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# Bumble Bee Abundance in New York City Community Gardens: Implications for Urban Agriculture

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We conservatively counted 25 species of crop plants in 19 surveyed gardens. The literature suggests that 92% of these crops are dependent, to some degree, on bee pollination in order to set fruit or seed. *Bombus impatiens* workers were observed visiting flowers of 78% of these pollination-dependent crops. Estimates of the number of *B. impatiens* workers visiting individual gardens during the study period ranged from 3 to 15 bees per $100m^2$ of total garden area and 6 to 29 bees per $100m^2$ of garden floral area. Of 229 *B. impatiens* workers marked, all recaptured individuals (45%) were found in gardens where they were initially marked. These results indicate an abundance of *B. impatiens* workers within New York City community gardens and suggest that, at least for certain time periods, many individual workers forage within single gardens. Both findings suggest that *B. impatiens* may be an especially important pollinator of several common crops grown within community gardens and other urban green spaces that are used for agricultural production. Studies of other pollinating insect species in urban habitats as well as the relationship between pollen movement and seed or fruit set will complement the findings of this study.

## Keywords

Bombus impatiens, bumble bee abundance, bumble bee mark-recapture, community gardens, urban agriculture, urban pollination

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Kevin C. Matteson and Gail A. Langellotto

**Abstract**

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## INTRODUCTION

It is estimated that 15% of the world's food is produced within a variety of landscapes generally classified as 'urban' (Armar-Klemesu 2000). Urban agriculture is especially common in developing countries (van Veenhuizen 2000). However, crops are increasingly grown in industrialized nations as well, predominantly in community, residential and rooftop gardens (Lawson 2005). Vegetables and fruits grown in gardens and other urban green spaces provide food security for those living in poverty (Brown and Jameton 2000) and nutrition for many who live in neighborhoods that lack affordable sources of fresh produce (Horowitz et al. 2004).

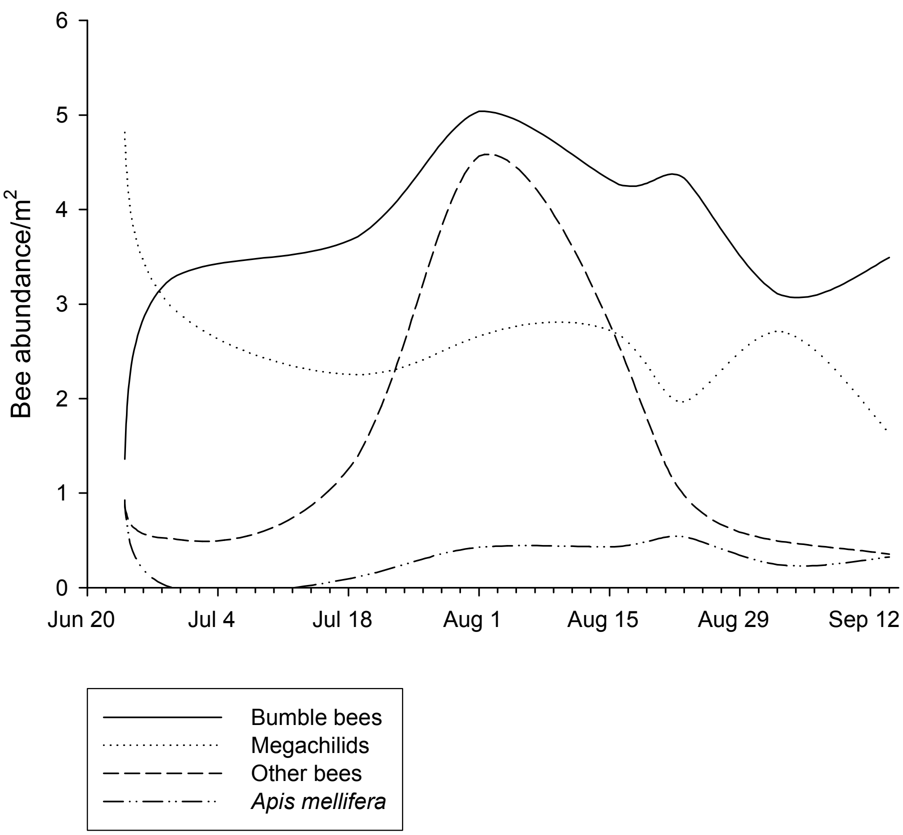
In community gardens of New York City, a variety of plants are grown specifically for the edible fruits, seeds, or leaves that they yield. Successful fruit and seed production in many of these crops is dependent on bee pollination (Klein et al. 2007); an ecosystem service that may be limited in the urban environment (Costanza et al. 1997). Honey bee hives are often placed into agricultural fields to supplement the pollination services for a variety of fruit-producing crops. In urban landscapes however, cultivated colonies of the European honey bee, *Apis mellifera* Linnaeus, 1758 (managed by recreational apiculturists), are a rare means of fostering crop pollination. As of March 2009, maintaining honey bee colonies is illegal in New York City, although a number of apiculturists nevertheless manage colonies in rooftop, community and private gardens throughout the five boroughs. In addition, some feral *A. mellifera* colonies can be found in city parks. While the presence of these colonies maintains a moderate abundance of *A. mellifera* workers in community gardens, pollination in urban gardens is likely more dependent on numerous 'wild' bees that naturally persist in heavily developed areas of the city (Matteson et al. 2008 and Figure 1, this paper).

