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Review

How Informed Design Can Make a Difference: Supporting Insect Pollinators in Cities

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Abstract: Pollinators are responsible for the reproduction of many plant and crop species and provide important diversity for food webs and cultural value. Despite the critical ecosystem services provided by pollinators, rapid pollinator declines are occurring in response to anthropogenic activities that cause the loss of suitable habitat. There is an opportunity for urban green space to support pollination ecosystem services locally and across the landscape. However, there is a lack of practical but evidence-based guidance on how urban green space can be designed effectively to provide floral resources and other habitat needs to a diverse assemblage of pollinators. We examine the existing pollinator research in this paper to address the following questions specific to insect pollinators in temperate urban settings: (1) Which pollinators can be the focus of efforts to increase pollinator ecosystem services in cities? (2) Which plants and what arrangements of plants are most attractive and supportive to urban pollinators? (3) What do urban pollinators need beyond floral resources? (4) How can the surrounding landscape inform where to prioritize new habitat creation within cities? Using these questions as a framework, we provide specific and informed management and planning recommendations that optimize pollinator ecosystem value in urban settings.

Keywords: pollinator; bees; pollination ecosystem services; urban green space; urban design; landscape typology; gardens; plant–pollinator interactions; urban biodiversity; research-practice gap

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1. Introduction

Pollinators are declining worldwide, and as pollinators are lost, so too are the ecosystem services they provide. Significant pollinator loss is occurring in response to several threats, including pesticides, pathogens, and habitat loss and fragmentation [1–4]. Loss of pollinator species and networks has been noted at the global scale [1,5], and through direct long-term studies in specific regions [6–9], which has significant implications for humans and the ecosystems on which they depend. An ecosystem service is a benefit, often economic, that nature provides to humans [10], and the service of animal-assisted reproduction of flowering plants, or pollination, is a recognized critical "regulating" ecosystem service [11]. Many pollinator species increase or ensure the reproduction of plants in both native plant communities and agricultural systems. Almost 90% of all wild flowering plant species depend, at least partially, on animal pollination services for their reproduction [12], and nearly 35% of global food crops rely on pollinators to reproduce [5,13], giving pollinators an estimated food provisioning service value in the USD billions [14]. The impact of pollinator declines is already measurable in agricultural systems [15]. In addition, the ecosystem service of value of pollinators extends beyond their role in food production and the persistence of natural plant communities to include supporting and even cultural ecosystem service value. Insect pollinators, in particular, are at the base of many food webs, providing rich, abundant resources for other species, which in turn support other ecosystem services [5]. The diversity of animals that serve as pollinators—from hummingbirds to metallic green bees—also provide aesthetic and cultural ecosystem service value, especially in cities where species richness enhances the psychological benefits of green space [16].

While urbanization has contributed to pollinator species loss, well-designed urban landscapes provide an opportunity not only to curb the pollination crisis but also to support the beneficial ecosystem services of pollinators, both within the city and beyond. Many of the drivers of pollinator loss are associated with urbanization, including the loss and fragmentation of pollinator habitat through increased land use intensity and impervious surfaces and threats such as non-native species, environmental contaminants, and urban warming [17–19]. While some studies have found pollinator declines along increasing urbanization gradients [20,21], the effect of urbanization on insects generally can vary greatly from negative to no impact to even positive effects [22]. In fact, cities can contain surprisingly abundant pollinators compared to rural or agricultural landscapes [19,23–25]. Hall et al. [24] suggest that cities with a variety of forage and nesting sites can serve as important refugia for pollinators compared to increasingly less hospitable rural and suburban landscapes that surround urban areas. The relatively small spatial and temporal scales of insect pollinators in terms of functional ecology (for example, habitat range, life cycle, and nesting behavior compared with larger mammals) offer opportunities for small actions to yield large benefits for pollinators [24]. This can support the ecosystem services of pollinators within the city itself, including the productivity of urban food gardens [26], and support the spillover of pollination ecosystem service benefits to agricultural and natural areas outside of the city [27,28].

Interest in urbanization as both a potential threat and opportunity for pollinators has accelerated research in pollinator urban ecology, but the actual practice of supporting pollinator ecosystem services in cities has not been fully realized. Our ability to inform urban design has been improved by systematic reviews of urban pollinators and pollination ecology [18,19,25,29], and general recommendations on ways to support pollinators in urban settings [19,30–32] and even assessments of pollinator ecosystem service value of green space in specific cities (from Grenada, Spain to Chicago, USA; [33,34]). However, there is inadequate specific and practical planning and management guidance directly linked to the research that supports it [19]. Gaps between research and practice are a common problem in conservation [35,36], highlighting the need for approaches that stimulate the connection between research and feasible implementation [37].

The purpose of this paper is to compile and organize relevant literature on pollinators in cities within a framework of practice-based questions relevant for urban designers, planners, and dwellers. The evidence-based and socially contextualized answers to these questions can guide ecologically informed design that maximizes pollinator ecosystem services in cities in the face of increasing urbanization. Specifically, we address the following questions:

- Which pollinators can be the focus of efforts to increase pollinator ecosystem services in cities?
- Which plants and what arrangements of plants are most attractive and supportive to pollinators in cities?
- What do urban pollinators need beyond floral resources?
- How can the surrounding landscape inform where to prioritize new habitat creation within cities?

We first discuss the relevant literature for each of these questions and also address the question of urban management practices that would support pollinator ecosystem services. Then, we provide a synthesis of recommendations for the local garden scale, including informed planting typologies for urban gardens and then, from an urban planning perspective, to guide landscape-scale management and design. Given the burgeoning field of urban pollination, we do not attempt to review all available evidence, but rather to contribute to the "research-implementation space" [37] in the form of some key actionable recommendations directly based on current knowledge and needs.

Although many urban design recommendations might apply to different pollinators and regions, we aimed to narrow our focus especially to *insect* pollinators for *temperate* zones, especially those native to North America. Our aim is to provide more species- and research-specific recommendations rather than make generic conclusions or falsely extrapolate to other systems. That is, recommended plant arrangements and typologies are likely to be quite different for temperate bees vs. tropical hummingbirds. We agree that the bias in the urban pollination literature to the global north is problematic [29,38], but specific recommendations for tropical cities (including bird and bat pollinators) are emerging as these systems are increasingly studied [38–40], and so parallel recommendations specific to other systems can become available over time.

2. Pollinators: Which Pollinators Can Be the Focus of Efforts to Increase Pollinator Ecosystem Services in Cities?

"Pollinator" is a large category of organisms defined by their function. Although bees and butterflies may be the most well known, pollinators span a range of taxonomic categories including not only wasps and other members of the *Apoidea* superfamily but also moths, which make up nearly 90% of species in the *Lepidoptera* order, as well as "hoverflies" in the *Syrphidae* family of the *Diptera* order (true flies). Even the term "bee" is a common name that can apply to a diversity of species within the *Anthophila* clade and includes not only honeybees and native (to North America) bumblebees but also mason, carpenter, and sweat bees. Birds and bats are also critical pollinators in many areas of the world, though insects remain the most frequently recorded pollinators in urban areas worldwide [29]. Specifically, across studies of urban areas globally, Hymenoptera, especially honeybees and bumblebees, were by far the most frequently recorded insects, followed by Lepidoptera and Diptera [29].

Public perceptions of pollinators or of "Save the Bees" campaigns often focus on the European honeybee (*Apis mellifera*), known for their honey production and pollination of certain crops [41]. In fact, wild bees are equally if not more critical for staple crop pollination (e.g., apples and blueberries [42]), and *A. mellifera* is non-native in most areas of the world and known to compete with native bees for limited floral resources [43]. While *A. mellifera* are the most frequently recorded and often the most abundant species in urban areas worldwide [29], an increase in urban beekeeping (hives specifically for *A. mellifera*) can negatively impact more diverse native bee assemblages in cities [44]. Thus, urban efforts to increase ecosystem services of pollination need to recognize the value of pollinator diversity to maintain services, as well as to consider the critical difference between managing habitat for pollinator services and preserving overall pollinator biodiversity [45]. Intense focus on honeybees spreads misinformation regarding pollinator biodiversity and its value, so it should be established that the term "pollinator" encompasses many species with different needs.

While pollinator responses to urbanization are quite varied and are trait- and scale-dependent, urbanization tends to lead to an increase in the abundance and dominance of generalist and social species and a higher rarity of specialist species [18,25,29]. For example, urban areas tend to support generalist, short-tongued bee species and not specialist bee species [46]. It may be possible to attract more specialist species with different plant selections (see below), but even if only generalist pollinator taxa are common in cities, these still span a diverse assemblage (Table 1) and so can support ecosystem services.

