

# The Bee Fauna of Residential Gardens in a Suburb of New York City (Hymenoptera: Apoidea)

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**ABSTRACT** As suburban landscapes expand, it is critical to understand their capacity to support wildlife. Pollinators, specifically bees (Hymenoptera: Apoidea: Anthophila), are to some degree compatible with urbanization and may be able to exist in suburbs in diverse assemblages. We surveyed 21 residential gardens for bees in Westchester County, a suburban area immediately north of New York City. From a sample of 1,675 individuals, we documented 110 species, of which 95% were native, 50% were solitary, and 93% were polylectic. In terms of abundance of specimens, eusocial (50% of specimens), native (97%), and polylectic (98%) bees were dominant. Contrary to our expectation, based on previous bee surveys in urban landscapes, the bee community documented was not depauperate in either soil-nesting or parasitic species (65 and 19% of species, respectively), nor was it enriched in exotic species (6% of species). Instead, the assemblage resembled the richer bee fauna documented at a 1,520-ha research preserve (forest) located in the same region, although certain specialist (oligolectic) and/or forest-associated species were absent. These results suggest that suburban landscapes in eastern North America have the potential to host relatively diverse and intact bee communities.

**KEY WORDS** suburban development, bee conservation, soil-nesting species, biodiversity, parasitic bees

Evidence is accumulating that both managed and wild honey bee and native bee populations are in decline (Kearns et al. 1998, Biesmeijer et al. 2006, Committee on the Status of Pollinators in North America, National Research Council 2007, Stokstad 2007). Unlike some taxa with habitat requirements incompatible with human development, many bees can persist in metropolitan areas (Saure 1996, McIntyre and Hostetler 2001, Tommasi et al. 2004, Cane 2005, Frankie et al. 2005, Cane et al. 2006, Hisamatsu and Yamane 2006, McFrederick and LeBuhn 2006; Matteson et al. 2008). Suburban areas in particular may be more favorable than urban landscapes for many bee species because they may retain habitat features that bees require for nesting and are enhanced in floral resources in the form of residential gardens.

Suburbs are defined as primarily residential areas, characterized by single-family homes and associated support services, located on the urban–rural fringe (DeStefano et al. 2005). These areas are expanding rapidly, subsuming the natural habitat upon which bees and other groups previously relied. Although metropolitan areas (each composed of a core [urban]

area containing a substantial population nucleus, together with adjacent [suburban] communities having a high degree of economic and social integration with that core; U.S. Census Bureau 2005) are expanding in general, suburbs comprise the majority of this growth. Between 1990 and 1998, human populations in U.S. suburbs grew by 11.9%, whereas U.S. central city populations grew 4.7% (U.S. Department of Housing and Urban Development 1999). The rate of habitat conversion attributable to suburban expansion is even more pronounced: between 1994 and 1997, land consumption in the United States grew at double the rate of population growth, and much of this growth was attributable to one acre plus lots on the suburban fringe (U.S. Department of Housing and Urban Development 1999). In the face of this rapid land conversion on the growing edge of metropolitan areas, it is vital to understand the viability of suburban landscapes as habitat for native taxa.

Gardens represent potentially rich manmade habitats for bees. Because nearly all eusocial and many solitary bees are polylectic (Waser et al. 1996, Minckley and Roulston 2006), capable of gathering pollen from a broad array of plant species, even exotic ornamental plants can provide food resources to many bee species (Frankie et al. 2005). In addition, gardens may contain materials and sites for nesting, such as bare soil, leaves, dead stems, and cavities in artificial structures. Because of the potential for gardens to support bees and other pollinators, conservation and

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gardening organizations recommend strategies for managing pollinator gardens (Shepherd et al. 2003). Nevertheless, only a few bee surveys have been conducted in U.S. gardens (McIntyre and Hostetler 2001, Frankie et al. 2005, Matteson et al. 2008), and none have examined gardens in a specifically suburban context in eastern North America.

The ecological character of the bee communities found in urban gardens reflects the nature of the resources available in urban landscapes. For example, the proportion of soil-nesting species tends to be reduced relative to cavity-nesters in urban landscapes (Cane 2005, Matteson et al. 2008), perhaps due to soil compaction, the maintenance of lawns to eliminate bare patches, or both. In addition, parasitic bee species can be less common in urban gardens than in more natural areas (Matteson et al. 2008), possibly due to inadequate populations of hosts (Cane 2005). Urban habitats also can harbor unusually large numbers of exotic bee species (Matteson et al. 2008), perhaps because these species in general have a propensity to nest in artificial structures and to visit exotic plants, and because high levels of commerce increase the probability of introduction and establishment.

The aim of this study was three-fold: 1) to record the bee species hosted by residential gardens in a suburban county adjacent to New York City, 2) to evaluate the ecological characteristics of these bee species, and 3) to draw comparisons between the suburban bee fauna and the bee fauna of nearby urban and natural areas. In this article, we classify the five boroughs of New York City, excluding large parks and preserves, such as Gateway National Recreation Area and Jamaica Bay National Wildlife Refuge, as urban, and landscapes that largely lack direct modification by humans as natural. Because suburban landscapes exhibit habitat features of both urban and natural landscapes, we expected bee richness and the ecological characteristics of the bee community to be intermediate between the two. Specifically, we hypothesized that the abundance of cleptoparasitic and soil-nesting species would be reduced in suburban gardens, relative to their numbers in undeveloped landscapes, but not to the extent seen in urban areas. We also hypothesized that exotic species in suburban gardens would be relatively more numerous than in natural areas, but less numerous than in urban areas.

This article can be viewed as a companion piece to Matteson et al. (2008) because it furthers the work of that study to synthesize patterns of bee occurrence in gardens and other manmade habitats in the greater New York City area.