Over 50 bee species have been documented within the community gardens of New York City (Matteson et al. 2008), including five species of bumble bee. The most abundant native bee is the common eastern bumble bee, *Bombus impatiens* Cresson 1863, which was the only bee observed in all community gardens sampled ($N = 19$) (Matteson et al. 2008) and which may be an especially important pollinator of crops in urban gardens (Figure 2). *Bombus impatiens* workers have been demonstrated to be effective alternates to *Apis mellifera* for pollination of greenhouse sweet peppers (Meisels and Chiasson 1997) and greenhouse tomatoes (Morandin et al. 2001) as well as field-grown blueberries (Stubbs and Drummond 2001), cucumbers and watermelon (Stanghellini et al. 2002). In addition, *B. impatiens* has been observed gathering pollen and/or nectar from a variety of crop flowers including cucumbers, tomatoes, eggplants, peppers, raspberries and more in New York City community gardens (Matteson, personal observations). Finally, in New York State, *B. impatiens* flies from April to November (with only *Apis mellifera* having a longer flight season) (Giles and Ascher 2006), suggesting that *B. impatiens* pollinates a variety of crops and other plants that flower throughout the growing season.

Although bumble bee workers in more natural landscapes have been found to forage several hundred meters from their nests (Dramstad 1996; Osborne et al. 1999; Walther-Hellwig and Frankl 2000), streets, buildings, car traffic and other hazards may limit bumble bee movements in urban landscapes. In order for *B. impatiens* bumble bees to effectively pollinate crop plants for food production, they must consistently visit individual urban gardens, or else effectively move among several garden sites to forage from and pollinate crop plants. However, the fragmented and dispersed nature of gardens and other green spaces within urban areas suggests that bumble bees may consistently forage within a single or a few gardens. A better understanding of bumble bee movement in urbanized landscapes may enable better management of pollinating species and ecosystem services they provide.

In this study, we investigated bumble bee abundance and movement within and between urban gardens. Specifically, we estimated the number of *B. impatiens* workers supported by individual gardens and evaluated the degree to which they were consistently found within a single garden, versus moved between adjacent gardens. In addition, we surveyed gardens in East Harlem and the Bronx (New York City), and compiled a list of edible crop plants that were being cultivated in these gardens. Using the literature, we determined the degree to which these crops depend upon bee pollination, and the degree to which bumble bees may foster pollination and food production in urban gardens.

**Figure 1.** Relative abundance of four groups of bees in New York City community gardens from June to September 2005. Bee abundance was determined during 60 second observations of 1-$m^2$ quadrats placed in sunlit flower beds with at least 60% of flowers in bloom. Relative abundance per date is the average of all observations taken on that date across 18 community gardens in the Bronx and East Harlem. 'Other bees' include *Andrena*, *Mellisodes* and *Xylocopa* but not smaller bees in the genera *Hylaeus*, *Lasioglossum* or *Ceratina*.




