tested. Invertebrate abundance and diversity, incidental seed recruitment, and aboveground vegetation growth was enhanced regardless of whether only bare soil was added or soil with vegetation. The number of woody plants (non-herbaceous plants with hard lignified tissues or woody parts e.g., stems and are adapted to survive from one year to the next i.e., through winter) in the backgardens predicted seed recruitment and number of plant species predicted winged invertebrate abundance. Hence, simple augmentation of private backgardens—even at an ecologically small-scale—can enhance the capacity of urban systems to provide appropriate habitats for organisms within a difficult matrix for many species.

**Keywords** Dispersal · Backgarden · Habitat · Microcosm · Invertebrate · Seeds

## Introduction

Cities comprise a significant component of landscapes within North America and have disproportionate and mostly deleterious impacts on climate and native species (Karl et al. 1988; Czech et al. 2000; McKinney 2002, 2006, 2008; Chace and Walsh 2006; Churkina 2008; Stone 2008). Within cities, a prominent land class is residential (Smith et al. 2005, 2006; Loram et al. 2007; Gill et al. 2008), and it is traditionally considered unimportant, ecologically uniform, and of limited value for dispersal of flora and fauna (Ricketts 2001; Vandermeer and Carvajal 2001). However, this matrix classification should be tested directly for ecological value. In Sheffield, UK, this cover class was described by surveying

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the plant communities in backgardens and extremely high levels of diversity were detected, i.e., higher levels of diversity relative to semi-natural and natural sites within the region (Thompson et al. 2003, 2004). In general, increases in plant biodiversity within the urban context can help attract and sustain invertebrate pollinator populations (Corbet et al. 2001), and since these organisms play fundamental roles in nutrient cycling, organic substance decomposition, pollination, and soil aeration (Kremen et al. 2007), it is reasonable to propose that increases in either the biotic diversity of backgardens or structural heterogeneity relevant to plants and invertebrates (Potts et al. 2003; Ghazoul 2006; Gruebler et al. 2008) would enhance urban ecosystems—even if changes occurred at local scales within the greater city (Loram et al. 2007). Hence, in this study, the relative importance of adding microcosm-level suitable habitats to backgardens to ascertain whether there is evidence for increased recruitment by organisms into this matrix class is examined.

The class of the matrix is important for many invertebrate communities in cities as the conditions are influenced by the length of the ecotones, the quality of the surrounding matrix, and the 'quality' of the patch (Aizen and Feinsinger 1994; Webb 1989; Âs 1999; Duelli et al. 1999; Golden and Crist 1999; Ricketts 2001; Hirsch et al. 2003). Quality of the patch, as determined by species-specific preferences, can refer to the increased area and diversity of foliage type and height (including grass cover), canopy cover, and the presence of woody debris and hollows (Hodgkison et al. 2007). Currently, many different classes of matrix within urban ecosystems do not provide habitats for the majority of organisms, i.e., concrete or even expanses of homogeneous lawns with limited biotic and abiotic heterogeneity (Byrne and Bruns 2004; Byrne 2007). In order to increase ecological function and connectivity within cities, there are several alternatives including the following: increase patch size (Hodgkison et al. 2007), decrease the distance or isolation between patches (Fahrig 2001, Rudd et al. 2002, Jules and Shahani 2003), or increase the structural heterogeneity of current matrix classes (Rudd et al. 2002; Jules and Shahani 2003; Hodgkison et al. 2007). In the latter instance, plants often establish the structural heterogeneity of the environment such as greater heterogeneity through trees versus shrubs versus grasses within a patch. Plants in turn impact the distribution of animal species (reviews in Lawton 1983; McCoy and Bell 1991). Furthermore, plant diversity is a principle predictor of insect diversity at small spatial scales (e.g., Southwood et al. 1979), and small-scale structural complexity has been shown to be important for tree-dwelling arthropods (Halaj et al. 2000), ground-dwelling arthropods (Byrne 2007; Byrne et al 2008), web spiders (Greenstone 1984), grasshoppers (Davidowitz and Rosenzweig 1998), and ground-dwelling beetles (Romero-Alcaraz and Avila 2000). Composite measures of environmental heterogeneity include both habitat and structural (both horizontal and vertical) heterogeneity (i.e., includes both abiotic and biotic variation within a patch) and higher heterogeneity promotes higher levels of biodiversity (Palmer 1992; Steiner and Kohler 2003; Vivian-Smith 1997; Huston 1999; Lundholm and Larson 2003; Statzner and Moss 2004; Dufour et al. 2006). Experimental manipulations within cities would ideally test these hypotheses at the scale of private backgardens but variation may be important at even smaller scales (e.g. Byrne 2007; Byrne et al 2008).