### Materials and Methods

Bees were collected in 21 residential gardens in Westchester County, NY, the county immediately north of New York City. All gardens were privately owned and occurred on lots ranging from 0.06 to 1.27 ha. During 21 July through 5 August 2006 and during 21 July through 3 August 2007, all plants in flower in all gardens were identified to genus, based on gar-

**Table 1.** Herbaceous plants and woody shrubs commonly visited by bees in residential gardens located in Westchester County, NY

Plant family	Plant genus
Apiaceae	<i>Coriandrum</i>
Apiaceae	<i>Foeniculum</i>
Asteraceae	<i>Achillea</i> <sup>c</sup>
Asteraceae	<i>Aster</i> <sup>bc</sup>
Asteraceae	<i>Chrysanthemum</i>
Asteraceae	<i>Coreopsis</i> <sup>c</sup>
Asteraceae	<i>Echinacea</i> <sup>c</sup>
Asteraceae	<i>Echinops</i>
Asteraceae	<i>Erigeron</i> <sup>bc</sup>
Asteraceae	<i>Eurybia</i> <sup>bc</sup>
Asteraceae	<i>Helianthus</i> <sup>c</sup>
Asteraceae	<i>Liatris</i> <sup>c</sup>
Asteraceae	<i>Rudbeckia</i> <sup>bc</sup>
Cucurbitaceae	<i>Cucurbita</i>
Geraniaceae	<i>Geranium</i> <sup>bc</sup>
Hydrangeaceae	<i>Hydrangea</i> <sup>a</sup>
Lamiaceae	<i>Lamium</i>
Lamiaceae	<i>Lavandula</i>
Lamiaceae	<i>Mentha</i>
Lamiaceae	<i>Monarda</i> <sup>bc</sup>
Lamiaceae	<i>Nepeta</i>
Lamiaceae	<i>Perovskia</i>
Lamiaceae	<i>Salvia</i> <sup>c</sup>
Lamiaceae	<i>Thymus</i>
Malvaceae	<i>Hibiscus</i>
Malvaceae	<i>Malva</i>
Onagraceae	<i>Oenothera</i> <sup>bc</sup>
Primulaceae	<i>Lysimachia</i>
Ranunculaceae	<i>Cimicifuga</i> <sup>bc</sup>
Scrophulariaceae	<i>Veronica</i>
Scrophulariaceae	<i>Veronicastrum</i> <sup>bc</sup>
Solanaceae	<i>Solanum</i>

<sup>a</sup> Specifically *H. macrophylla*. Other *Hydrangea* varieties were not commonly visited by bees.

<sup>b</sup> Included one or more species native to the New York metropolitan area. Designations based on BBG (2008).

<sup>c</sup> Included one or more species native to the continental United States. Designations based on USDA-NRCS (2008).

dener records with verification by using Bryant (2003). The gardens were largely characterized by perennial flowering plants, such as *Geranium*, *Rudbeckia*, *Spiraea*, *Rhododendron*, *Coreopsis*, and *Dahlia*. Several gardens also contained vegetable and herb plots. Although some gardens contained bee-pollinated spring-flowering trees, primarily *Prunus* and *Malus*, most flowering in the gardens occurred from late May through late September. Although some gardens contained a few plants species native to the northeastern United States, such as *Asclepias tuberosa* L., *Aster novae-angliae* L., *Actaea racemosa* L., and *Aquilegia canadensis* L., most plantings were ornamentals of European origin widely available in nurseries throughout northeastern United States. A list of the flowering herbaceous plants and flowering woody shrubs visited by bees and commonly occurring in the surveyed gardens is given in Table 1.

Most of the study site gardens were set within yards characterized by large tracts of well-manicured lawn. All yards contained deciduous shade trees, such as *Acer* and *Quercus*, but the canopy above the garden itself was in almost all cases open. The properties varied in use of herbicides, pesticides, and commercial fertilizers.

The landscape matrix surrounding the gardens was primarily residential, ranging from very low (less than five houses, apartments, or condos per ha) to high density (>50 houses, apartments, and condos per ha). In low-density areas, large segments of the landscape were comprised of privately and/or publicly owned second-growth eastern deciduous forest. Several of the high-density neighborhoods were located within the city boundaries of White Plains and New Rochelle, which in 2000 had human population densities of 2091 and 2692 people per km<sup>2</sup> respectively (U.S. Census Bureau 2000). Although the specific neighborhoods where the study gardens were located are by local standards considered suburban, it is important to recognize that some of these neighborhoods might be considered as urban in regions far less developed than the greater New York City metropolitan area. Housing in all neighborhoods was almost exclusively single-family unattached homes with yards, many of which contained flowering plants. For our study sites, however, we chose gardens that were large (range, 170–1800 m<sup>2</sup>; mean, 600 m<sup>2</sup>) and planted with an abundance and diversity of perennial flowering plants, to survey the maximum diversity of bees.

Bee collections were made in two ways: via water pan traps and hand collections. Water pan traps were 460-ml plastic bowls (Greenbrier International, Inc., Chesapeake, VI), each painted with white, fluorescent yellow, or fluorescent blue paint (Risk Reactor, Inc., Huntington Beach, CA). These traps were placed on the ground, dispersed singly throughout each study site, randomized as to color. They were filled with water and a drop of unscented Dawn dish soap (Proctor and Gamble, Cincinnati, OH) to act as a surfactant. After 24 h, the traps were retrieved, and the contents poured through a strainer (0.3-mm mesh size) and stored in 70% ethanol. Hand collections of bees on flowers were made using vials and jars. Netting was avoided to prevent damage to ornamental plantings. Hand-collected bees were stored in a cooler in the field and then transferred to a freezer for a minimum of 3 d before pinning.

Due to frequent lawn mowing, and in some cases herbicide treatment, lawn flowers were sparse at the study sites. Accordingly, during most of our sampling rounds, bees focused their foraging activity in flowerbeds (E.D.F., unpublished data). Our one springtime sampling round represented an exception to this, because during this period, bees were found foraging mostly at flowering trees. As a result, we sampled more intensively at flowerbeds than on lawns, as follows: We calculated pan trap numbers for each garden by allotting one trap for each 0.1 ha of lawn and one trap for each 125 m<sup>2</sup> of flowerbed. Hand collections were made for 24 min per 0.1 ha of flowerbed (within flowerbeds) and 3 min per 0.1 ha of lawn (within lawns). Sampling at springtime flowering trees was restricted to passive sampling via water pan traps.

All bees collected by pan traps or hand-collections were pinned by E.D.F. and Max Wagner, Louis Calder Biological Field Station, Fordham University in Armonk, NY. Identifications were made primarily by

J.S.A.; some *Nomada* and female *Lasioglossum* (*Dialictus*) specimens were identified by Sam Droege, and *Triepeolus* was identified by Molly G. Rightmyer. A synoptic collection is maintained at the Louis Calder Biological Field Station of Fordham University. Voucher specimens were deposited in the collection of the American Museum of Natural History (New York, NY).

Sampling occurred over the course of 3 yr, as follows: pan traps were used at each site once in 2005 (August), four times in 2006 (early June, late June, late July, and October), and twice in 2007 (early May and late July). Hand collections were made once in August 2005, once each in late July and October 2006, and once in late July 2007. In total, 1,081 pan traps were deployed and 32.5 h were spent hand collecting.