Table 1. A list of generalist insect pollinator families and genera (italicized) based on ref. [47].

Category	Species
Bees	Many (but not all): bumblebees (*Bombus* spp.), sweat bees (*Halictus* sp. *and Lasioglossum* sp.), leaf-cutter bees (*Megachile* sp.), carpenter bees (*Xylocopa* sp.)
Wasps	Paper wasps (*Polistes* sp.), yellowjacket (*Vespula*), bald-faced hornet (*Dolichovespula*)
Butterflies and moths	Hummingbird moths *(Hemaris* sp.), sulphurs (*Colias* sp.), swallowtails (*Papilio* sp.), fritillaries (*Speyeria* sp.)
Flies	Families: bee flies (*Bombyliidae*), Syrphid (hover) flies *(Syrphidae*), Tachinid flies (*Tachinidae*), thick-headed flies (*Conopidae*)
Beetles	Families: soldier beetles (*Cantharidae*), long-horned beetles (*Cerambycidae*), leaf beetles (*Chrysomelidae*), snout beetles (*Curculionidae*)

Understanding the finer-scale differential effects of urbanization on pollinators can allow urban designers to focus on providing habitat to the pollinator species most likely to be present or to take informed approaches to improve habitat suitability for missing taxa. For example, ground-nesting bee species richness decreases with an increase in the impervious surface of an area [48] as ground-nesting species require patches of bare dirt in which to nest. Conversely, cavity-nesting and aboveground-nesting bee species are more abundant in more densely built urban areas, given that they are able to build their nests in pre-existing cavities of urban structures [18,48]. Research also shows that even just the presence of permanent grassland can increase the number of rare bee species supported [48]. Thus, design efforts that increase bare soil and permanent grassland habitat in areas of highly impervious surfaces can diversify the pollinator assemblage. As we further discuss below, habitat patch size can also affect pollinator composition. Suburban and urban sites containing smaller habitat patches show an increases in small bee, social bee, and solitary cavity-nesting bee species [49]. These urban habitat patches also favor species in the family *Halictidae* (sweat bees) over *Apidae* (honey, bumble, carpenter, and cuckoo bees). Study results such as these can better direct plant selection and habitat construction in urban areas based on the floral preferences of the more favored species; for example, sweat bees prefer flowers from the plant families *Asteraceae* (asters and daisies) and *Lamiaceae* (mints) [47].

Managing habitats for diverse pollinator assemblages in cities is feasible, because although they may have different habitat and floral resource needs, there are many overlaps in needs within temperate insect pollinator communities. This overlap provides opportunities to create beneficial habitat for many pollinator groups at once [47]. For example, 30% of the 4000 bees native to the United States are cavity-nesting species, using dead wood and plant stems as shelter for developing larvae [50]. These cavity-nesting bees include mason, leafcutter, and carpenter bees, which all belong to different genera. Similarly, well-chosen plants, as we discuss below, can attract pollinators from completely different insect orders, e.g., butterflies and moths (*Lepidoptera*), bees (*Hymenoptera*), beetles (*Coleoptera*), and flies (*Diptera*).

3. Plants: Which Plants and What Arrangements of Plants Are Most Attractive and Supportive to Pollinators in Cities?

While more green space in urban areas is associated with increased pollinator species richness [25], the characteristics of that green space strongly influences the pollinators present [51] add [18,29] and therefore the ecosystem services they can provide. Urban green space spans a huge variety of types, from individual flowerbeds to private or community gardens planted with flowering and/or edible plants and to lawns, green roofs, recreational parks, remnant natural areas, vacant lots, and even urban cemeteries, golf courses, and university campuses [29,52]. These spaces differ in landscape management intensity, vegetation composition, vertical structure, microclimate, and patch size, all of which can have effects on pollinator populations [18,53]. Broadly speaking, the presence of floral foraging resources is consistently found to influence the presence of pollinators in urban areas [19,24]. More specifically, urban areas with higher floral diversity [54,55] and floral abundance [56–58] tend to have a higher pollinator abundance and/or diversity. This pattern holds even for a vertically isolated habitat in a highly urbanized context—green roofs in Chicago planted with native plants and with the highest plant diversity have the highest bee species richness and abundance [59]. These studies support the idea that it is not necessarily the degree of "urban-ness," but instead the specific characteristics of each urban green space that ultimately influence pollinator abundance and diversity. In this section on plant choice, we provide specific information to guide decisions at this *local* scale of a green space [18], including factors such as the origin, floral features, and arrangement of vegetation within a green space, noting how these factors influence the ability of an urban green space to support insect pollinators.

3.1. Native vs. Non-Native Plants

In recent years, gardeners and researchers alike have been debating the role of native and non-native ornamental plants in supporting local biodiversity and ecosystem function. Given the long history of coevolution between native plants and their insects, the widespread use of non-native plants across urban and non-urban landscapes has likely contributed to global insect declines through the loss of suitable food and habitat [60]. Although pollinators are often attracted to various non-native ornamental plants in urban landscapes [56,61], research increasingly demonstrates that overall pollinator abundance and diversity are greatest in landscapes with native plants [55,59,62]. Pardee and Philpott [56], for example, found that for city backyard gardens, both bee richness and abundance are higher in gardens that contain more native plants and thus have more floral abundance, taller vegetation, more cover, and more potential nesting sites. Similarly, Rollings and Goulson [63] found a significantly higher diversity of pollinators attracted to native plants as opposed to ornamental plants in backyard gardens. Additionally, there may be a native plant "threshold" of eight or more species of native plants within a landscape to increase the abundance and diversity of native bees [64,65]. These findings suggest that incorporating native plants into the urban landscape is critically important for supporting abundant, diverse pollinator populations. The use of native plants is especially important for supporting specialist species, for which non-host plant pollen is not only non-preferred but toxic [66], so cities without sufficient quantities of host plant pollen would have an overall lower bee species richness. While rare specialist pollinator species may not contribute as significantly to crop pollination ecosystem services [67], in an urban context, specialist pollinators and their associated plants can provide cultural and aesthetic ecosystem service value while contributing to overall diversity.

Beyond the value of native plants for pollinator diversity and ecosystem services, they should be favored in urban green spaces due to the risks posed by non-native plants. The flowers of non-native plants, especially when abundant, can draw pollinators away from native plants and thereby decrease their reproductive success, especially when the non-native flowers are similar to the native ones [68]. Thus, the use of non-native plants in city plantings can undermine the ecosystem service value of pollination for native plant communities. Non-native plantings also increase the risk of invasive species spread, which can further degrade natural ecosystems. Urban and suburban gardens are not only a key entry point for many invasive plant species but also a source for secondary escape and spread into natural area remnants within cities or along the urban–wildland interface surrounding cities [69,70].

Some non-native ornamental plants do offer important social value, and so if their risks of spread or competition with natives are low, they can play a valuable role as part of a mixed planting of both native and non-native species to support pollinator ecosystem services. Landscape aesthetics are a powerful cultural driver of a green space's success and long-term sustainability [71]. Non-native, ornamental plants have been human-selected for their beauty, scent, reliability, or cultural relevance among other socially determined reasons. It follows that these plants are familiar, broadly socially accepted, and legible to the general public. These spaces inherently feel orderly and cared for, which exemplifies Joan Nassauer's "Cues to Care" [72]—the social importance of cues to care cannot be underestimated, but it can be signaled in other intentional ways in plantings that are less ubiquitous or orderly. Regardless, the social legibility of culturally beloved, ornamental plants such as peonies, roses, or boxwoods can be leveraged to make less-familiar, more "wild" native plantings more socially acceptable and therefore more likely to be cared for and persist over the long-term, which is what pollinators depend on. Additionally, not all gardeners want to plant an all-native garden but want to help pollinators. By not vilifying ornamentals and instead encouraging a mix of ornamental and native plants, we may offer a steppingstone and olive branch for anyone who wants to garden for pollinators.

Beyond their potential social value, some non-native ornamental plants do directly provide resources for pollinators. For example, many popular, easy-to-grow annuals and perennials, as well as non-native flowering trees, can be very attractive to pollinators and provide abundant floral resource availability [61,73,74]. However, there is growing evidence that non-native plants attract a subset of pollinators, and frequently these pollinators are more generalist in their foraging preferences [57,61]. This support for generalists is valuable, especially in urban environments, which may be resource-poor, but it is important to acknowledge this limitation and provide a variety of foraging resources for both specialist and generalist species. The value of non-native plants is important to consider in the face of climate change. Many non-native plants are selected for longer blooming periods and blooming periods for the "shoulder" seasons of early spring and late fall, all of which can extend foraging resource availability temporally for pollinators [75], which may be especially important with climate change. Thus, in making decisions about which plant species to include in urban green spaces, it is important to not only consider their origin [76] but also their risks, social value, which pollinators they support, and their value for urban climate adaptation.