In this study, the importance of urban environmental heterogeneity is tested at two ecological scales using experimental microcosms. Microcosms are ideal for exploring functional components (such as decomposition and nutrient mobilization) of an ecosystem (Verhoef 1996). Past research in urban ecosystems using this approach includes eco-toxicology and eutrophication risk assessments (e.g., Loureiro et al. 2005; Manyin and Rowe 2006; Snodgrass et al. 2008), nutrient cycling, soil ecology (e.g., Steinberg et al. 1997; Pieper and Weigmann 2008) and food web interaction studies (e.g., Walton et al.

2006). The importance of variation in recruitment of plants and invertebrates at the garden level is tested via addition of microcosms to backgardens with varying levels of diversity, and the significance of fine-scale variation is tested by varying microcosm quality directly. The overarching hypothesis is that backgardens can act as refuges for plants and invertebrates or at least habitats available for increased connectivity and dispersal. More directly, it is predicted that (i) environmentally diverse backgardens have higher levels of plant and invertebrate diversity available to recruit into microcosms and that (ii) small-scale microcosms (at the scale of 12-inch or 30.5 cm diameter) provide enhanced capacity to backgardens by increasing habitat.

## Methods

### Garden-level diversity

Twenty private backgardens sites throughout the Greater Toronto Area (GTA) were randomly selected using GPS in 2007; selection was based on even distribution across the city. For all sites, the following measures were recorded: the linear dimensions and area of each backgarden, total number of different microhabitats (i.e., categorized into five types: grass, impervious surfaces, flowerbed, pot, under-canopy of shrubs/trees), and total number of woody plants. Square quadrats, measuring 0.5 × 0.5 m, were then placed within each microhabitat (the total number of quadrats depending on the number of microhabitats present), using a grid-based randomly generated coordinate method (Quinn and Keough 2002), to estimate the richness and percent cover of vegetative and non-vegetative classifications. Plants present and rooted within the quadrat were identified to species level. Cumulative total number of plant species was then calculated for each backgarden.

Two semi-natural sites, sites modified by human influence yet retaining significant native components, were used as comparisons for recruitment into the microcosms in backgardens. A 36 $m^2$-sized meadow on York University's Keele campus characterized by Cow vetch (*Vicia cracca*), Canada thistle (*Cirsium arvense*), Bird's-foot trefoil (*Lotus corniculatus*), and mixed grass species, and a local 36 $m^2$-sized forested conservation site along the Don Valley River characterized by Sugar maple (*Acer saccharum*), Norway maple (*Acer platanoides*), Manitoba maple (*Acer negundo*), Black cherry (*Prunus serotina*), Dog strangling vine (*Vincetoxicum nigrum L.*), Garlic mustard (*Alliaria petiolata*), Poison ivy (*Toxicodendron radicans*), and Bloodroot (*Sanguinaria canadensis*).

### Microcosm-level diversity and sampling design

Large pots, 12-inches (30.5 cm) in diameter, served as microcosms for simple habitat augmentation within the urban matrix with one of two treatments applied. Triple-mix soil (an equal combination of topsoil, compost, and peat) or this soil mix with quick start grass seed mix (C-I-L Golfgreen—50% Perennial ryegrass (*Lolium perenne L.*), 35% Kentucky bluegrass (*Poa pratensis L.*), 15% Creeping Red Fescue (*Festuca rubra L.*) was added to each backgarden. One microcosm for each treatment type was placed in each of 20 backgardens on a grass substrate in a visible central location. In the semi-natural sites, 10 replicates of each treatment type were placed in pairs, at least 2 m apart, evenly in a line throughout the site. At the beginning and end of the experiment, a single quadrat was placed on either side of the pair of microcosms and percent cover of vegetation was recorded to estimate changes in the vegetation within each backgarden over time.