Ecological characteristics of each bee species were compiled from primary literature, catalogs, and revisions, following the format of Giles and Ascher (2006) and Matteson et al. (2008). Accordingly, bees were classified as follows: 1) native or exotic to North America; 2) polylectic or oligolectic; 3) nesting in soil, hard wood, soft wood, pith, cavities, or hives; and 4) solitary, subsocial, eusocial, or parasitic. The parasitic designation included both cleptoparasitic and social parasitic species. All bees that normally restrict their pollen gathering to a single genus or single family of plants were considered oligolectic; no attempt was made to quantify degree of oligolecty. In certain cases where species-specific ecological data were lacking, characteristics were inferred from those of closely related congeners.

Species richness was calculated as the total number of species documented across all 21 surveyed gardens. Three putative species, identified as *Lasioglossum* (*Dialictus*) sp. 1, *Nomada* form H, and *Nomada* form K, were included in the species richness calculation. All other unidentified or ambiguous species were excluded. Specimens classified as *Lasioglossum* sp. 1 exhibited characteristics of both *L. rohweri* (Robertson) and *L. lineatulum* (Crawford). This form has been found throughout the northeastern United States and may represent a distinct species (S. Droege, personal communication). *Nomada* form H resembled *N. bella* Cresson, *N. lepida* Cresson, and *N. ovata* (Robertson), but it could not be definitively classified as any of these three species. Likewise, *Nomada* form K resembled *N. perplexa* Cresson, but it could not be definitively identified. Abundance for each species was calculated as the sum of all individuals of that species collected using both sampling techniques. In addition, the percentage of all collected specimens belonging to each species and the frequency of occurrence of each species (i.e., percentage of gardens in which a species was documented) were determined.

To provide a context for the Westchester suburban garden bee community (current study; abbreviated henceforth as WSG), qualitative comparisons were made with two reference faunas, as well as the regional species pool.

*Black Rock Forest (BRF)*. BRF is a 1,520-ha forested research preserve located in Orange County, ≈40 km

northwest of Westchester County and  $\approx 80$  miles north of New York City. The landscape is comprised mostly of upland hardwood forest dominated by *Quercus* spp. (Barringer and Clemants 2003) and includes bee habitat in the form of spring-blooming forest understory wildflowers, small meadows, exposed road and reservoir edges, dams, and marshes. A survey at BRF in 2003 used a combination of pan traps, hand netting, and trap-nests (the latter yielding very few bees) (Giles and Ascher 2006).

*New York City Community Gardens (NYCG)*. Nineteen community gardens located in highly urban areas of the Bronx and East Harlem (upper Manhattan), NY, were sampled for bees during the growing seasons of 2003–2005, by using pan traps and hand netting (Matteson et al. 2008). The gardens ranged from  $\approx 200$  to 2000 m<sup>2</sup> and were planted with both native and exotic ornamentals and crop plants. The landscape surrounding the gardens, although varying among gardens in percentage of green space, was composed largely of abiotic elements, such as streets and apartment buildings.

*Southern New York Regional Pool*. This species list draws from the five boroughs of New York City (NYC), Long Island (Suffolk County), and seven counties north of NYC: Dutchess, Orange, Putnam, Rockland, Sullivan, and Ulster, in addition to Westchester. It represents a compilation by J.S.A. of historic and contemporary insect collections housed at the American Museum of Natural History (AMNH), the Cornell University Insect Collection, and Parker Gambino's personal collection (affiliated with AMNH). The natural ecosystems of this region are characterized by broad-leaved oak–hickory forest and, in its northern reaches, hardwood forest dominated by aspen and birch.

Comparisons were made among the three locale-specific faunas (WSG, BRF, and NYCG) concerning species richness and the frequency of the ecological characteristics listed above. The calculations for frequencies of nest habits and floral specificities were made in two ways: first, with parasitic species included as 1) nesting in the substrate of their hosts and 2) polylectic; and second, with parasitic species excluded. The results of these two methods of calculation were very similar; so, frequencies based on the first method are reported unless otherwise noted. The Chao one estimate of true species richness was calculated for each of these three data sets, by using Estimate S software, version 8.0.0 (Colwell 2006). Differences in sampling methodologies prevented statistical comparisons between the three bee faunas (WSG, BRF, and NYCG); nevertheless, qualitative comparisons among them can provide insight into patterns in bee species occurrence and the ecological factors underlying them. Comparisons were also made to the southern New York species list to examine the extent to which the WSG fauna reflected the regional species pool. It is important to bear in mind that the regional data set differs markedly from the three locale-specific data sets in breadth of geographic coverage and in the time period over which the data were

collected. In particular, the regional data set includes numerous species that have been documented with great rarity.

## Results

**Composition of Suburban Garden Bee Fauna.** In all, 1,675 bee specimens, representing the five bee families commonly occurring in the northeastern United States, were collected. The observed species count was 110 (Table 2); the Chao 1 species richness estimate was 145 species. The collection was characterized by a large number of rarely occurring species and a few common species. Of the 110 species, 47 (43% of collected species) were singletons (30%) or doubletons (13%). Three identifiable forms—the sweat bee *Lasioglossum tegulare* (Robertson), the bumble bee *Bombus impatiens* Cresson, and the small carpenter bees *Ceratina calcarata* Robertson and/or *dupla* Say (females of these could not be distinguished)—were each represented by >100 specimens. Together, these three forms made up 25% of all collected specimens. Several halictid species were collected in lesser numbers but occurred in a high proportion ( $\geq 66\%$ ) of the surveyed gardens: *Halictus confusus* Smith, *H. ligatus* Say, *Augochlora pura* (Say), and *Agapostemon virescens* (F.).

The ecological characteristics of the documented bee community are presented in Table 3. In general, there was a strong correspondence between the number of species in any particular ecological grouping and the abundance of collected individuals belonging to that grouping. Most bees were native (94% of species, 97% of individuals), soil-nesting (65% of species, 64% of individuals), and polylectic (93% of species, 98% of individuals). When parasitic species were excluded from the nest substrate and floral specificity calculations, the results were similar: soil-nesting bees composed 63% of species and 58% of individuals, and polylectic bees composed 91% of species and 98% of individuals. Although more recorded species were solitary, rather than any other lifestyle (48% of species), solitary individuals were outnumbered by eusocial individuals (25 versus 49% of individuals). The best-represented families were Halictidae (35% of species, 53% of individuals) and Apidae (29% of species, 33% of individuals). Bees in the family Colletidae were scarce (4% of species, 3% of individuals).