## METHODS

### Incidence and Pollination Dependent Crops in Community Gardens

There are over 700 community gardens in New York City (Matteson 2007). Between May and September of 2005, we surveyed crop plants grown in 19 community gardens located in the Bronx and East Harlem (Manhattan) in New York City. In order to represent the diversity of gardens in NYC, gardens were chosen that varied widely in size (range of 224 to 2188 $m^2$) and gardener management (amount of floral area, degree of disturbance, etc.). The mean area (910 $m^2 \pm 540$ $m^2$, mean ± *SD*) of the 19 sampled gardens was similar to the mean size of all community gardens, across New York City (704 $m^2 \pm 856$ $m^2$, mean ± *SD*) (Matteson 2007). Crops grown within community gardens often reflect the cultural heritage of the gardeners and the gardens sampled in this study were predominantly managed by gardeners of African and Latin American heritage. Therefore, there may be other crops not found during



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our survey, especially within New York City community gardens managed by gardeners with other ethnic and cultural backgrounds.

We calculated the incidence of each crop as the number of gardens where the crop was grown, divided by the 19 surveyed gardens. In a recent review, Klein et al. (2007) classify the benefits of animal pollination for a variety of crops. For each crop, Klein et al. (2007) classified the 'positive impact by animal pollination' based on the reduction in crop yield when animal pollinators are absent as follows: little- absence of animal pollinators results in 0-<10% yield reduction (as determined by reductions in seed or fruit set, seed quality or fruit weight); modest- 10-<40% reduction; great- 40-<90% reduction; essential- ≥90% reduction. We classified crops in community gardens not included in Klein et al. (2007) as "important" if they were included in Corbet et al. (1991) or Morse and Calderone (2000).

**Figure 2.** The development of many crops grown in community gardens benefits from pollination by bees. The common eastern bumble bee *Bombus impatiens* is shown here on an eggplant flower.

**Bumble Bee Mark-Recapture**

From 21 August through 12 September 2005, bumble bees were captured and marked in a subset of three community gardens in the Bronx (Fordham Bedford Lot Busters, Tremont Community Garden, Garden of Happiness) and three community gardens in East Harlem (Holy Rosary Garden, El Sitio Feliz/Union Settlement, El Gallo Social Club). The short study period precluded estimating birth rates, death rates or changes in population size throughout the season or between years. However, as part of a separate study, we measured relative abundance of bee groups in these gardens (including bumble bees, *Apis mellifera*, Megachilidae and other bees) from June to September in 2005. The results of this separate study (briefly presented here in Figure 1) indicate that bumble bee abundance in these community gardens (which included other bumble bee species in addition to *B. impatiens*) peaked in early August 2005 and declined slightly during the time period of the mark-recapture experiment in late August and September.

Therefore, the estimated abundance presented in this paper can be interpreted as an underestimation of peak abundance of *B. impatiens* during one year in NYC community gardens.

All sampling took place on warm, sunny days between 10:00 and 18:00. Bees were captured with a hand-net and then carefully transferred into small glass vials which were placed in a cooler with ice. After approximately two minutes of cooling, the bees were inactive for a short time period (~30 seconds), making it possible to mark the dorsal thorax using a permanent paint pen (Uchida of America, Corp., Torrance, CA). In order to identify the garden in which each bumble bee was marked during later censuses, we used a different color pen for each garden site. After marking, bees were allowed to warm in the sunlight and fly away. We visited each of the six marking locations (gardens) as well as 12 other nearby gardens every 2-3 days, during which time we visually inspected all bumble bees for marks. Locations of all 18 gardens are reported in Matteson et al. (2008). In addition, maps of these gardens (and all community gardens in NYC) can be found by accessing http://www.oasisnyc.net/. The linear distance between the three marking locations and the other gardens visited in the Bronx ranged from 180 to 2970 m (mean distance = 1440 m). In East Harlem, marking gardens were located between 240 and 1490 m from the other sampled gardens (mean distance = 830 m).