Following a two-week acclimation period, three colours of pan traps (white, yellow, blue) were set up in each microcosm for one day every two weeks for six weeks to measure winged, flying invertebrate visitation rates. The pans were set out in randomized sequences (different orders) between 6:30–8:00 A.M. and collected between 3:00–5:00 P.M. The pan traps were two-thirds filled with a water-diluted dishwashing soap solution (five drops of Blue Dawn dishwashing soap per litre of water). Winged, flying invertebrates were identified to family and wingless invertebrates in pan traps were counted.

At the conclusion of the growing season, a destructive soil analysis was conducted to assay for the presence of seeds and vegetative growth of plants (above and belowground). Mass of plant material was recorded following two days of drying at 60°C.

### Statistical analyses

The importance of the backgarden-level attributes and the microcosm treatment in providing habitat for invertebrates and plants was tested with generalized linear models. The relative area of microhabitats in backgardens on plant species richness estimated was assessed with a One-way ANOVA. The spatial patterning of the garden-level attributes, specifically number of woody plants and plant species richness, was evaluated with Moran's *I* index (Moran 1948, 1950). The numbers of winged and wingless invertebrates were fit to a Poisson distribution with a log function while mass response variables were modeled as linear and normal. A one-way ANOVA was used to determine differences in relative abundance of winged and wingless invertebrate visitation to each ecosystem: city (represented by backgradens), grassland, and forest. Regressions of the raw data are presented when a significant factor was identified (alpha set at $p<0.05$) (Moran 2003). T-tests were used to determine whether the effect of microcosms was different from no effect (i.e., zero) (Murtaugh 2007). While two-way ANOVAs were used to screen for the effects of site by microcosm treatment on each recruitment factors, the recruitment capacity of the broader scale semi-natural sites was tested with a one-way ANOVA and t-tests for differences from no effect. A repeated-measure ANOVA was used to test for differences between the three colours of pan traps used to sample invertebrates and census was also included as a random effect in the model. The importance of differential change immediately adjacent to the microcosms was tested with a repeated-measure ANOVA with backgarden as a random effect.

## Results

### Garden-level diversity

The mean area of backgardens included in this experiment was 311 (± 37) $m^2$, and the mean number of microhabitats in the backgardens was 3.7 (± 0.2) commonly including grassy areas, pavement or patios, and flowerbeds. The relative area of microhabitats was determined not to be an important influence on the plant species richness estimated in backgardens (One-way ANOVA, $F_{richness}=1.32$, $p=0.31$, df=5,19). On average, there were 25 trees and/or shrubs (mean=25.0±4.0) and 17 different plant species per backgarden (mean=17.0±1.4). Only two garden-levels attributes predicted recruitment in backgardens—number of woody plants positively predicted seed mass captured and total number of plant species predicted number of winged invertebrates (Table 1, Fig. 1). Four data values of backgarden attributes were found to lie outside the periphery of the range of data, however,

**Table 1** A summary of the generalized linear models used to test the importance of garden-level attributes and microcosm treatment in the urban context in the Greater Toronto Area. See text for details of factors. Area refers to the size of the backgarden and microcosm refers to the paired treatments of soil and soil with vegetation added to each backgarden in separate pots. In the instance of invertebrate counts, the data was modeled as log to a Poisson distribution, and for mass measures, a linear model was fit ($N$=20 backgardens, DF=1, 34 in all instances). Conservatively, alpha was set at 0.01 and is bolded

| Measure | Factor | Chi-square | Prob>Chi-square |
|---|---|---|---|
| Winged invertebrates | Area | 0.16 | 0.6800 |
| | # Microhabitats | 1.35 | 0.2500 |
| | # Woody plants | 0.21 | 0.6500 |
| | Richness of plants | 7.27 | **0.0070** |
| | Microcosm | 0.04 | 0.8500 |
| Wingless invertebrates | Area | 0.20 | 0.6500 |
| | # Microhabitats | 2.20 | 0.1300 |
| | # Woody plants | 0.09 | 0.7700 |
| | Richness of plants | 0.86 | 0.3500 |
| | Microcosm | 0.10 | 0.7500 |
| Seed mass | Area | 1.02 | 0.3100 |
| | # Microhabitats | 0.16 | 0.6800 |
| | # Woody plants | 15.2 | **0.0001** |
| | Richness of plants | 0.88 | 0.3500 |
| | Microcosm | 1.96 | 0.1600 |
| Plant mass | Area | 0.50 | 0.5000 |
| | # Microhabitats | 0.92 | 0.3400 |
| | # Woody plants | 0.39 | 0.5300 |
| | Richness of plants | 0.87 | 0.3500 |
| | Microcosm | 3.08 | 0.0800 |