Oligolectic species, which collect pollen from within a single family or genus of plants, made up a small proportion of the suburban bee community (7% of species, but only 2% of individuals). Notable among the oligoleges was *Lasioglossum (Evyllaesus) oenotherae* (Stevens) (also known as *Sphecodagastra oenotherae*), a specialist on Onagraceae and dependent for pollen in parts of its range on garden plantings of *Oenothera biennis* L. (Knerer and MacKay 1969). *Andrena arabis* Robertson, oligolectic on Brassicaceae, may use garlic mustard [*Allaria petiolata* (Bieberstein)], an exotic invasive herb that is ubiquitous in Westchester County during the spring flight season of this bee. Several other oligolectic bees found specialize on Asteraceae: *Melissodes agilis* Cresson, *M. subillata*

Table 2. Bee species occurring in 21 suburban residential gardens, in Westchester County, NY, 2005–2007

Species	Abundance	% Individuals <sup>a</sup>	% Gardens where present	Native vs exotic	Pollen specificity <sup>a</sup>	Nest substrate <sup>a</sup>	Sociality <sup>a</sup>
<i>Colletes inaequalis</i> Say, 1837	2	0.1	9.5	N	P	S	S
<i>Hylaeus (Hylaeus) mesillae</i> (Cockerell, 1896)	3	0.2	9.5	N	P	C	S
<i>Hylaeus (Prosopis) modestus</i> Say, 1837	7	0.4	19.0	N	P	C	S
<i>Hylaeus (Prosopis) modestus</i> Say, 1837 [or <i>affinis</i> (Smith, 1853)] females	26	1.5	38.1	N	P	C	S
<i>Hylaeus (Spatulariella) hyalinatus</i> Smith, 1842	7	0.4	9.5	E	P	C	S
<i>Augochlorella aurata</i> (Smith 1853), [= <i>striata</i> (Provancher 1888)]	43	2.6	42.9	N	P	S	E
<i>Augochlora (Augochlora) pura</i> (Say, 1837)	42	2.5	66.7	N	P	SW	S
<i>Agapostemon (Agapostemon) sericeus</i> (Förster, 1771)	2	0.1	4.8	N	P	S	S
<i>Agapostemon (Agapostemon) virescens</i> (F., 1775)	66	3.9	66.7	N	P	S	S
<i>Sphecodes cressonii</i> (Robertson, 1903)	2	0.1	9.5	N	[P]	[S]	CP
<i>Halictus (Odontalictus) ligatus</i> Say 1837	73	4.4	71.4	N	P	S	E
<i>Halictus (Prothaliclus) rubicundus</i> (Christ, 1791)	9	0.5	38.1	N	P	S	E
<i>Halictus (Seladonia) confusus</i> Smith, 1853	57	3.4	81.0	N	P	S	E
<i>Lasioglossum (Lasioglossum) coriaceum</i> (Smith, 1853)	10	0.6	28.6	N	P	S	S
<i>Lasioglossum (Lasioglossum) fuscipenne</i> (Smith, 1853)	1	0.1	4.8	N	P	S	S
<i>Lasioglossum (Dialictus) admirandum</i> (Sandhouse, 1924)	12	0.7	28.6	N	P	S	E
<i>Lasioglossum (Dialictus) bruneri</i> (Crawford, 1902)	23	1.4	57.1	N	P	S	E
<i>Lasioglossum (Dialictus) cellatae</i> (Ellis, 1913)	6	0.4	19.0	N	P	S	E
<i>Lasioglossum (Dialictus) cephalotes</i> (Dalla Torre, 1896)	1	0.1	4.8	N	[P]	[S]	SP
<i>Lasioglossum (Dialictus) coeruleum</i> (Robertson, 1893)	8	0.5	23.8	N	P	SW	E
<i>Lasioglossum (Dialictus) coreopsis</i> (Robertson, 1902)	1	0.1	4.8	N	P	S	E
<i>Lasioglossum (Dialictus) cressonii</i> (Robertson, 1890)	19	1.1	42.9	N	P	SW	E
<i>Lasioglossum (Dialictus) foxii</i> (Robertson, 1895)	1	0.1	4.8	N	P	S	S
<i>Lasioglossum (Dialictus) heterognathum</i> (Mitchell, 1960)	1	0.1	4.8	N	P	S	E
<i>Lasioglossum (Dialictus) illinoense</i> (Robertson, 1892)	51	3.0	42.9	N	P	S	E
<i>Lasioglossum (Dialictus) imitatum</i> (Smith, 1853)	28	1.7	23.8	N	P	S	E
<i>Lasioglossum (Dialictus) laevissimum</i> (Smith, 1853)	10	0.6	23.8	N	P	S	E
<i>Lasioglossum (Dialictus) lineatulum</i> (Crawford, 1906)	21	1.3	28.6	N	P	S	E
<i>Lasioglossum (Dialictus) nymphaeorum</i> (Robertson, 1895)	4	0.2	9.5	N	P	S	E
<i>Lasioglossum (Dialictus) oblongum</i> (Lovell, 1905)	58	3.5	85.7	N	P	SW	E
<i>Lasioglossum (Dialictus) obscurum</i> (Robertson, 1892)	15	0.9	33.3	N	[P]	[S]	—
<i>Lasioglossum (Dialictus) pectorale</i> (Smith, 1853)	6	0.4	14.3	N	P	S	S
<i>Lasioglossum (Dialictus) rohweri</i> (Ellis, 1915)	57	3.4	61.9	N	P	S	E
<i>Lasioglossum (Dialictus) tegulare</i> (Robertson, 1890)	147	8.8	61.9	N	P	S	E
<i>Lasioglossum (Dialictus) versans</i> (Lovell, 1905)	8	0.5	14.3	N	P	S	E
<i>Lasioglossum (Dialictus) zephyrum</i> (Smith, 1853)	1	0.1	4.8	N	P	S	E
<i>Lasioglossum (Dialictus) sp. 1</i>	20	1.2	52.4	[N]	—	—	—
<i>Lasioglossum (Dialictus) undet. (metallic)</i>	46	2.7	81.0	N	—	—	—
<i>Lasioglossum (Evylaeus) cinctipes</i> (Provancher, 1888)	2	0.1	9.5	N	P	S	E
<i>Lasioglossum (Evylaeus) macoupinense</i> (Robertson, 1895)	2	0.1	9.5	N	P	S	S
<i>Lasioglossum (Evylaeus) oenotherae</i> (Stevens, 1920)	7	0.4	23.8	N	O	S	S
<i>Lasioglossum (Evylaeus) quebecense</i> (Crawford, 1907)	29	1.7	38.1	N	P	S	S
<i>Lasioglossum (Evylaeus) truncatum</i> (Robertson, 1901)	1	0.1	4.8	N	P	S	E
<i>Lasioglossum (Paralictus) platyparium</i> (Robertson, 1895)	1	0.1	4.8	N	[P]	[S]	SP
<i>Andrena (Andrena) frigida</i> Smith, 1853	3	0.2	14.3	N	O	S	S
<i>Andrena (Andrena) mandibularis</i> Robertson, 1892	1	0.1	4.8	N	P	S	S
<i>Andrena (Andrena) tridens</i> Robertson, 1902	3	0.2	9.5	N	P	S	S
<i>Andrena (Holandrena) cressonii</i> Robertson, 1891	6	0.4	19.0	N	P	S	S
<i>Andrena (Larandrena) miserabilis</i> Cresson, 1872	13	0.8	38.1	N	P	S	S
<i>Andrena (Leucandrena) barbilabris</i> (Kirby, 1802)	1	0.1	4.8	N	P	S	S
<i>Andrena (Melandrena) carlini</i> Cockerell, 1901	20	1.2	38.1	N	P	S	S
<i>Andrena (Melandrena) commoda</i> Smith, 1879	1	0.1	4.8	N	P	S	S
<i>Andrena (Melandrena) pruni</i> Robertson, 1891	3	0.2	9.5	N	P	S	S
<i>Andrena (Melandrena) vicina</i> Smith, 1853	1	0.1	4.8	N	P	S	S
<i>Andrena (Micrandrena) neonana</i> Viereck, 1917	1	0.1	4.8	N	P	S	S
<i>Andrena (Scaphandrena) arabis</i> Robertson, 1897	7	0.4	4.8	N	P*	S	S
<i>Andrena (Scrapteropsis) alleghaniensis</i> Viereck, 1907	2	0.1	4.8	N	P	S	S
<i>Andrena (Scrapteropsis) imitatrix</i> Cresson, 1872	1	0.1	4.8	N	P	S	S
<i>Andrena (Scrapteropsis) morrisonella</i> Viereck, 1917	1	0.1	4.8	N	P	S	S
<i>Andrena (Simandrena) nasonii</i> Robertson, 1895	53	3.2	61.9	N	P	S	S
<i>Andrena (Taeniandrena) wilkella</i> (Kirby 1802)	3	0.2	9.5	E	P	S	S