The growing number of "nativars," or cultivated varieties of native plants, in horticulture has raised questions about how the horticultural modification of plant traits affects the ecological function of native plants. To date, this research has produced variable answers. Cultivated plants are often selected for desirable growth traits (disease resistance, longer bloom time, tidy form, etc.) or aesthetic traits (double blooms, larger blooms, bloom color variety, variegated leaf/stem color, etc.). Either for growth form or aesthetics, alterations that change the physical traits of a plant may alter its attractiveness or resource availability to insects and thus change their ecological function. Robust garden trials from Mt. Cuba Center in Delaware are actively testing pollinator use (ecological function) alongside horticultural performance (social function). Though only a few genera have been tested so far (*Baptisia* spp., *Coreopsis* spp., *Echinacea* spp., *Monarda* spp.) results vary widely, with some cultivated varieties actually attracting more pollinators than the "straight" native plant. For example, within Monarda varieties, moths and butterflies were more attracted to selections that offered the largest abundance of 2–3″ wide flowers, with *M. fistulosa* 'Claire Grace' attracting substantially more pollinator visits than the straight native *M. fistulosa* [77]. Importantly, the Mt. Cuba researchers note that this artificially resource-rich "buffet" of dense *Monarda* plantings may reveal pollinator preferences given unlimited options, but any of these *Monarda* varieties on their own in a landscape setting may perform equally well. Although the current research is limited regarding which specific alterations may affect ecological function, Tallamy et al. [60] found that native varieties that had leaves that altered from green to red, blue, or purple were eaten significantly less by herbivorous insects. The same study found no effect of altered plant habit, fruit size, disease resistance, or fall color, but leaf variegation seemed to increase insect herbivory. These limited studies suggest that some "nativars" still provide resources for pollinators and herbivorous insects [78], although more research is still needed to test cultivated varieties of more plant species and to investigate alterations to pollen and nectar quantity and quality and their potential invasiveness risk.

3.2. Floral Features

Beyond plant origin (native or non-native), it is known that floral features such as fragrance, color, shape, and nutritional quantity and quality influence pollinator attractiveness [47,61,79]. The broadest diversity of pollinator groups can be supported by representing a diversity of their associated flower traits (Table 2) within the garden or green space.

Table 2. Flower color and trait preferences of different insect pollinators.

Pollinator	Flower Trait Association
Bees	Primary color: pink, purple, or blue Secondary: white or yellow.
Wasps	Shallow corollas for nectar; white.
Butterflies and day-foraging moths	Flat-topped flowers or a structure to grasp while nectaring. Prefer composite flowers.
Night-foraging moths	White or cream with a strong fragrance.
Flies	Flat or bowl shapes, umbels. White or cream color. Musty fragrance.

Pollinator response to floral color varies across plant genera [61], but there are certain color–species associations based upon pollinators' species-specific ability to perceive a certain range of colors and some species' preferences. Red, for example, is perceived as black to bees [47], and so the color red is not attractive to bees; however, red is particularly attractive to hummingbirds, which are also essential pollinators. Bees and many other insect pollinators perceive ultraviolet light cues that often serve as nectar guides but are imperceptible to humans. White, cream, or green-colored flowers are attractive to the less popular but no less important pollinators: wasps, beetles, flies, and night-foraging moths. While these general color associations are helpful for attracting some pollinators, many other floral traits may be more important.

Flower shape, structure, and size also influence the type of pollinator that can access the floral resources, i.e., nectar and pollen. First, pollinators vary in their pollen- and nectar-gathering strategies and have different physical structures to gather, consume, and store these resources. Some physical structures that alter a pollinator's foraging strategy include tongue length, the presence of external storage structures (e.g., hairs), body size, and body weight. Long-tongued bees, butterflies, and moths can easily access tubular flowers, but short-tongued bees, beetles, and wasps can only access shallow, open nectaries (unless they "steal" resources by cutting into the flower base). For large, closed flowers such as *Baptisia* spp. or *Lobelia siphilitica*, resource access is limited to strong, large-bodied bumblebees that can push apart the heavy petals or very tiny bees that can slip in through the gaps. Flat-topped, umbel-shaped flowers including *Pycnanthemum* spp., *Eutrochium* spp., and *Zizia* spp. offer shallow nectaries that attract a greater diversity of pollinators with both short and long tongues. Floret-dense, open, composite flowers of the Asteraceae family including *Symphyotrichum* spp. (asters), *Echinacea* spp. (coneflowers), and *Solidago* spp. (goldenrods) also feature shallow nectaries accessible to a variety of pollinators at a high density, offering a large quantity of resources and a suitable landing pad for large-bodied butterflies. Given that flower shape, size, and structure influence resource availability to a certain subset of pollinators, it follows that by providing a diversity of floral morphologies, a diverse garden will attract a more diverse assemblage of pollinators.

Putting all of these features of certain flowers known to attract pollinators together, there are many existing lists of recommended pollinator-friendly plant species for urban green space designers to consider. While this can be exciting for those looking to improve their pollinator habitat, such recommendation lists have limitations. Garbuzov and Ratnieks [71] reviewed fifteen plant recommendation lists from various sources including pamphlets, websites, books, and botanical garden information stands/leaflets. They found that while these lists are useful communication tools for a general audience—and a good starting point for future research—they often contain poor recommendations, omit what would be good recommendations, lack overlap even when considering the same geographical regions, and are based on author experience rather than empirical evidence. They note "a list is only as good as the data that went into it," and the lists they reviewed "almost never refer to the empirical sources on which they are based." (p. 1019). Thus, traits and field observations may be more reliable to inform plant choice.

3.3. Floral Arrangement in Time

Providing not just a diversity of floral traits but also flowers that bloom throughout the growing season is key to supporting a diverse and abundant population of pollinators [47]. Phenology, or the timing of seasonal biological events, frequently orchestrates a tightly evolved relationship between plants and their pollinators. Different plant species bloom at different times for many reasons, including taking advantage of water availability, to have a competitive advantage over other plants and to attract specific pollinators. Many pollinators, especially native bees, live short lives and emerge, feed, and reproduce over a period of weeks or months. Mason bees (*Osmia* spp.), for example, are active only from spring to early summer, and overwintering queen bumblebees are some of the first pollinators to emerge during spring thaw. These early spring pollinators require pollen and nectar from early-blooming, often spring ephemeral flowers such as *Geranium maculatum* (wild geranium). In fall, many pollinators are preparing to overwinter or migrate (such as the monarch butterfly) and rely on late-blooming plants including *Solidago* spp. (goldenrods) and *Symphyotrichum* spp. (American asters). By providing a diversity of blooms from spring to fall, green spaces can support a greater diversity of pollinators throughout their life cycles. Flowering trees can also play a critical role in providing abundant floral resources over a whole season and can fill gaps in floral resource availability [52,73].

Additionally, the mowing management of lawns—a potentially critical green space in an urban area—can have significant effects on the timing of available floral resources for pollinators. Lawns are iconic to Western cities; they occupy a large proportion of urban areas and are culturally and aesthetically valued [80,81]. Many municipalities enforce 'weed laws' to ensure the conformity of the lawn ideal by restricting grass height (e.g., a Chicago ordinance prohibits lawn vegetation from exceeding 24.4 cm; Municipal Code of Chicago: §7-28-120). Households mow to conform to societal expectations, city ordinances, and the personal satisfaction of a neat and tidy yard [80]. Intensive lawn management requires time and financial commitments and is often driven by aesthetics and social norms to adhere to ideals of orderly, weed-free, lush carpets of green grass [72,82–84]. However, frequent mowing restricts plant diversity in urban lawns to only a few species that are able to tolerate repeated defoliation and soil disturbance, i.e., *Bellis perennis*, *Glechoma hederacea*, *Lolium perenne*, *Plantago major*, *Prunella vulgaris*, and *Trifolium repens* [85]. The homogeneity of plant species, together with herbicide application, deplete lawns of floral resources for pollinators [86]. Adjusting mowing frequency can lead to increases in pollinator value. Lerman et al. [87] found that the lawn with lowest mowing frequency has the highest floral abundance but not the highest bee abundance. They suggested that taller grass in less-mown yards might have prohibited access to the flowers and rendered the floral-abundant lawns less attractive to pollinators. Alternatively, the lawn flowers might lack the performance traits necessary for competing with the tall grass, leading to pollen limitation and hence less attractive habitats for bees [88]. Thus, an appropriate mowing frequency and the addition of floral diversity are both needed for urban lawns to support more pollinators throughout their active season.