being that they were legitimate values falling within the range of data for other backgarden attributes they were not removed from the analysis. When included, the number of woody plants were positively correlated with the seed mass and the plant richness was positively correlated with the winged invertebrates. When the suspect outliers were removed, neither displayed any relationship, however, area was negatively correlated to both winged and wingless invertebrates and the number of microhabitats also negatively correlated with wingless invertebrates. The GLMs were not sensitive to exclusion of extremely diverse or impoverished backgardens. Furthermore, spatial autocorrelation tests indicated that the values of the number of woody plants (trees and shrubs) as well as the number of plant species estimated in backgardens exhibited no significant departure from random (Moran's $I$=−0.11, $p$=0.725).

## Microcosm-level effects on recruitment

There was a significant effect of microcosm treatment when modeled within ecosystem (Two-way ANOVAs, p <0.01 for all except seed mass, $p$=0.16); however, there were no significant differences between the two microcosm treatments on the recruitment responses measured in the urban context (Table 1, listed as 'microcosm' effects). The effect of microcosms within backgardens always averaged positive and significantly different from

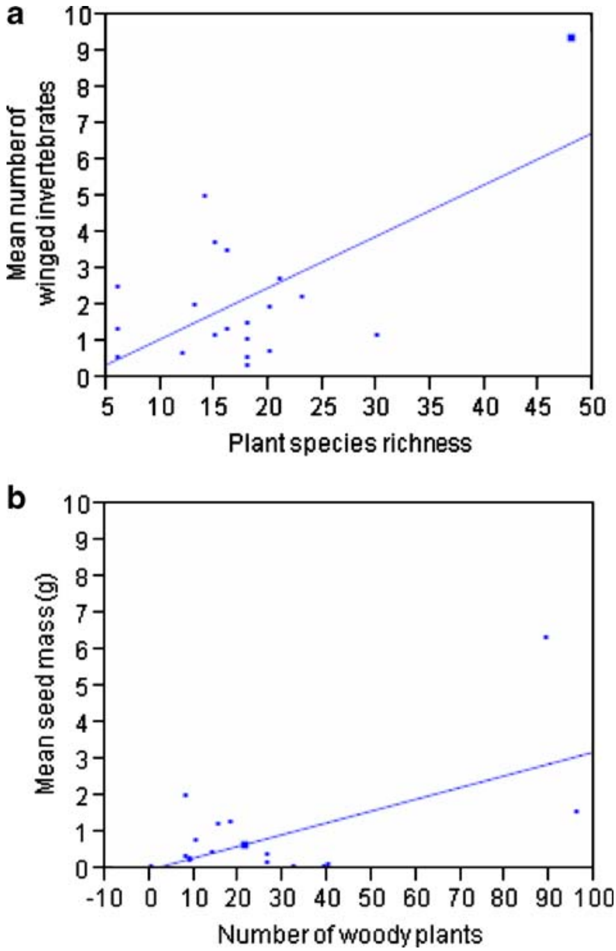


**Fig. 1** The importance of garden-level attributes within an urban context on the recruitment of invertebrates and plants. Generalized linear models were used to screen important factors, and here the raw data is presented as regressions (in first instance, $r^2=0.6$, $p=0.0004$ and in the latter, $r^2=0.44$, $p=0.006$). Richness of plant species is the cumulative total number of different plant species sampled within backgardens and number of woody plants is the total number of trees and/or shrubs within the garden

zero (Table 2, Fig. 2a). Among the backgardens, there were no significant differences in the relative coverage of vegetation immediately adjacent to microcosms at the start and completion of the experiment (RM Anova, $F_{garden}=0.85$, $p=0.7$, df=1,19). There were no significant differences interactions of the pan trap colour and the microcosm treatment (RM Anova, $F_{microcosm\ x\ colour}=0.2$, $p=0.8$, df=2,5), but the yellow pan traps were universally the most effective at capturing invertebrates (RM ANOVA, $F_{colour}=16.5$, $p=0.0001$, df=2,5 with post hoc contrasts $p<0.0001$). Similarly, in grassland and forest the microcosm treatments did not differ significantly (One-way ANOVAs, all $p>0.05$). The effect of microcosms was positive and significantly different from zero for the recruitment of invertebrates in both semi-natural systems, however, no effect of microcosm was observed for either seed or plant mass recruitment in the forest (Table 2, Fig. 2b, c).