Continued on following page

Table 2. Continued

Species	Abundance	% Individuals <sup>a</sup>	% Gardens where present	Native vs exotic	Pollen specificity <sup>a</sup>	Nest substrate <sup>a</sup>	Sociality <sup>a</sup>
<i>Calliopsis (Calliopsis) andreniformis</i> Smith, 1853	19	1.1	28.6	N	P	S	S
<i>Anthidium (Anthidium) manicatum</i> (Linnaeus, 1758)	6	0.4	19.0	E	P	C	S
<i>Heriades (Neotrypetes) carinatus</i> Cresson, 1864	1	0.1	4.8	N	P	C	S
<i>Chelostoma (Prochelostoma) philadelphia</i> (Robertson, 1891)	1	0.1	4.8	N	P	C	S
<i>Hoplitis (Alcidamea) pilosifrons</i> (Cresson, 1864)	1	0.1	4.8	N	P	P	S
<i>Hoplitis (Alcidamea) producta</i> (Cresson, 1864)	4	0.2	14.3	N	P	P	S
<i>Osmia (Melanosmia) pumila</i> Cresson, 1864	14	0.8	33.3	N	P	C	S
<i>Osmia (Osmia) cornifrons</i> (Radoszkowski, 1887)	8	0.5	28.6	E	P	C	S
<i>Osmia (Osmia) lignaria</i> Say, 1837	1	0.1	4.8	N	P	C	S
<i>Megachile (Chelostomoides) campanulae</i> (Robertson, 1903)	2	0.1	9.5	N	P	[C]	S
<i>Megachile (Eutricharaea) rotundata</i> (Fabricius, 1793)	2	0.1	4.8	E	P	C	S
<i>Megachile (Litomegachile) mendica</i> Cresson, 1878	1	0.1	4.8	N	P	C	S
<i>Megachile (Megachile) centumularis</i> , (Linnaeus, 1758)	3	0.2	9.5	N*	P	C	S
<i>Megachile (Sayapis) inimica</i> Cresson, 1872	1	0.1	4.8	N	P	C	S
<i>Megachile (Sayapis) pugnata</i> Say, 1837	2	0.1	9.5	N	P*	C	S
<i>Megachile (Xanthosarus) addenda</i> Cresson, 1878	1	0.1	4.8	N	P	S	S
<i>Megachile (Xanthosarus) gemula</i> Cresson, 1878	2	0.1	9.5	N	P	—	S
<i>Coelioxys (Boreocoelioxys) sayi</i> Robertson, 1897	3	0.2	14.3	N	[P]	[C]	CP
<i>Coelioxys (Cyrtocoelioxys) modesta</i> Smith, 1854	1	0.1	4.8	N	[P]	[C]	CP
<i>Xylocopa (Xylocopoides) virginica</i> (L., 1771)	14	0.8	42.9	N	P	W	B
<i>Ceratina (Zadontomerus) calcarata</i> Robertson, 1900	20	1.2	42.9	N	P	P	B
<i>Ceratina (Zadontomerus) calcarata</i> Robertson, 1900 or <i>dupla</i> Say, 1837 females	161	9.6	100	N	P	P	B
<i>Ceratina (Zadontomerus) dupla</i> Say, 1837	1	0.1	4.8	N	P	P	B
<i>Ceratina (Zadontomerus) strenua</i> Smith, 1879	46	2.7	57.1	N	P	P	—
<i>Nomada articulata</i> Smith, 1854	4	0.2	14.3	N	[P]	[S]	CP
<i>Nomada cressonii</i> Robertson, 1893	2	0.1	4.8	N	[P]	[S]	CP
<i>Nomada denticulata</i> Robertson, 1902	1	0.1	4.8	N	[P]	[S]	CP
<i>Nomada dreisbachi</i> Mitchell, 1962	1	0.1	4.8	N	[P]	[S]	CP
<i>Nomada form H (cf. bella, lepida, or ovata)</i>	1	0.1	4.8	N	[P]	[S]	CP
<i>Nomada form K (cf. perplexa)</i>	3	0.2	9.5	N	[P]	[S]	CP
<i>Nomada illinoensis</i> Robertson, 1900	1	0.1	4.8	N	[P]	[S]	CP
<i>Nomada imbricata</i> Smith, 1854	3	0.2	14.3	N	[P]	[S]	CP
<i>Nomada inepta</i> Mitchell, 1962	1	0.1	4.8	N	[P]	[S]	CP
<i>Nomada luteoloides</i> Robertson, 1895	8	0.5	14.3	N	[P]	[S]	CP
<i>Nomada maculata</i> Cresson, 1863	25	1.5	42.9	N	[P]	[S]	CP
<i>Nomada (Nomada) ovata</i> (Robertson, 1903)	2	0.1	9.5	N	[P]	[S]	CP
<i>Nomada pygmaea</i> Cresson, 1863	7	0.4	14.3	N	[P]	[S]	CP
<i>Nomada (ruficornis species group) undet.</i>	2	0.1	9.5	N	[P]	[S]	CP
<i>Triepeolus cressonii</i> (Robertson, 1897)	1	0.1	4.8	N	[P]	[S]	CP
<i>Melissodes (Eumelissodes) agilis</i> Cresson, 1878	1	0.1	4.8	N	O	S	S
<i>Melissodes (Eumelissodes) denticulata</i> Smith, 1854	7	0.4	4.8	N	O	S	S
<i>Melissodes (Eumelissodes) subillata</i> LaBerge 1961	2	0.1	9.5	N	O	S	S
<i>Peponapis (Peponapis) pruinosa</i> (Say, 1837)	1	0.1	4.8	N	O	S	S
<i>Anthophora (Clisodon) terminalis</i> Cresson, 1869	2	0.1	9.5	N	P	SW	S
<i>Bombus (Thoracobombus) fervidus</i> (Fabricius, 1798)	1	0.1	4.8	N	P	H	E
<i>Bombus (Psithyrus) citrinus</i> (Smith, 1854)	44	2.6	66.7	N	P	[H]	SP
<i>Bombus (Pyrobombus) bimaculatus</i> Cresson 1863	13	0.8	33.3	N	P	H	E
<i>Bombus (Pyrobombus) impatiens</i> Cresson 1863	108	6.4	95.2	N	P	H	E
<i>Bombus (Pyrobombus) perplexus</i> Cresson, 1863	22	1.3	42.9	N	P	H	E
<i>Bombus (Pyrobombus) vagans</i> Smith, 1854	3	0.2	14.3	N	P	H	E
<i>Bombus (Cullumanobombus) griseocollis</i> (DeGeer 1773)	7	0.4	23.8	N	P	H	E
<i>Apis (Apis) mellifera</i> L., 1758	31	1.8	61.9	E	P	H	E