3.4. Floral Arrangement within a Green Space

In addition to the origin, floral features, and flowering timing of the plants within a green space, another important local-scale consideration to support urban pollinators is the arrangement of floral resources *within* the green space or garden, which may be more important even than its size. For example, some research suggests that while garden size does not influence invertebrate communities [89], floral density (the number of blooms per unit area) frequently has a positive effect on pollinator abundance and diversity [90]. Keasar [91] found that clustering flowers, even if these clusters included resource-sterile plants, increased native bee visitation rates. Small community gardens that are densely packed with a variety of floral resources are highly attractive to pollinators [52,92], and increasing such plantings within larger recreational parks could increase the parks' pollinator value.

The spatial arrangement of flowers can strongly affect not only how many but which pollinator species visit a garden. Plascencia and Philpott [93] found that the honeybee was more abundant in sites with patchy floral resources (larger nearest-neighbor ratio of quadrats with $\geq$15 flowers), likely because it is a generalist species, and its medium size permits it to forage large distances. By contrast, native bee species were most abundant in gardens with clustered floral resources (smaller nearest-neighbor ratio). Thus, the local and small-scale arrangement of flowering plants can favor certain pollinators over others, and so heterogeneous arrangements are likely to support the greatest diversity of pollinators. In Section 5, we also discuss landscape-scale spatial considerations for supporting pollinators, such as the variety of green space sizes and their placement in an urban setting.

4. Nesting Habitat: What Do Urban Pollinators Need beyond Floral Resources?

Quality pollinator habitat includes more than just floral and foraging resources. Within the same local scale as floral resources, native pollinators, especially wild bees, must have habitat for nesting and overwintering. Variability in insect pollinator composition among urban green spaces can depend less on floral density or cover and more on available nesting habitat [53]. Many native bees nest in plant material such as hollow plant stems and leaf litter, while others require bare ground to nest. For example, across Californian urban gardens, Quistberg et al. [94] found that the number of cavity-nesting bees depended on the percent of leaf litter cover and the number of ground bees increased with an increased percentage of bare ground and decreased with wood chip mulching. Landscaping practices such as the widespread use of wood mulch can thus be detrimental to ground-nesting bees. Tree and shrub pruning/leaf removal, especially as "fall/spring clean ups," can also greatly diminish the nesting habitat for pollinators [32]. Leaving such materials can pose an aesthetic challenge, especially in urban gardens and campuses where the city or school may have yard care guidelines. Campaigns such as "Leave the Leaves!" are spreading thanks to the Xerces Society and the National Wildlife Federation. Both organizations have published materials explaining the ecological value to pollinators of leaf litter, plant stems, and other dead and decaying plant debris. Butterfly larva such as that of the great spangled fritillary (*Speyeria cybele*) overwinter in piles of leaves, and other species such as the red-banded hairstreak (*Calycopis cecrops*) lay their eggs on fallen oak leaves, which the hatched caterpillars will eat in the spring. Bumblebees *(Bombus* spp.) are a well-known pollinator group that depend on leaf litter for protection over the winter. These are just a few of many examples, demonstrating that planting pollinator-friendly plants is only one part of creating a quality pollinator habitat.

Bees can be organized into three guilds based on their nesting habits: ground-nesting, above-ground-nesting, and cleptoparasitic [95]. The ground-nesting guild is dominated by the families *Andrenidae*, *Melittidae*, *Halictidae*, and *Colletidae*, while the above-ground-nesting guild includes mostly Megachilidae and Apidae species [96]. Nesting sites for cavity-nesting bees in the form of "bee hotels" are increasingly being promoted as a way to aid pollinator conservation. Bee hotels vary in size and are typically constructed from wood and contain different-sized cavities and a variety of materials to be used for nesting, such as bamboo tubes and bricks with holes. Unfortunately, installing bee hotels can be counterproductive because most of North America's native bee species (and 70% of the ~20,000 bee species worldwide) nest under—not above—the ground [97]. A large majority of bees either nest underground or parasitize other bees' nests, which limits the value of above-ground-created habitats such as bee hotels.

Bee hotels are widely touted as a positive addition to any pollinator garden, but numerous studies have documented increased parasitization of native bees nesting inside such hotels [97]. Additionally, non-native and non-pollinating bee and wasp species have been demonstrated to use bee hotels more often than native, pollinating bee species, thus outcompeting native bees for nearby resources [97]. Geslin et al. [98] found that 40% of all individuals recorded using the 96 bee hotels they installed were *Megachile sculpturalis*, a leafcutting bee native to Japan and China. They also found a negative correlation between the presence of *M. sculpturalis* and native bees in the hotels. MacIvor and Packer [97] coined the term "bee-washing" (a form of green-washing) to warn promoters and users of bee hotels against spreading potentially misleading information. They note that, much like pamphlets of pollinator-friendly plants, bee hotels are useful tools for engaging the public in citizen science and pollinator conservation outreach but that their potential pitfalls must be thoroughly researched before they are recommended as "pollinator friendly".

Although bee hotels may not necessarily be the best choice for bee nesting sites, bees still do need habitat in which to nest and overwinter—nesting requirements are as important to consider as floral resources [99]. Bumblebees (*Bombus* spp.) often overwinter beneath the base of clumped grasses, while many ground-nesting bees will utilize bare patches of soil for nesting. Bare patches in particular pose an aesthetic challenge in an urban setting; those who do not know the purpose of the bare soil may find it less aesthetically pleasing than a patch of foliage or flowers. Such challenges could be overcome by signage that explains the purpose of the bare patches and their value to native pollinators. Alternatively, soil squares—smaller patches of bare soil that form a 0.5 m deep hole in the ground—could be constructed to provide nesting sites for cavity-nesting bees [100]. An interesting study by Cane [101] shows that native species of *Halictus* prefer to nest beneath decorative landscaping pebbles instead of bare soil patches. Much like providing an array of floral resources will tend to attract the most diverse pollinator assemblage, providing a variety of nesting materials and sites that can be maintained (rid of harmful parasites if necessary) is most beneficial to urban pollinators.

5. Landscape-Level Planning and Connectivity—How Can the Surrounding Landscape Inform Where to Prioritize New Habitat Creation within Cities?

Thus far, we have discussed local-scale factors that influence the ability of a green space to support pollinators effectively, but designing for pollinator ecosystem services in cities requires considering habitat at different scales, from the quality and size of the green space itself to the arrangement of potential habitat within the landscape and the quality of the urban context (Figure 1). Urbanization essentially fragments pollinator habitat, a process that can reduce pollinator and plant pollen movement among fragments and reduce pollinator abundance and diversity, especially for species sensitive to fragmentation [17]. Green space fragments that contain more floral resources and a higher diversity of flowering plants (e.g., community gardens, residential gardens) have significantly more abundant and diverse pollinator communities [102]. The patchwork of other urban habitat types (e.g., open parks, lawns, paved areas, buildings) surrounding these floral "hotspots" represent a resource-poor "matrix" that may be unusable and even impermeable to pollinators.

Pollinator habitat planning at a city-wide or landscape scale thus must also consider the spatial distribution of existing pollinator habitat and the land cover in between. While local, garden-scale characteristics are often stronger predictors of pollinator abundance and richness [56,103], the surrounding landscape matrix may influence the accessibility or quality of any individual garden. For isolated garden patches, finding opportunities to create "corridors" of even marginal pollinator habitat to connect patches of higher-quality habitat can facilitate movement across a landscape, encouraging opportunities for short- or long-distance migration, shifting life cycle habitat requirements, and genetic exchange. In contrast, some urban cover types or features such as buildings or busy roads may present barriers to pollinator movement across an urban landscape. Additionally, proximity to more natural habitat types such as forests, wetlands, or grasslands can provide additional resources for pollinators and thus increase pollinator use of nearby garden patches in an urban context. Below, we provide more specific evidence to guide landscape-scale planning for pollinators.