The number of winged, flying invertebrates that visited microcosms in each ecosystem differed significantly (One-way ANOVA, $F_{winged}=31.7$, $p<0.0001$, df=2, 119, with post hoc contrasts $p<0.001$), and the community composition of visiting invertebrates in each ecosystem is described in Table 3. The number of wingless, sessile invertebrates also differed between ecosystems (One-way ANOVA, $F_{wingless}=23.4$, df=2, 119, $p<0.0001$).

**Table 2** A summary of the t-tests exploring whether the net effect of microcosms on recruitment of invertebrates and plants was significantly different from no effect ($N$=20 microcosms in each ecosystem, DF=39 in all instances) in the Greater Toronto Area

| Ecosystem | Measure | T | P |
|---|---|---|---|
| City | Winged invertebrates | 6.41 | 0.0001 |
| | Wingless invertebrates | 6.20 | 0.0001 |
| | Seed mass | 3.03 | 0.0001 |
| | Plant mass | 3.02 | 0.0001 |
| Grassland | Winged invertebrates | 14.81 | 0.0001 |
| | Wingless invertebrates | 11.48 | 0.0001 |
| | Seed mass | 7.95 | 0.0001 |
| | Plant mass | 3.10 | 0.0036 |
| Forest | Winged invertebrates | 9.61 | 0.0001 |
| | Wingless invertebrates | 5.76 | 0.0001 |
| | Seed mass | 1.50 | 0.1400 |
| | Plant mass | 1.43 | 0.1500 |

Post hoc contrasts revealed that these differences were significant between the forest and city ecosystems (represented by backgarden sites, $p < 0.0001$) and between the forest and grassland ecosystems ($p < 0.0001$), whereas the grassland and city ecosystems did not differ significantly in the number of wingless invertebrate visitors ($p$=0.57).

## Discussion

Cities are significant ecosystems globally, and private backgardens comprise a large proportion of cities in North America (Loram et al. 2007). As such, backgardens provide an opportunity for increasing the net ecological function and biodiversity of urban environments by individual citizens. In this study, the general hypothesis that backgardens can serve as refuges or habitats for dispersal within a city was supported via the addition of habitat microcosms that provided a standard, simple substrate for seeds, plants, and invertebrates. All measures of recruitment showed positive and significant responses to the addition of the microcosm, regardless of the attributes of the backgarden and the treatment applied to the microcosm. Importantly, this means that even the addition of a small patch of soil in backgardens provided space for seeds and invertebrates (e.g., Byrne 2007). Admittedly, plants, seeds, and invertebrates may already reside in the backgardens or migrate though them, but it is nonetheless reasonable to suggest that this is a biologically meaningful result in that augmentation of backgardens can enhance the capacity of these spaces to provide habitat.

The first prediction tested that increasing environmental diversity of backgardens increases recruitment. This was supported to a limited extent for winged, flying invertebrates with higher plant species richness, while increased seed recruitment was positively related to a greater number of woody plants. In urban ecosystems, there is significant pressure on pollinators and other invertebrates as urban development, human activities, undeveloped and ecologically uniform habitat, and fragmented natural areas limit the number of habitats which are suitable for foraging, nesting, and dispersal of these organisms (Aizen and Feinsinger 1994; Tscharntke et al. 1998; Kremen et al. 2002; Byrne