Abundance: total number of specimens collected across all sites and all years. % of individuals: percentage of total collection identified as this species ( $n = 1675$ ). Native vs. exotic: native or exotic to North America, based on Cane (2003); N\* indicates putative native status (see Giles and Ascher 2006; see also Matteson et al. 2008, table 2, footnote H). Pollen specificity: classification as either polylectic (collecting pollen from multiple plant families) or oligolectic (collecting pollen from a single plant family or genus); [P] indicates parasitic species that do not collect pollen; P\* indicates species that gather pollen from multiple plant families across their geographic range but that may be functionally oligolectic at these study sites; dashes (—) indicate attribute is unknown. Nest substrate: classification of the nest substrate of each nonparasitic species as C, cavity, H, hive, P, pith, S, soil, SW, soft/rotting wood, and W, wood; letters in brackets ([ ]) indicate the nest substrate of the host of a parasitic species; dashes (—) indicate attribute is unknown. Sociality: classification as either B, subsocial; E, eusocial; CP, cleptoparasitic; SP, social parasitic; or S, solitary; dashes (—) indicate attribute is unknown.

<sup>a</sup> Some ecological characteristics of some species are inferred based on characteristics of closely related species.

*Bombus* names follow the simplified subgeneric classification recently proposed by Williams et al. (2008).

Underlined species could not be identified definitively to species.

**Table 3. Bee species richness and abundance according to taxonomic and ecological groupings within suburban residential gardens in Westchester County, NY**

	% Species (n = 110)	% Individuals (n = 1,651)
Family		
Colletidae	4	3
Halictidae	35	53
Andrenidae	16	8
Megachilidae	16	3
Apidae	29	33
Introduced/native		
Introduced	6	3
Native	94	97
Floral specificity		
Oligolectic	7	2
Polylectic	93	98
Nesting site		
Cavity	17	5
Hive	7	16
Hard wood	3	5
Pith	4	5
Soil	65	64
Soft wood	4	5
Sociality		
Solitary	48	25
Parasitic	18	7
Eusocial	27	49
Subsocial	3	12

Where groups do not sum to 100, attribute is unknown for some species.

LaBerge, *M. denticulata* Smith, and *Megachile pugnata* Say. Note that although *M. pugnata* may be polylectic across its range, it is likely to be functionally oligolectic, restricted to pollen gathering on Asteraceae, within the region of this study. *M. denticulata*, previously considered to be a specialist on ironweed (*Vernonia* spp.), has been observed gathering pollen from two exotic knapweed species (*Centaurea x pratensis* Thuillier and *Centaurea maculosa* Lamarck) growing in dense stands in and around sand and gravel pits in the Fingerlakes region of central New York (J.S.A. and N. Trigoboff, unpublished data).

Parasitic species, particularly in the genus *Nomada*, were fairly well represented (19% of species, 6.9% of individuals). The most abundant parasite was the bumble bee *Bombus (Psithyrus) citrinus* (Smith), which is a social parasite of the ubiquitous native bumble bee *B. impatiens*. We also documented *Lasioglossum (Dialictus) platyparium* (Robertson) (a member of the former subgenus *Paralictus*, now considered a synonym of subgenus *Dialictus*), which is a social parasite of pollen-collecting *Lasioglossum (Dialictus)* spp., and *Triepeolus cressonii* (Robertson), a cleptoparasite of *Melissodes*. Both *L. platyparium* and *T. cressonii* are rarely found in New York, which is at the northern edge of their ranges (Mitchell 1960, 1962).