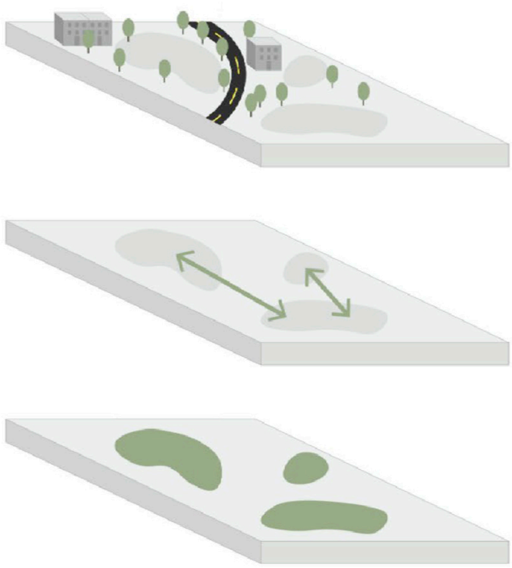

Figure 1. The inter-related levels to consider in planning pollinator habitat, from bottom to top: the size and quality of individual gardens or green spaces, the arrangement and connection among green spaces, and the matrix or context surrounding the green spaces.

5.1. Matrix Quality

Overall, landscape-level variables are frequently not as strong as garden-level characteristics at predicting pollinator population metrics; however, the effect of the surrounding landscape matrix type may differ by pollinator guild. In the urban habitats of Chicago, Tonietto et al. [59] found that bee species richness positively correlates with the proportion of natural area within a 500 m radius. Pardee and Philpott [56] found that cavity-nesting bee abundance was higher in urban gardens with more natural areas within 1 km, and they hypothesized that a mix of natural and man-made resources may assist with nest building. Ground-nesting bees were more abundant where wetlands were within 1 km, which suggests an association with wet habitats. Increased forest cover within 500 m and 2 km was associated with increased abundance of both cavity- and ground-nesting bees, respectively [56]. The authors speculate that the smaller-bodied cavity-nesting species they captured had smaller foraging distances and thus were more associated with nearby forest resources, whereas larger-bodied ground-nesting bees could travel farther and utilize more distant resources. These studies suggest that the effect of the landscape matrix is species-specific and influences life cycle needs and foraging distance.

In addition to the quantity of different land cover types within the matrix, the quality and permeability of the matrix may influence pollinator populations. As opposed to the rigid definitions of usable patches and linear corridors within an unusable matrix, matrix permeability describes a more fluid gradient of use that “spills over” into and within the matrix. A meta-analysis of wildlife habitat creation in agricultural areas suggests that increasing the permeability of a matrix by improving the quality of the matrix may be a more effective method to increase fragment connectivity and reduce the negative effects of patch isolation [104]. With this in mind, perhaps urban pollinator habitat improvement efforts should consider not just creating more patches or corridors of habitat but also improve the quality of the surrounding matrix.

5.2. Size, Arrangement, and Connectivity of Green Space within the Urban Matrix

The quality, size, and isolation of an urban green space can interact to determine its value for supporting insect pollinators. While the species–area relationship suggests that larger fragments have higher species richness, when it comes to urban pollinators, the relationship between size and quality is more complex. As noted above, high-quality small gardens can have an equivalent or higher pollinator habitat value than larger green space [52,92], even if isolated [59]. Reviews on the optimal size of green space to support insect pollinators suggests that it depends on the mobility of the pollinator [17,18,105]. Pollinator foraging distances are species-specific and influenced by body size, foraging specificity, and eusocial lifestyle [47]. While smaller-bodied species may persist within small patches of habitat more characteristic of urban areas, larger-bodied species are able to travel further and cover larger distances in search of resources, especially within a fragmented urban landscape [20,106]. For example, larger, colony-nesting bees such as bumblebees are considered more generalist pollinators and have larger foraging ranges than smaller, solitary bees. Bumblebees (10–23 mm body length) can forage up to one mile from the nest, while smaller mason bees (6–11 mm body length) forage within 300 feet from the nest [47]. Hinners et al. [49], studying suburban green space fragments in Colorado, found that species richness increased with area up to a point, but they also found that there was a shift in bee species composition from small to larger areas, some of which reflects mobility differences. Smaller areas harbored more bees that were eusocial, small-bodied, and cavity-nesters, whereas larger areas shifted to dominance by solitary, large-bodied, and ground-nesting species. Even if these same patterns do not apply elsewhere, the important lesson for planners is that a diversity of green space sizes across the landscape can increase the diversity of pollinators supported overall, due to differences in the response to green space characteristics.

Patch *isolation* is one measure that could negatively impact pollinator use of any one patch and the metapopulation of pollinators as a whole. Several studies have found that as a habitat patch becomes more isolated from a natural habitat, pollinator populations begin to decrease [107,108]. However, in the urban grassland areas of Berlin, Fischer et al. [109] found that only one pollinator species (*Bombus terrestris*) was affected by degree of habitat isolation (negatively), but the authors note that the goodness-of-fit for this model was low and the results should be used cautiously. One possible solution is the use of small "stepping stones" of pollinator habitat to connect isolated patches across a landscape [110]. While flight distances vary by body size and local site conditions, using estimates of flight distance may provide a starting point to determining how far away a functional stepping-stone habitat should be (Figure 2). Creating stepping stones between habitat patches could essentially increase the quality of the matrix and facilitate pollinator movement across the landscape. Especially for smaller pollinators with a limited foraging range, the proximity of abundant floral resources is critically important for survival and successful reproduction. Even across a small area, such as an urban or campus promenade, having frequent patches of dense foraging resources will ensure that pollinators with small foraging ranges will have accessible resources.

Although much of the research on pollinator corridor habitat has focused on agriculture, corridors of linear habitat may serve to connect habitat patches and facilitate pollinator movement across the urban landscape as well. In croplands, linear habitat in ditches can increase pollen dispersal between isolated habitat patches [111]. A similar study of linear hedgerows in cropland in southern England suggests that both hedgerow quality (absence of gaps, high species diversity, and an abundant, flowering understory layer) and landscape context (hedgerows were more valuable in intensively managed landscapes) influenced the value of hedgerows to pollinators and other insects [112]. Comparisons can be made between an inhospitable matrix of monoculture crops and a matrix of resource-poor urban environments such as traditional lawns or parking lots. Linear corridors of unbroken, floral-rich habitat may facilitate movement through intensively managed landscapes devoid of pollinator resources, however, the strategy of increasing matrix permeability, as discussed above, should also be considered.

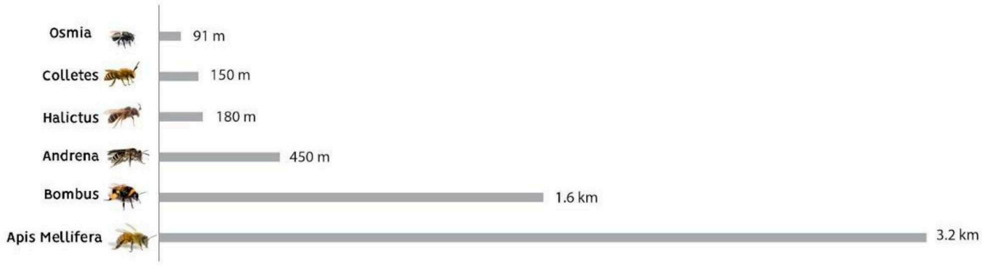

Figure 2. Estimated flight distances of bees [47] can provide insights into stepping stone spacing of pollinator habitat.

In conclusion, much research suggests that landscape-scale variables are less important than garden-scale variables in determining pollinator populations; however, pollinator foraging distances and proximity to natural habitats may be helpful factors to consider when prioritizing locations for new pollinator habitat. Where feasible, improving matrix quality and creating linear habitat corridors are two potential strategies that may improve overall urban landscape connectivity for pollinators, and these are areas needing more research. Interestingly, there is some evidence that the heterogeneous, dynamic, and cosmopolitan nature of urban landscapes has actually increased the number of species that can thrive there and perhaps is evolutionarily selecting for species that are more tolerant of these conditions [113].

6. Management—What Urban Management Practices Would Support Pollinator Ecosystem Services?

Individual decisions in urban yard and garden management are critical to consider in supporting pollinator habitat [114,115]. Currently, many common urban green space management practices threaten biodiversity in cities [32]. These include the continued maintenance of turf grass lawns, which leads to a lack of foraging resources, the application of pesticides and herbicides, and tree and shrub pruning/leaf removal (especially as "fall/spring clean ups," which can greatly diminish nesting habitat for pollinators).

Mowing management, as discussed above, has been studied in a way that allows for specific applications to improve practices for pollinator ecosystem services. Less intensively managed urban lawns host more plant species [116]. If coordinated, then even a small percentage of adoptees of a lower mowing frequency, delayed mowing, or no mowing can scale up and might have positive conservation implications for bee habitat [24,114]. A reduction in mowing frequency from every few weeks to only once or twice per season causes a species turnover and increases the plant species richness of urban lawns by 30% [85]. Moreover, the change in management also increases the spatial heterogeneity within and between lawns. Lerman et al. [87] suggest a 'lazymower' approach as a practical, economical, and time-saving alternative that also helps to promote bee conservation. They argue this approach might garner broad public support (compared with lawn reduction or replacement), because it more closely aligns with current single-family homeowner motivations for adopting lawn-dominated yardscapes. However, less is not always better. A very low mowing frequency might exceed the aesthetic tolerance of many homeowners and their neighbors.