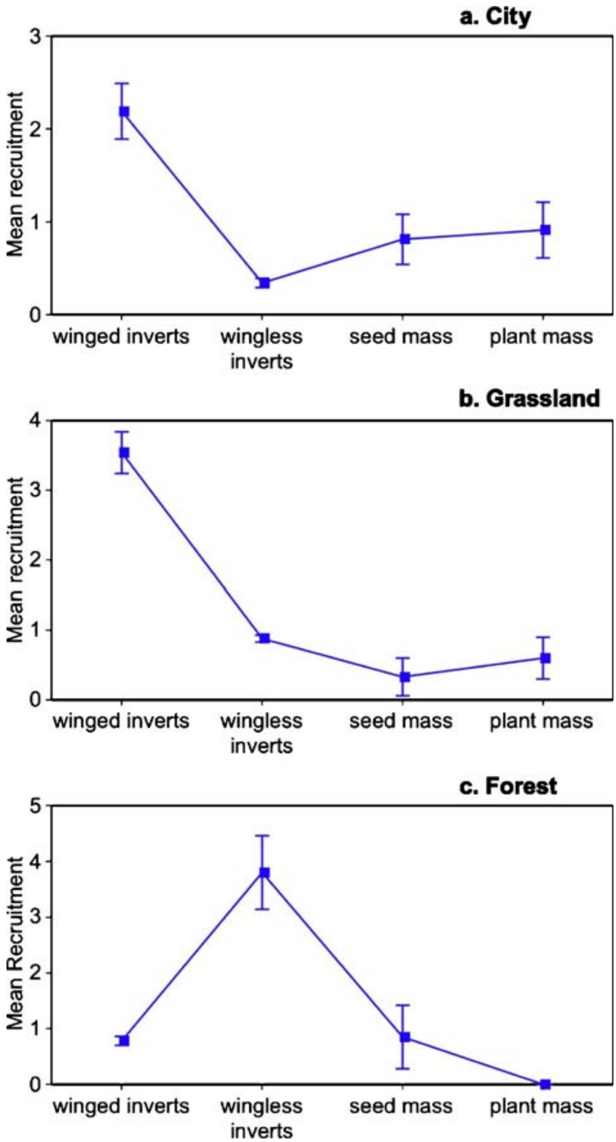


**Fig. 2** The net effect of microcosms added to backgardens within the city, a grassland, and a forest in the Greater Toronto Area. Sites in the city were private backgardens, the grassland was on private university property, and the forest was public land in the city proper. See text for description of responses plotted. Mean +/- 1 s.e. shown. Recruitment refers to the number of invertebrates (abbreviated as inverts) collected in microcosms over the growing seasons and seed and plants refer to the mass harvested at the end of the growing season above and belowground

and Bruns 2004). For instance, Frankie et al. (2005) monitored flowering plants within two cities in California and established that diverse assemblages of solitary and social native bee species could exist in urban ecosystems provided that there were sufficient nesting sites and flowering plants (even exotic horticultural varieties). The increased number of plant species in the backgardens studied here also likely increased the resource diversity available to all invertebrates (e.g., Kevan 1999; Potts et al. 2003; Makino et al. 2007). The correlation of mean seed mass captured in microcosms with number of woody plant species in the backgarden was likely driven by increased seed rain from these species, but it is also likely that woody species provided nesting and perching habitats for birds which further increases seed dispersal into and between backgardens (Daniels and Kirkpatrick 2006; Day 1995).

**Table 3** A summary of the cumulative abundance and family-level classification of winged, flying invertebrates in the three ecosystems: city (represented by backgardens), grassland, and forest, in the Greater Toronto Area

| | CITY | GRASSLAND | FOREST |
|---|---|---|---|
| *DIPTERA* | 452 | 79 | 38 |
| *Sarcophagidae* | 29 | 31 | 9 |
| *Calliphoridae* | 1 | 1 | 0 |
| *Asilidae* | 1 | 0 | 0 |
| *Conopidae* | 1 | 0 | 0 |
| *Pipunculidae* | 1 | 0 | 0 |
| *Tachinidae* | 0 | 2 | 0 |
| *Dolichopodidae* | 368 | 36 | 17 |
| *Syrphidae* | 22 | 7 | 2 |
| *Sciomyzidae* | 1 | 0 | 1 |
| *Heleomyzidae* | 48 | 2 | 9 |
| *HEMIPTERA* | 28 | 265 | 31 |
| *Cicadellidae* | 19 | 244 | 30 |
| *Cerocopidae* | 0 | 17 | 0 |
| *Membracidae* | 2 | 3 | 0 |
| *Miridae* | 3 | 1 | 1 |
| *Tingidae* | 2 | 0 | 0 |
| *Lygaeidae* | 2 | 0 | 0 |
| *HYMENOPTERA* | 43 | 47 | 5 |
| *Hylaeinae* | 1 | 4 | 1 |
| *Halictidae* | 20 | 25 | 0 |
| *Apidae* | 1 | 1 | 0 |
| *Megachilidae* | 2 | 5 | 0 |
| *Sphecidae* | 11 | 8 | 0 |
| *Pompilidae* | 1 | 2 | 1 |
| *Braconidae* | 2 | 0 | 0 |
| *Ichneumonidae* | 3 | 0 | 3 |
| *Diapriidae* | 0 | 1 | 0 |
| *Formicidae* | 0 | 1 | 0 |
| *LEPIDOPTERA* | 1 | 0 | 1 |
| *COLEOPTERA* | 0 | 1 | 0 |
| **TOTAL** | **524** | **392** | **75** |