**Comparison to Reference Bee Faunas.** The Westchester suburban garden bee community (WSG) was similar to that of Black Rock Forest (BRF) in most ecological characteristics (Table 4). In particular,

**Table 4. Bee species richness according to taxonomic and ecological characteristics in three southern New York bee faunas, as well as the regional species pool**

	WSG, % of species (n = 110) <sup>a</sup>	NYCG, % of species (n = 54) <sup>ab</sup>	BRF, % of species (n = 146) <sup>c</sup>	Regional pool, % of species (n = 355) <sup>a</sup>
Family				
Colletidae	4	11	2	8
Halictidae	35	32	29	23
Andrenidae	16	5	29	25
Melittidae	0	0	0	1
Megachilidae	16	22	17	16
Apidae	29	30	23	27
Introduced/native				
Introduced	6	19	4	4
Native	94	81	96	96
Floral specificity				
Oligolectic	7	11	15	21
Polylectic	93	89	85	79
Nesting site				
Cavity	17	33	17	18
Hive	7	11	7	6
Hard wood	3	2	2	1
Pith	4	2	3	2
Soil	65	44	67	72
Soft wood	4	7	4	1
Sociality				
Solitary/communal	48	56	57	56
Parasitic	18	6	20	25
Eusocial	27	35	21	14
Subsocial	3	4	2	1

The three faunas, from Westchester suburban gardens (WSG), New York City community gardens (NYCG), and Black Rock Forest (BRF) represent the findings of three temporally discrete, site-specific bee surveys, whereas the regional species pool is a multiyear tally of bee species documented by multiple surveys conducted throughout southern New York.

<sup>a</sup> When percentages do not total 100, character state is unknown for some species.

<sup>b</sup> From Matteson et al. (2008).

<sup>c</sup> From Giles and Ascher (2006).

both were dominated by soil-nesting species (65%, WSG; 67%, BRF), whereas the NYCG fauna was markedly reduced in this ecological group (44% of species).

Both the observed species richness (110 species) and the Chao 1 estimates for WSG (145 species) were lower than those of BRF (144 and 176 species, respectively; Table 3), but much higher than the richness of NYCG (54 species, Chao 1: 60 species).

Both WSG and NYCG were somewhat reduced in oligolectic species (7 and 11% of species, respectively) relative to BRF (15% of species). WSG boasted a proportion of exotic species similar to BRF (six and 4%, respectively). In contrast, NYCG was strikingly enhanced in exotic species, at 19%.

WSG also more closely resembled BRF than NYCG in proportions of parasitic species. NYCG had markedly fewer parasitic species than the other two sites (WSG: 21 spp., 18% of species; BRF: 29 spp., 20% of species; NYCG: three spp., 6% of species).

Marked differences existed among the bee faunas in the identity of the dominant species. Two of the most frequently encountered species in BRF were augochlorine halictids: the soil-nesting *Augochlorella aurata* (Smith) and the wood-nesting *Augochlora pura*. Although these species were also common in WSG, they were quite scarce in the NYCG fauna. The most common identifiable form in WSG, *Ceratina calcarata/dupla*, was also abundant in NYCG, but less so at BRF. Two exotic Colletidae, *Hylaeus leptocephalus* (Morawitz) and *H. hyalinatus* Smith, were particularly numerous in the NYCG, whereas *H. leptocephalus* was absent from both the WSG and BRF data sets, and *H. hyalinatus* was missing from BRF and made up only seven individuals in WSG. The native bumble bee species *Bombus impatiens* was highly abundant in all three locale-specific faunas.

None of the three site-specific faunas rivaled the regional pool (355 species) in species richness. This is not surprising, owing to the historical nature of the regional data set, its broad geographic focus, and the inclusion of many bee species that have never been regularly collected and/or identified. The ecological makeup of both the WSG and BRF faunas, however, resembled that of the regional pool in almost all respects (Table 4). The primary incongruity between the WSG fauna and the regional pool from which it was drawn was reduced proportions of Andrenidae (mostly *Andrena*) and Colletidae (especially *Colletes*) in WSG.

## Discussion

Previous bee surveys have yielded mixed results on whether developed landscapes support diverse bee populations (Saure 1996, McIntyre and Hostetler 2001, Tommasi et al. 2004). The work presented here reveals a suburban garden bee community that strongly resembles the bee community in a regionally located 1520 ha research preserve (BRF) in ecological characteristics, and is only moderately reduced in species richness. These similarities suggest that suburban residential gardens in this region of the United States,

despite overlapping little in plant species composition with natural ecosystems, can be important habitat for an ecologically and taxonomically diverse bee fauna. Our results are in accord with Winfree et al. (2007) who found that in the Pine Barrens region of New Jersey habitat fragments located in areas of suburban development hosted as many bee species as did fragments within extensive forest. Our findings extend theirs to highlight the value of manmade suburban garden habitats for bees. The species richness (110 species; Chao 1 estimate: 145 species) documented here contrasts sharply with that documented in New York City community gardens (54 species; Chao 1: 60 species), which are only 40 km away (Matteson et al. 2008). Our data suggest that the suburban environment, within the context of the northeastern deciduous forest ecosystem, may be able to support a considerably larger proportion of the regional bee fauna than the urban environment.

Several mechanisms may drive the differences in ecological characteristics and species richness between the proximally located suburban garden (WSG) and New York City community garden (NYCG) bee faunas. First, the landscape matrix in which habitat fragments are embedded can exert influence over bee abundance and diversity (Steffan-Dewenter et al. 2002, McFrederick and LeBuhn 2006). Both intensity of development and socioeconomic factors can underlie these landscape-level effects (Germaine and Wakeling 2001, Hope et al. 2003, Kinzig et al. 2005). Westchester County, where the current study was undertaken, differs radically from the NYCG neighborhoods of the Bronx and East Harlem in these respects. Population density in Westchester in 2000 averaged 823 people per km<sup>2</sup> and median income in 2004 was \$63,924 (U.S. Census Bureau 2000). In contrast, population densities in the NYCG neighborhoods in 2005 were 14,600–18,900 people per km<sup>2</sup> (Matteson 2007). Median incomes in the Bronx and Manhattan (\$28,173 and \$45,290 in 2004, respectively; U.S. Census Bureau 2000) are lower than in Westchester County, but in many of the neighborhoods where Matteson et al.'s study sites were located, particularly those in East Harlem, median incomes are substantially less than these borough-wide averages (New York City Department of City Planning 2007). The matrix surrounding the urban community gardens is largely abiotic: contiguous streets, sidewalks, and apartment buildings with street trees and occasional plantings as the sole greenery. The landscape surrounding the suburban garden sites, although also highly modified, is blanketed with green yards, vegetated roadsides, and mature deciduous tree species, many of them native, which compose the region's forests. Although the urban matrix probably provides few resources to bees, the suburban matrix may be used by bees both for floral resources and nesting habitat.