7. Conclusions and Planning Recommendations

We have framed the current literature within actionable design questions that aim to guide urban design for pollinator ecosystem services. It is clear from this review that urban green spaces present ample opportunity for meaningful—and quantifiable—improvements in pollinator habitat in the face of increasing urbanization. Here, we summarize the recommendations based on the evidence reviewed above and provide evidence-based and feasible planting typologies.

7.1. Summary of Planting Recommendations at the Local Scale

Urbanized areas, especially less densely built areas more characteristic of "suburban" or "urban sprawl" that still have a high proportion of vegetated areas, represent a matrix for some bee species, especially large-bodied, generalist, and cavity-nesting species, while many specialist species may have habitat requirements that are incompatible with most levels of urbanization. Urban environments may be able to support a diverse assemblage of bee communities by improving habitat quality at a relatively small scale. Actions to diversify urban bee community assemblages and improve the genetic diversity of existing populations should emphasize provisioning habitat and resource requirements for smaller-bodied and ground-nesting species, which make up 75% of bee species [25].

For urban habitats, it is not necessarily the degree of "urban-ness" but instead the specific characteristics of each urban green space that ultimately influence pollinator abundance and diversity. Urban areas with a higher floral diversity and floral abundance tend to have a higher pollinator abundance and/or diversity. Native gardens typically feature greater floral abundance, taller vegetation, more cover, and more potential nesting sites that likely attract pollinators. Incorporating native plants into the urban landscape is critically important for supporting abundant, diverse pollinator populations. However, even though plant nativity has been found to positively affect bee abundance and richness, it need not be the only consideration in floral resource management. Many non-native, ornamental plants serve the dual purpose of providing pollinator resources (e.g., nectar, pollen, structure) and signaling important social cues, including legibility and familiarity, that influence the acceptance, care, and longevity of gardens. Public park managers, landscapers, and even homeowners should prioritize native flowering species, but they should not be afraid to fill in gaps in flowering periods with non-native species when needed [57], if the risks discussed above are considered.

Floral morphology is another important factor to consider while improving the quality of pollinator habitat. A garden with diverse flower shapes, colors, and other features will attract a more diverse assemblage of pollinators. Moreover, providing a diversity of flowers across the entire growing season will support a greater diversity of pollinators throughout their life cycles. The seasonality of flowering times and food availability throughout the growing season is essential to ensure that a diverse community of bees can persist even within a relatively small area [65]. An array of plant species that allow for consistent flowering, from spring ephemerals to late-season bloomers, has been shown to be of greater significance to bee populations than high plant nativity. Though plant selection is often focused on herbaceous species, trees represent significant sources of floral resources when in bloom due to the size and abundance of inflorescences. Including native flowering tree species into the landscape can provide a substantial pollinator resource within a very small footprint [73] as well as woody vegetation for cavity-nesters [56]. Leaf litter, plant stems, dead and decaying plant debris, bare soil, as well as other habitats that are beyond floral resources, provide valuable nesting and overwintering spots for pollinators.

Given the research findings reviewed, to support pollinators in urban green spaces through planting design, in summary, we recommend the following:

- Incorporate high densities of flowering plants, including flowering trees.
- Incorporate a high diversity of flowering species by varying the species and floral features in each bed across the landscape.

- Utilize species with flowering times that span the entire growing season, including beneficial spring bulbs and late-blooming fall flowers.
- In areas with high aesthetic and maintenance requirements, utilize non-native, ornamental, or "nativar" plants that provide pollinator resources but do not pose a risk of invasive spread.
- In areas with lower aesthetic and maintenance requirements, utilize as many native plants as possible.
- Seek out native plants that are well-adapted to the harsh conditions of urban environments. Some desirable characteristics include salt, heat, and drought tolerance and higher pH tolerance.
- Avoid the widespread use of wood mulch; instead, create a mix of bare ground and leaf litter cover to support bees with different nesting requirements.
- Where appropriate, use plants as "living mulch" to maximize plant resources and reduce weeding and watering requirements.
- Look for opportunities to "improve the matrix" between garden beds. Consider bee-friendly lawns, flowering trees, and functional planters that can provide additional support between garden beds.

Taking these recommendations and the research into consideration, we designed four replicable garden typologies that provide multifunctional benefits to people and pollinators in an urban or suburban setting. A typology describes a design solution for a particular set of conditions. We propose typologies that address four main design goals for urban pollinator gardens: pollinator needs, safety, ease of maintenance, and cultural aesthetics (Figure 3). The four proposed typologies (Figures 4–7) represent planting templates for four common urban site conditions with plants specific to the midwestern United States. In terms of pollinator needs, the typologies consider key features such as high floral diversity and abundance, high diversity and density of native plants, sufficient floral resources throughout the growing season, and diverse floral shapes. In terms of safety concerns, it may be an urban requirement that vegetation height be less than 3 feet or canopy height greater than 6 feet to provide clear visibility. The typologies also consider ease of maintenance by using seven species or less planted at a high density that will form a tightly growing mass to shade out weeds. Several cultivated native plants (i.e., "nativars") are used that were selected for their superior landscape performance characteristics, such as drought tolerance, tidy habit, or more attractive blooms. Finally, the designs feature plants that are visually attractive, including beautiful flowers and foliage, with an emphasis on plants that provide multiple seasons of interest. These ecological and social goals inform the proposed typologies, creating design solutions that provide numerous benefits when implemented in an urban setting (Figure 8).

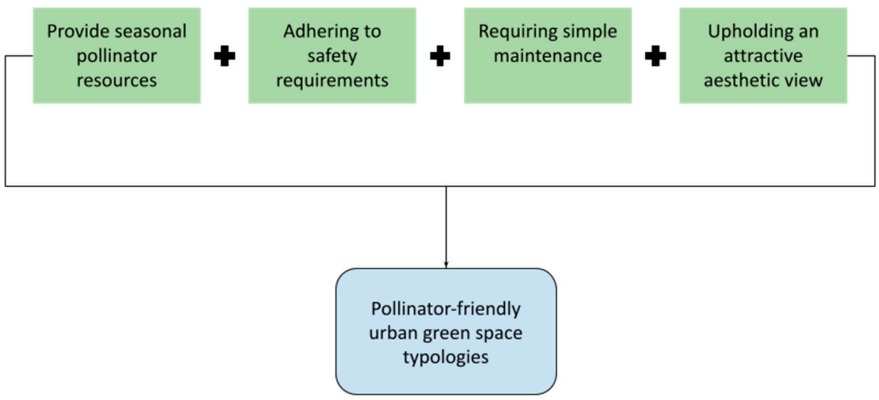

Figure 3. Guiding principles for creating informed pollinator garden typologies in an urbanized setting.

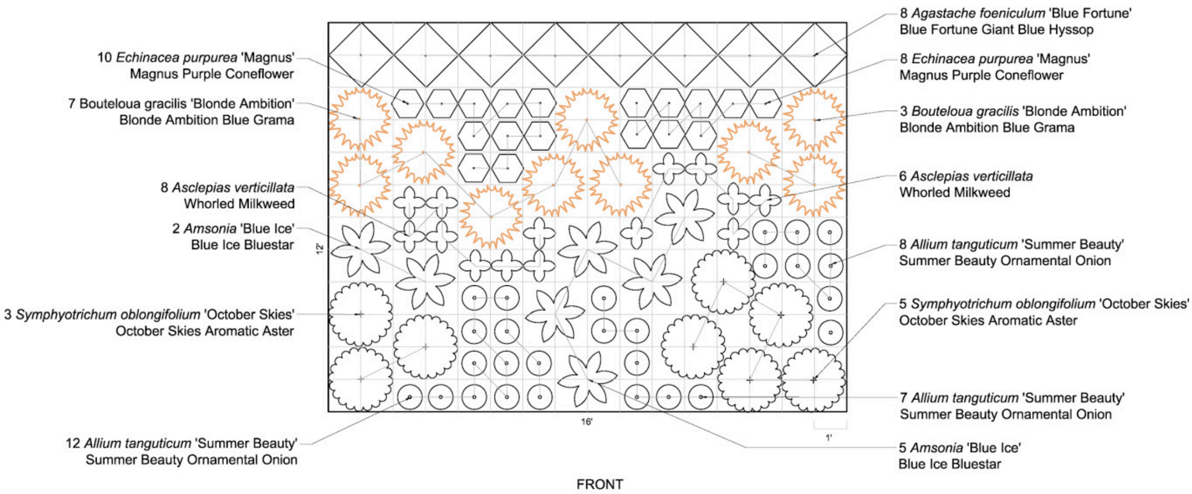

Figure 4. Typology 1: Full sun, medium moisture, high visibility (e.g., showy sidewalk garden).