There are many formulas that estimate abundance of organisms within a focal location. Most of these are derivations of simple estimators that use the ratio of the total number of previously marked individuals to the number of individuals recaptured with marks. As a simple example, imagine that ten individuals are marked on the first day of a study. If on the second day eight individuals are captured, two of which have marks, then the estimate of abundance for that location would be: (10 * 8)/2 = 40 individuals. Because we conducted mark-recapture sampling over several occasions, we used Schumacher's method (Krebs 1989) to estimate worker populations in gardens. This method is similar to the above formula, but summed and averaged across several marking periods. To account for the potential effects of differences in garden size on our estimate of bumble bee abundance within gardens, we also calculated the number of bees per meter squared of garden area, by dividing our estimate of bumble bee abundance by the total area of a garden. There are several assumptions of the Schumacher method (and other mark-recapture methods). Specific to the calculations we used, it is assumed that animals are equally catchable and that there are no deaths, births, emigration or immigration within the population during the time frame of the study (Krebs 1989). Although our study was conducted over a short time period (~3 weeks), it is still likely that some individuals entered (via birth or immigration) or exited (via death or emigration) the population during the study.

## RESULTS

### Incidence and Pollination Dependence of Crops Grown in Community Gardens

On average, 23% of the area of the surveyed NYC community gardens was used for vegetable beds (range of 3% to 48%, $N = 18$) (Matteson 2007). Within these vegetable beds, we conservatively documented 25 crops (Table 1). Commonly grown crops included hot and sweet peppers, mints and other herbs, kale and collards, tomatoes and tomatillos, strawberries and cucumbers (Table 1). Although some crops were found in over three quarters of surveyed gardens, these may not provide the greatest yield if plants are small and not grown in mass. For instance, peach and apple trees (found in 61% of the sampled gardens) yield more fruit than sweet and hot peppers, which were grown in 100% of the sampled gardens.

Those crops from which fruits are harvested (e.g. cucumbers, strawberries, zucchini) are most likely to be directly affected by animal pollination. Specifically, the crops most likely to suffer reduced yield in the absence of animal pollinators include gourds such as pumpkins, squash and zucchini, cucumbers and fruits such as peaches, apples, plums and raspberries (Table 1). The harvest of crops from which edible leaves are consumed (e.g. kale, collards, herbs) may not be directly affected by animal pollination within gardens, because many gardeners buy new seeds each year. However, pollination may be important even for crops with edible leaves if gardeners allow plants to set seed and collect seeds for future planting.

**Table 1.** Crops commonly grown in New York City community gardens and their dependence on animal pollination. Crops are listed by the percentage of gardens in which they were grown (out of 19 total gardens surveyed in the Bronx and East Harlem). Classification of 'positive impact by animal pollination' follows Klein et al. (2007), unless otherwise noted, and is based on the reduction in crop yield when animal pollinators are absent (as determined by seed or fruit set, seed quality or fruit weight). The category entitled 'Bumble bee visitation observed in NYC community gardens?' is based on informal observations conducted by the first author during five years of field work in these gardens.

| Crops grown in NYC community gardens | Crop scientific name | % of gardens growing ($N$ = 19) | Plant part harvested | Positive impact by animal pollination | Bumble bee visitation observed in NYC community gardens? |
|---|---|---|---|---|---|
| Bell pepper, Chile pepper | *Capsicum frutescens, C. annuum* | 100 | Fruit | Little | Yes |
| Mints, Oregano, Basil | *Mentha spp., Origanum vulgare, Ocimum basilicum* | 100 | Leaves | "Important" [a, b] | Yes |
| Kale/collards | *Brassica chinensis* | 94 | Leaves | "Important" [a, c] | Yes [d] |
| Tomato, Tomatillos | *Lycopersicon esculentum* | 89 | Fruit | Little | Yes [e] |
| Strawberry | *Fragaria spp.* | 83 | Fruit | Modest | No |
| Cucumber (Gherkin) | *Cucumis sativus* | 78 | Fruit | Great | Yes |
| Lettuce | *Lactuca sativa* | 72 | Leaves | "Important" [a, b] | Yes [d] |
| Cilantro/Coriander | *Coriandrum sativum* | 67 | Leaves/ seeds | Great [a] | Yes |
| Beans | *Phaseolus spp.* | 67 | Fruit | Little | Yes |
| Peach | *Prunus persica* | 61 | Fruit | Great | No [g] |
| Apple | *Malus domesticus* | 61 | Fruit | Great | No [g] |
| Sunflower | *Helianthus annuus* | 56 | Seeds | Modest | Yes [f] |
| Broccoli | *Brassica oleracea* | 44 | Stalk, buds | "Important" [a, b] | No [d] |
| Eggplant | *Solanum melongena* | 33 | Fruit | Modest | Yes |
| Table grape/Vine grape | *Vitis vinifera* | 28 | Fruit | No increase | No |
| Okra/Gumbo | *Abelmoschus esculentus* | 28 | Fruit | Modest | Yes |
| Corn | *Zea mays* | 22 | Fruit | No increase | No [h] |
| Pumpkin, Squash, Zucchini | *Cucurbita maxima, C. mixta, C. pepo* | 17 | Fruit | Essential | Yes |
| Plum | *Prunus domestica* | 11 | Fruit | Great | No [g] |
| Raspberry | *Rubus idaeus* | 11 | Fruit | Great | Yes |