Differences in garden habitat quality independent of the surrounding landscape also can influence the composition of a garden bee fauna and may underlie differences between the WSG and NYCG bee com-

munities. McIntyre and Hostetler (2001) found significantly more species in xeriscaped as opposed to mesiscaped yards in Tucson. In Vancouver, Canada, Tommasi et al. (2004) documented greater species richness in community and botanical gardens than in traditional flowerbeds, which were planted with petunias, tulips, ornamental roses and other flowers that are not attractive to bees. Additionally, in a survey of bees using ornamental plants in two northern California cities, the highest diversity and abundance of bees were found in sites with the greatest diversity of bee-attracting plants (Frankie et al. 2005). The current study was conducted in perennial gardens with large planted areas (mean, 600 m<sup>2</sup>) and numerous blooms of diverse species throughout much of the growing season. The New York City community gardens were on average smaller, contained less planted area (mean, 318 m<sup>2</sup>; calculated as sum of floral and vegetable areas), and devoted proportionately far greater space to crop plants [(66% of urban gardens versus 4% of planted areas in suburban gardens) (Matteson 2007)]. Both this within-garden habitat variation as well as the differing intensities of surrounding development likely contributed to the differences in the bee faunas documented in the Westchester suburban gardens and New York City community gardens.

The retention of regional proportions of soil-nesting species (65% of species) in our suburban garden fauna is of particular note, given that urban bee communities can be depauperate in these species (Cane 2005, Cane et al. 2006). Despite the frequent soil disturbance that occurs in suburban areas, sufficient suitable soil nest sites clearly are available to support a fairly diverse suite of soil-nesting bees. Whether these nest sites occur within gardens or in the surrounding landscape is an important question outside of the scope of this study.

Parasitic species also occurred in our collection approximately as frequently as in BRF. Some bee studies in developed landscapes have reported reduced numbers of parasitic bees, possibly owing to insufficient host populations (Owen 1991, Matteson et al. 2008). Our results suggest that lack of hosts does not limit parasitic species in the suburban garden environment studied here. The proportion of parasitic species present in the regional fauna, however, is greater than in any of the individual bee surveys examined in this article. This is likely due to the high number of rare and difficult to identify cleptoparasites in the genera *Nomada* and *Sphex*, many species of which are known from a single sex or even a single specimen (Mitchell 1960, 1962).

Several differences between the Black Rock Forest, regional, and suburban garden data sets may reflect underlying ecological disparities between the habitats surveyed. First, the proportion of exotic species in the suburban gardens is slightly higher than the regional or BRF proportion. This may reflect a trend toward the increasing presence of exotic species with urbanization. Matteson et al. (2008) found greatly magnified proportions of exotic bees in NYCC, both in terms of

species (10 species, 19% of fauna), and numbers of specimens (27% of specimens). Indeed, the two numerically dominant species were exotic *Hylaeus*. The authors suggest that the prevalence of exotics they found was due both to losses of native species and also to a good ecological fit between the life histories of many exotic species and the habitat found in urban areas. Our data revealed that in the far less densely developed Westchester County, the proportion of exotic species and individuals is slightly elevated above that in the natural habitat of BRF, but far lower than in NYCC.

Second, the WSG collection had a southern component not seen at BRF. These species, whose ranges lie largely south of New York State, include *Lasioglossum illinoense* (Robertson), *Andrena neonana* Viereck, and *Megachile addenda* Cresson. Likewise, several northern components in the BRF fauna were absent from the WSG collection, such as *Osmia (Melanosmia) inermis* (Zetterstedt) and *Bombus (Pyrobombus) ternarius* Say. Evidently, even the small climatic and vegetational shift between Westchester County and BRF to the northwest is enough to significantly influence their bee faunas.

Despite the overall robust species richness documented in this study, there were notable absences, such as several invasive species that were recorded in NYCC but not found in WSG. Many native species of interest were also missing from the Westchester garden fauna. Further sampling would be required to determine that these species are absent from garden habitats in this region; however, the data presented here are sufficient to conclude that these species are not using the surveyed gardens in significant numbers. Most notably, numerous *Andrena* species documented in BRF and the region were not represented in the WSG data set; for BRF, 40 species, composing fully 28% of the collection, were *Andrena*. In contrast, *Andrena* composed only 15% (17 species) of the WSG fauna. The reduced representation of *Andrena*, many of which are floral specialists, largely accounts for the lower proportion of oligolectic species in the WSG fauna relative to BRF. Several reasons may underlie the apparent absence of these species: first, host plants of several specialist (oligolectic) *Andrena*, such as trout lily (*Erythronium* spp.), the sole pollen source for *A. erythronii* Robertson, are missing from gardens (Frankie et al. 2005). Second, blooms in general tended to be sparse in the gardens during the vernal flight seasons of most *Andrena* (E.D.F., unpublished data). Many polylectic *Andrena*, and other forest-associated vernal bees (e.g., *Osmia bucephala* Cresson) therefore may also lack sufficient resources in gardens. In addition, bee sampling during the vernal flight period was restricted in this study to pan trapping; the lack of hand collections may in part explain the lowered *Andrena* species count. As a result, we cannot definitively say whether the lack of *Andrena* species in our WSG samples was due to their absence or rarity at these sites, our lack of hand collecting during the vernal flight season of *Andrena*, or a combination of these factors. Nevertheless, targeted planting of

springtime bee-attracting blooms, particularly flowering trees, such as cherry (*Prunus*), apple (*Malus*), and willow (*Salix*), could enhance garden foraging habitat for certain species. The host plants of other vernal species may be incompatible with garden cultivation. Therefore, bee species requiring native forest understory wildflowers may require conservation action to preserve them in the face of expanding suburbanization of landscapes.

Overall, our findings are promising for the conservation of many wild bee species. The species richness reported here for suburban gardens is only moderately less than that documented at a large nearby research preserve, which better represents the historic habitat for bees in this region, and is much greater than that recorded from highly urban sites in the region. In addition, our data suggest that unlike denser urban areas, the suburban environment is not excluding soil nesting or cleptoparasitic bee species, although it likely excludes certain oligolectic or habitat-specialist species. It is important to note that the findings of our study in suburbs of the northeastern United States may not translate to regions where the suburban landscape is more dramatically modified relative to the natural landscape. Nevertheless, this study suggests that human activity, in the form of home gardening, can act to conserve and attract a diverse assemblage of bees in sufficient numbers for them to serve as ecologically important pollinators.

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