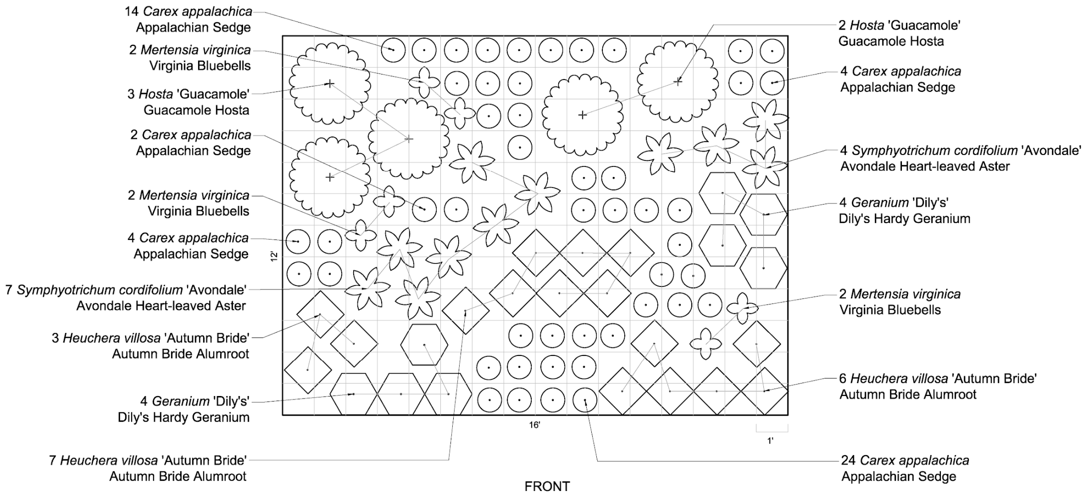

Figure 5. Typology 2: Shade, dry, high visibility (e.g., under tree canopy).

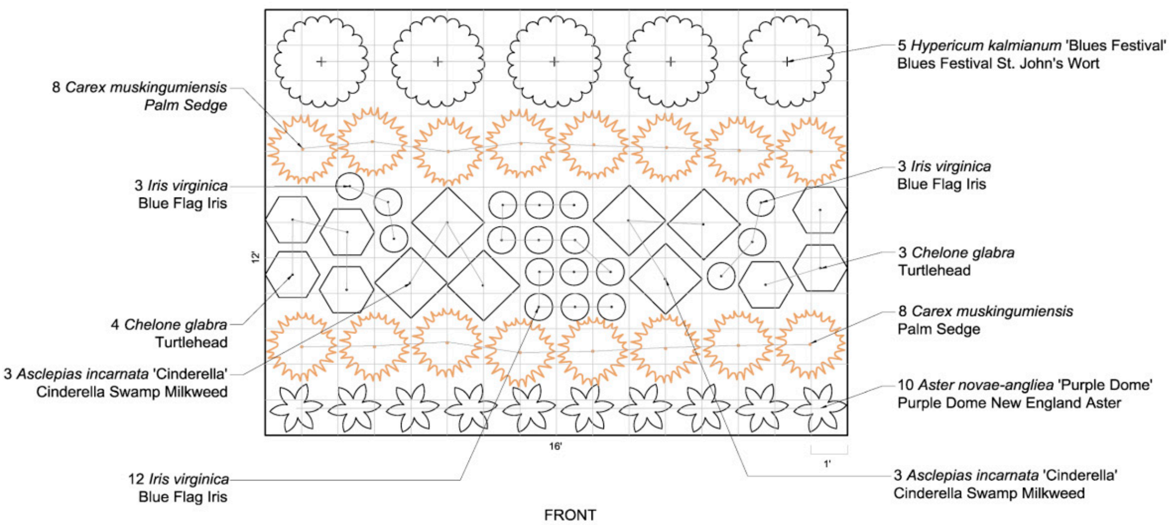

Figure 6. Typology 3: Partial sun, frequently wet (e.g., rain garden).

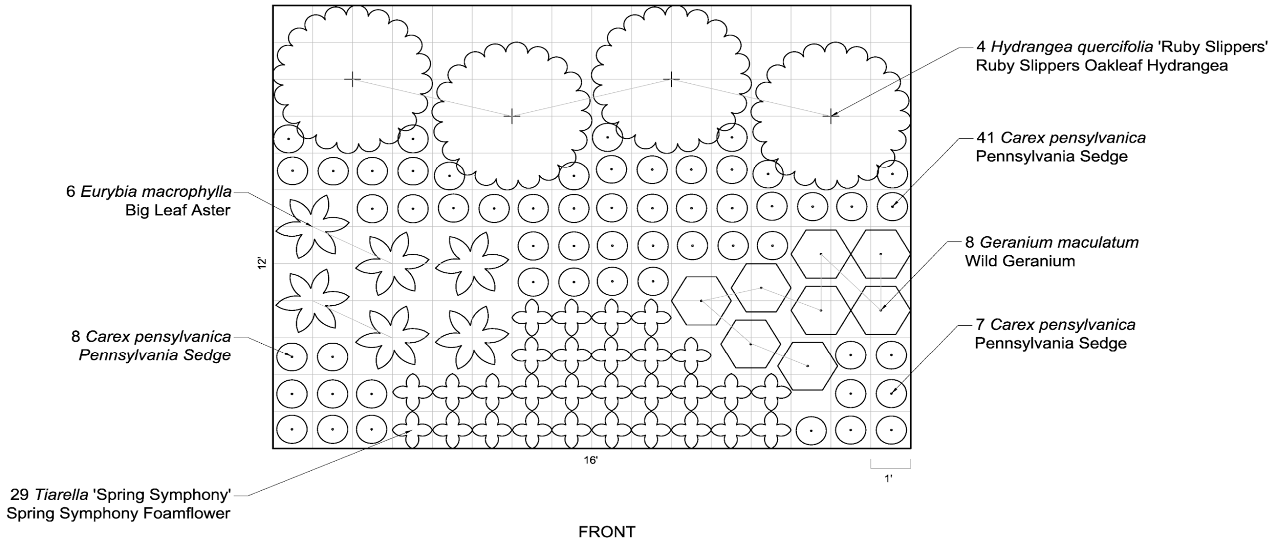

Figure 7. Typology 4: Shade, medium moisture, low visibility (e.g., foundation hedge).

Figure 8. Visual to illustrate application of Typology 3 and Typology 4 in an urban setting, where it provides multifunctional benefits of pollinator habitat, improved water infiltration (shown as arrows), and aesthetic enjoyment.

7.2. Summary of Landscape-Scale Recommendations for Urban Planning

While local garden-scale characteristics are critical for attracting and supporting pollinators, the consideration of a broader landscape-scale perspective can better inform urban planning to promote the ecosystem service value of pollinators. Pollinator foraging distances and proximity to natural habitats can be helpful factors to prioritize locations for new pollinator habitat and improve matrix quality. Linking quality, source habitats to the surrounding habitat is essential to support metapopulations of diverse bee species. Because the mean range for bee species is much smaller than for other animals, unpaved, unbuilt areas larger than 100 square meters can support abundant floral resources and may even represent viable habitat for small-bodied species [117], and even smaller spaces can be corridors. Small, unpaved surfaces in urban areas, such as along sidewalk edges or in-between buildings, should be planted with flowering herbs and trees to function as stepping-stones between habitat patches within an urban matrix [110]. By prioritizing existing urban green spaces for land-sparing and emphasizing land-sharing across the broader matrix through improvements in habitat quality, communities of more bee species may be able to establish large, connected, and persistent populations in urbanized environments. Beyond gardens designed for aesthetics, vegetable gardens can also provide the floral resources that pollinators require [56]. Property owners, especially those adjacent and near green spaces, should be encouraged to increase the overall structural and vegetative heterogeneity of their yards, but even for the most resistant of individuals, simply minimizing the presence and area of turf can be beneficial [118].