See Table 1. Footnotes next page.

**Table 1.** Footnotes

[a] For seed production
[b] Source: Corbet et al. (1991)
[c] Source: Morse and Calderone (2000)
[d] Although kale/collards and lettuces are rarely allowed to go to flower in community gardens
[e] Very high bumble bee abundance and visitation. Bumble bees are important pollinators of tomatoes because they 'buzz-pollinate' (vibrate wings while visiting the flower) which facilitates the release of pollen from poricidal anthers.
[f] Very high bumble bee abundance and visitation. Two long-horned bees, *Melissodes agilis* and *M. bimaculatus* (Apidae), also were commonly observed visitors of sunflowers.
[g] These fruit trees flower early (April-May) and therefore are dependent on bees most active during this time period (*B. impatiens* flies during this time period but is less abundant). Andrenidae also are active during this period but few have been documented in these gardens (Matteson et al. 2008). *Apis mellifera*, Bombus *griseocollis*, flower flies (Syrphidae: Diptera) and other early pollinators may be of special importance for these crops.
[h] Wind-pollinated

### Bumble bee mark-recapture

Bumble bees were abundant in gardens and were observed visiting flowers of 78% of pollination-dependent crops (Table 1). During the course of the mark-recapture experiment, a total of 229 *B. impatiens* workers were marked in six community gardens. Marking sessions in gardens typically lasted ~30 minutes during which time an average of 12 *B. impatiens* (range of 8 to 22; $N = 7$ marking periods) were captured and marked. Of those marked, 102 individual workers were recaptured (45%). Recapture rates in individual gardens ranged from 30% to 68% (Table 2). There were no captures of *B. impatiens* bumble bees in any gardens other than those in which they were originally marked.

Estimates of the number of *B. impatiens* using community gardens ranged from 46 to 164 workers (mean of 88) per garden (Table 2). These estimates of bumble bee abundance are surprisingly high considering the small size of these gardens (the six marking gardens had a mean area of 1320 $m^2$, range of 640 to 2188 $m^2$). Taking garden area into account resulted in estimates of 3 to 15 *B. impatiens* workers (mean of 8) per 100 $m^2$ of total garden area (Table 2). When omitting the area of gardens without flower beds (ornamental, crop or unmanaged), the estimated density during this time period increased to 6 to 29 *B. impatiens* workers (mean of 15) per 100 $m^2$ of garden floral area.

**Table 2.** Garden marking sites, garden area, and the total number of bees marked and recaptured within New York City community gardens from 21 August 2005 through 12 September 2005. Estimated bee abundance was determined using Shumacher's method.

| Community garden name | Garden area ($m^2$) | Total number of bees marked | Number of bees recaptured | Percent of bees recaptured | Estimated bee abundance per garden (95% confidence interval) | Bee density per 100 $m^2$ |
|---|---|---|---|---|---|---|
| Fordham Bedford Lot Busters | 1036 | 30 | 19 | 63% | 46 (29 - 105) | 4 |
| El Sitio Feliz (Union Settlement) | 1527 | 28 | 19 | 68% | 50 (37 - 76) | 3 |
| Holy Rosary Garden | 759 | 32 | 10 | 31% | 60 (48 - 79) | 8 |
| El Gallo Social Club | 640 | 27 | 8 | 30% | 99 (72 - 157) | 15 |
| Tremont Community Garden | 1651 | 45 | 23 | 51% | 108 (80 - 167) | 7 |
| Garden of Happiness | 1440 | 67 | 23 | 34% | 164 (116 - 279) | 11 |