While many studies have focused primarily on singular aspects of habitat heterogeneity or measured the number of habitat types within an ecosystem, the influence of spatial aggregation on species richness within the environment is seldom tested (but see Palmer 1992; Lundholm and Larson 2003; Steiner and Kohler 2003). Species-diverse backgardens with trees and/or shrubs can thus enhance the urban environment by providing patches of both resources and habitats. A comparable analog would be the use of hedgerows by many species in the similarly difficult matrix of agricultural systems (Anon 1995; Forman and Baudry 1984; Vandermeer and Perfecto 2002). In these systems, it is recommended that efforts to enhance invertebrate abundance in agricultural landscapes should be focused on increasing the number of structural components, such as hedgerows, trees, and orchards (e.g., Lewis 1969a, b; Bowden and Dean 1977; Maudsley 2000; Gruebler et al. 2008). Similarly in the urban context, the number of trees and total number of plant species wherein the microcosms were situated, positively co-varied with seed and invertebrate abundance in the microcosm. This suggests that structure is also an important consideration in cities that deserves future, preferably manipulative, study.

The second prediction: that small-scale microcosms provide habitat, was clearly supported regardless of whether the microcosm was simply soil or soil with vegetation added. Interestingly, this effect persisted for all measures in grassland and for the number of invertebrates in the forest. This suggests that the experimental design is either i) an effective means to assay local abundance and diversity of these organisms, ii) that it similarly provides the capacity for species to use as realized habitat, or iii) both. The magnitude of responses and variation of microcosms within the semi-natural sites were comparable to those found in the city, which suggests that at least in the Greater Toronto Area, there is a persistent regional species pool for plants and invertebrates that can found in backgardens. Admittedly, the semi-natural systems were also highly disturbed, within the city, and were larger in area than individual backgardens, however, microcosms were placed in each of the three ecosystem contexts in order to evaluate differences in recruitment of plants and invertebrates. Related studies have also shown that heterogeneity in microhabitats, floral resources, and structural diversity were closely linked with invertebrate abundance (Potts et al. 2003; Tews et al. 2004; Ghazoul 2006; Makino et al. 2007; Byrne 2007; Byrne et al. 2008). Most interestingly from an urban management perspective was that the patterns detected were not influenced by the area of backgardens. Backgardens in this study ranged from 100 to over 1,000 $m^2$ (the statistically minimum and maximum values) and the positive effects of microcosm addition persisted. This is a profound finding in that even very small areas benefited from the addition of even smaller habitats (microcosms less than 33 cm) in their ability to attract pollinators and invertebrates. The lack of difference in visitation rates between soil and grass microcosms observed in this study, is likely due to the small size of microcosms and backgarden properties relative to other urban green spaces. Hence, connectivity within a city can be increased through the use of these small private holdings—potentially even within the more intensive urban residential cores where properties are significantly smaller. Aggregation of these pollinator- and invertebrate-suitable habitats on a landscape level would have a more dramatic positive influence on densities of these organisms (Westphal et al. 2003). A future study should establish long-term micro- and mesocosms within the city to determine if the patterns detected here accurately reflect recruitment and establishment into these small spaces or simply dispersal and movement within the backgardens. Nonetheless, it is an important ecological finding that short-term estimates of abundance of seeds and invertebrates in the microcosms were comparable to those of the microcosms in urban grasslands and forests.

## Conclusions

Backgardens provide an opportunity for ecological restoration with cities. Here, microcosm addition successfully captured seed, plant, and invertebrates and likely also provided additional albeit ephemeral habitat. Hence, there is a local species pool available within the city, and the recruitment levels were comparable to an urban grassland and forest. Total plant species richness and total number of woody species present were positive attributes within backgardens and should be used as enhancements by private landowners and city councils while the addition of vegetation to microcosms did not differ from soil only. While it is hypothesized that microcosm addition with native plant vegetation will improve visitation rates of invertebrates, these novel findings suggest that even the presence of soil or useable uninhabited space in the urban matrix is a positive addition to backgardens.

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