## DISCUSSION

Pollination by bees and other pollinators has the potential to increase production of several crops commonly grown in community gardens of New York City, including peaches, apples, strawberries, tomatoes, peppers, cucumbers and zucchini. Although gardeners tend to recognize the general role of bees in crop production, few realize the degree to which certain crops benefit from pollination by bees and other insects (Matteson, personal observation). Therefore, it is important to promote increased awareness of the specific benefits provided to humans by urban pollinators. Furthermore, while gardeners have traditionally focused gardening efforts on watering, composting, fertilizing and weeding of vegetable beds, an additional activity that may contribute to a productive garden is management of the garden to increase bee diversity or abundance. Inclusion of garden pollinator conservation under the auspices of a productive garden may be an effective means of fostering greater involvement in urban ecology and conservation.

In addition, it is important to increase awareness of pollinators other than the European honey bee (*Apis mellifera*), particularly in non-agricultural settings such as cities where there are few managed honey bee colonies. Over 220 bee species have been documented in the New York City limits (Giles and Ascher 2006) with 54 species found specifically within New York City community gardens (Matteson et al. 2008). Many of these species are known to be important pollinators (see discussion below) and many are more abundant than *A. mellifera* in this system (Matteson et al. 2008). Specifically, the relative abundance of bumble bees in these gardens was more than five times greater than *A. mellifera* (Figure 1).

Our estimates of bumble bee abundance were surprisingly high, particularly given the urban locality and small sizes of the surveyed gardens (range of 640 to 2188 $m^2$). Specifically, we estimated that florally rich community gardens may be utilized by over 100 bumble bee workers, with a density of 8 bumble bees per 100 $m^2$ of garden area. In comparison, grassland habitats in Sweden were found to have a mean density of less than 1 bumble bee per 100 $m^2$ (Öckinger and Smith 2007). Similarly, relatively fewer bumble bees (4 to 5 per sampling date) were found in 400 $m^2$ plots within agricultural fields in England, UK (Carvell et al. 2004). This is not the only study to find an abundance of bumble bees in urban habitats. In a study of *Bombus terrestris* (Linnaeus, 1758), Goulson et al. (2002) found greater diversity of pollen and over all colony growth in suburban landscapes than in agricultural landscapes. In a genetic analysis, Chapman et al. (2003) estimated that urban cemeteries and public parks in London (each being roughly 1 ha in size) support over 50 separate bumble bee colonies and concluded that urban habitats support large bumble bee populations. The abundance of some bumble bees in urbanized landscapes may partially be due to the diversity and abundance of floral resources in gardens (Owen 1991) and other urban green spaces (Chapman et al. 2003).

We did not conduct supplementary hand pollination experiments or search vegetable beds for aborted fruits. Therefore, we cannot rule out the possibility that, despite the abundance of *B. impatiens* in these gardens, pollination by bees is a limiting service for crop production in these gardens. Nevertheless, our results suggest that there may be a sufficient abundance of bumble bees (in addition to other pollinating insects in urban gardens) to provide pollination services to many crops grown in community gardens. It is estimated that five bumble bee workers are needed to provide sufficient pollination for 100 $m^2$ of greenhouse tomatoes (Morandin et al. 2001), which is fewer than the minimum estimated worker abundance (6 per 100 $m^2$ of floral area) in these gardens. In addition, most community gardens are small relative to agricultural fields and few are intensively utilized for agricultural production, further suggesting that pollination services may not be limited in this setting.

Although some gardens were located within foraging range of each other (<500 m), no *B. impatiens* workers were found to move between gardens of their own accord in the mark-recapture experiment. We are not aware of any specific estimates of *B. impatiens* foraging range, but the maximum foraging range of four other bumble bee species in an agricultural landscape ranged from 449 m (for *B. pascuorum*) to 758 m (for *B. terrestris*) (Knight et al. 2005). While this suggests that *B. impatiens* may be capable of moving among gardens and other urban green spaces, optimal foraging theory suggests that bumble bees will gather the maximum amount of pollen attainable with minimum flight effort (Heinrich 1979). In addition, floral and patch constancy, whereby individual workers revisit the same flowers or area, is common in many bumble bee species and habitats (Bowers 1985; Heinrich 1979; Osborne and Williams 2001). *Bombus impatiens* is a generalist bumblebee (Heinrich 1979) and workers have been observed visiting both crop and ornamental flowers in these gardens. Because many ornamental garden flowers (e.g. marigolds, zinnias, coneflowers, sunflowers) bloom for relatively long periods, urban gardens may provide a relatively constant source of nectar and pollen. Similar to our results in the urban landscape, workers of *Bombus flavifrons* Cresson, 1863 in the Uinta Mountains of Utah were recaptured only in the meadow in which they were marked, despite proximity of the meadows to each other (Bowers 1985). It was concluded that the mountain meadows represented discrete systems of plant-pollinator interactions (Bowers 1985). This may also be the case for bumble bees in community gardens and other florally rich urban green spaces, at least over some time periods. Supporting this notion, a study in a Massachusetts suburb also found high levels of patch constancy of bumble bees, including *B. impatiens*, foraging on patches of flowering pepperbush (Bhattacharya et al. 2003).

We did not conduct a systematic search for bumble bee nests which may be inconspicuous even in heavily utilized garden habitats (Matteson, personal observation), particularly if located in tree cavities. Nevertheless, over the course of five years of data collection, no bumble bee nests were observed in these community gardens or reported to us by the gardeners that actively manage these sites. In addition, bumble bees were often observed to fly up and away from gardens after foraging on flowers within gardens, suggesting that bumble bee nests are located outside of gardens. Bumble bees are known to use tree cavities and rodent burrows for colony nesting sites (Kearns and Thomson 2001). Nesting sites in street trees or trees in other urban green spaces may be less likely to be disturbed by humans, relative to nests within gardens in burrows in the ground. Alternately, bumble bees may be dependent on larger urban parks for relatively undisturbed ground nesting sites (McFrederick and Lebuhn 2006). Several large city parks and green spaces (including the Bronx Zoo, the New York Botanical Garden, Crotona Park, Central Park and Marcus Garvey Park) were located between 100 and 700 m from the community gardens of this study. Therefore, depending on the foraging capabilities of *B. impatiens* in the urbanized landscape, workers may 'commute' from colonies located in parks or other urban green spaces (e.g. vacant lots, greenways, etc.) to forage in florally rich urban garden patches.

Several other insects, besides *B. impatiens*, may be important pollinators in urban community gardens of New York City. Although less abundant overall, *Bombus griseocollis* (DeGeer, 1773) is abundant earlier in the growing season (May-June, as opposed to *B. impatiens* which peaks from late June through August) and therefore may be an important pollinator of early flowering crops. In addition, three leaf-cutter bees (Megachilidae) were especially abundant in these gardens (Matteson et al. 2008). These include (in order of abundance in the community gardens), *Megachile centuncularis* (Linnaeus, 1758), *M. texana* Cresson, 1878 and the introduced alfalfa leaf-cutter bee, *M. rotundata* (Fabricius, 1793) (Matteson et al. 2008). Leaf-cutter bees are medium-sized bees that carry pollen on the ventral side of their abdomen, thereby easily transmitting pollen to female flowers. Small-bodied bees (*Lasioglossum*, *Hylaeus*, *Ceratina*) also were abundant in these gardens (Matteson et al. 2008) and New York City parks (Yurlina 1998) but may be less efficient pollinators on a per visit basis because they carry less pollen and are less likely to come into contact with anthers and/or stigmas (Kandori 2002). *Hylaeus spp.* (Colletidae) may be especially inefficient pollinators because they transport pollen internally (in their crop) and have relatively few body hairs and no external pollen-transmitting structures (Michener 2000). Nevertheless, 'inefficient pollinators' may still be important to the reproductive success of plants if the pollinators are extremely abundant (Olsen 1997) as is the case with these groups in NYC community gardens and parks. Finally, other insects such as butterflies, flies and some wasps may be important pollinators in this



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system. In particular, flower flies (Diptera: Syrphidae) were observed on a variety of flowers in these community gardens and were particularly abundant during cooler days when bees were less active (Matteson, personal observation). More studies, specifically linking abundance and diversity of urban pollinators to pollen movement among crop and other flowers, will add to our understanding of the ecosystems service of pollination within cities.

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