7.3. Conclusions

The field of urban pollinator landscape ecology is still developing, but there is no question that there is high potential for urban landscapes to support functional pollinator habitat. As the value of urban green spaces is increasingly being recognized, and we have accumulated a body of research on the specific features of effective pollinator habitat at the local and landscape scale, this knowledge can be directly applied to the design of individual gardens and planning across urban landscapes.

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References

1. Potts, S.G.; Biesmeijer, J.C.; Kremen, C.; Neumann, P.; Schweiger, O.; Kunin, W.E. Global Pollinator Declines: Trends, Impacts and Drivers. *Trends Ecol. Evol.* **2010**, *25*, 345–353. [CrossRef]
2. Pleasants, J.M.; Oberhauser, K.S. Milkweed Loss in Agricultural Fields Because of Herbicide Use: Effect on the Monarch Butterfly Population. *Insect Conserv. Divers.* **2013**, *6*, 135–144. [CrossRef]
3. Goulson, D.; Nicholls, E.; Botías, C.; Rotheray, E.L. Bee Declines Driven by Combined Stress from Parasites, Pesticides, and Lack of Flowers. *Science* **2015**, *347*, 1255957. [CrossRef]
4. Nicolson, S.W.; Wright, G.A. Plant—Pollinator Interactions and Threats to Pollination. *Funct. Ecol.* **2017**, *31*, 22–25. [CrossRef]
5. IPBES. *The Assessment Report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on Pollinators, Pollination and Food Production*; Potts, S.G., Imperatriz-Fonseca, V.L., Ngo, H.T., Eds.; Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services: Bonn, Germany, 2016; 552p.
6. Biesmeijer, J.C.; Roberts, S.P.M.; Reemer, M.; Ohlemüller, R.; Edwards, M.; Peeters, T.; Schaffers, A.P.; Potts, S.G.; Kleukers, R.; Thomas, C.D.; et al. Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands. *Science* **2006**, *313*, 351–354. [CrossRef] [PubMed]
7. Burkle, L.A.; Marlin, J.C.; Knight, T.M. Plant-Pollinator Interactions over 120 Years: Loss of Species, Co-Occurrence, and Function. *Science* **2013**, *339*, 1611–1615. [CrossRef] [PubMed]
8. Cameron, S.A.; Lozier, J.D.; Strange, J.P.; Koch, J.B.; Cordes, N.; Solter, L.F.; Griswold, T.L. Patterns of Widespread Decline in North American Bumble Bees. *Proc. Natl. Acad. Sci.* **2011**, *108*, 662–667. [CrossRef] [PubMed]
9. Martins, A.C.; Gonçalves, R.B.; Melo, G.A.R. Changes in Wild Bee Fauna of a Grassland in Brazil Reveal Negative Effects Associated with Growing Urbanization during the Last 40 Years. *Zoologia (Curitiba)* **2013**, *30*, 157–176. [CrossRef]
10. Balmford, A.; Bruner, A.; Cooper, P.; Costanza, R.; Farber, S.; Green, R.E.; Jenkins, M.; Jefferiss, P.; Jessamy, V.; Madden, J.; et al. Ecology: Economic Reasons for Conserving Wild Nature. *Science* **2002**, *297*, 950–953. [CrossRef]
11. Leemans, R.; Groot, R.S. *de Millennium Ecosystem Assessment: Ecosystems and Human Well-Being: A Framework for Assessment*; Island Press: Washington, DC, USA, 2003; ISBN 978-1-55963-402-1.
12. Ollerton, J.; Winfree, R.; Tarrant, S. How Many Flowering Plants Are Pollinated by Animals? *Oikos* **2011**, *120*, 321–326. [CrossRef]

13. Klein, A.-M.; Vaissière, B.E.; Cane, J.H.; Steffan-Dewenter, I.; Cunningham, S.A.; Kremen, C.; Tscharntke, T. Importance of Pollinators in Changing Landscapes for World Crops. *Proc. R. Soc. B Biol. Sci.* **2007**, *274*, 303–313. [CrossRef]
14. Gallai, N.; Salles, J.-M.; Settele, J.; Vaissière, B.E. Economic Valuation of the Vulnerability of World Agriculture Confronted with Pollinator Decline. *Ecol. Econ.* **2009**, *68*, 810–821. [CrossRef]
15. Reilly, J.R.; Artz, D.R.; Biddinger, D.; Bobiwash, K.; Boyle, N.K.; Brittain, C.; Brokaw, J.; Campbell, J.W.; Daniels, J.; Elle, E.; et al. Crop Production in the USA Is Frequently Limited by a Lack of Pollinators. *Proc. R. Soc. B Biol. Sci.* **2020**, *287*, 20200922. [CrossRef] [PubMed]
16. Fuller, R.A.; Irvine, K.N.; Devine-Wright, P.; Warren, P.H.; Gaston, K.J. Psychological Benefits of Greenspace Increase with Biodiversity. *Biol. Lett.* **2007**, *3*, 390–394. [CrossRef] [PubMed]
17. Harrison, T.; Winfree, R. Urban Drivers of Plant-Pollinator Interactions. *Funct. Ecol.* **2015**, *29*, 879–888. [CrossRef]
18. Ayers, A.C.; Rehan, S.M. Supporting Bees in Cities: How Bees Are Influenced by Local and Landscape Features. *Insects* **2021**, *12*, 128. [CrossRef]
19. Prendergast, K.S.; Dixon, K.W.; Bateman, P.W. A Global Review of Determinants of Native Bee Assemblages in Urbanised Landscapes. *Insect Conserv. Divers.* **2022**, *15*, 385–405. [CrossRef]
20. Ahrné, K.; Bengtsson, J.; Elmqvist, T. Bumble Bees (*Bombus* spp.) along a Gradient of Increasing Urbanization. *PLoS ONE* **2009**, *4*, e5574. [CrossRef]
21. Geslin, B.; Gauzens, B.; Thébault, E.; Dajoz, I. Plant Pollinator Networks along a Gradient of Urbanisation. *PLoS ONE* **2013**, *8*, e63421. [CrossRef]
22. Jones, E.L.; Leather, S.R. Invertebrates in Urban Areas: A Review. *EJE* **2013**, *109*, 463–478. [CrossRef]
23. Baldock, K.C.; Goddard, M.A.; Hicks, D.M.; Kunin, W.E.; Mitschunas, N.; Osgathorpe, L.M.; Potts, S.G.; Robertson, K.M.; Scott, A.V.; Stone, G.N. Where Is the UK's Pollinator Biodiversity? The Importance of Urban Areas for Flower-Visiting Insects. *Proc. R. Soc. B Biol. Sci.* **2015**, *282*, 20142849. [CrossRef]
24. Hall, D.M.; Camilo, G.R.; Tonietto, R.K.; Ollerton, J.; Ahrné, K.; Arduser, M.; Ascher, J.S.; Baldock, K.C.R.; Fowler, R.; Frankie, G.; et al. The city as a refuge for insect pollinators. *Conserv. Biol.* **2017**, *31*, 24–29. [CrossRef]
25. Wenzel, A.; Grass, I.; Belavadi, V.V.; Tscharntke, T. How Urbanization Is Driving Pollinator Diversity and Pollination—A Systematic Review. *Biol. Conserv.* **2020**, *241*, 108321. [CrossRef]
26. Potter, A.; LeBuhn, G. Pollination Service to Urban Agriculture in San Francisco, CA. *Urban Ecosyst.* **2015**, *18*, 885–893. [CrossRef]
27. Goulson, D.; Lepais, O.; O'connor, S.; Osborne, J.L.; Sanderson, R.A.; Cussans, J.; Goffe, L.; Darvill, B. Effects of Land Use at a Landscape Scale on Bumblebee Nest Density and Survival. *J. Appl. Ecol.* **2010**, *47*, 1207–1215. [CrossRef]
28. Langellotto, G.A.; Melathopoulos, A.; Messer, I.; Anderson, A.; McClintock, N.; Costner, L. Garden Pollinators and the Potential for Ecosystem Service Flow to Urban and Peri-Urban Agriculture. *Sustainability* **2018**, *10*, 2047. [CrossRef]
29. Silva, V.H.D.; Gomes, I.N.; Cardoso, J.C.F.; Bosenbecker, C.; Silva, J.L.S.; Cruz-Neto, O.; Oliveira, W.; Stewart, A.B.; Lopes, A.V.; Maruyama, P.K. Diverse Urban Pollinators and Where to Find Them. *Biol. Conserv.* **2023**, *281*, 110036. [CrossRef]
30. Baldock, K.C. Opportunities and Threats for Pollinator Conservation in Global Towns and Cities. *Curr. Opin. Insect Sci.* **2020**, *38*, 63–71. [CrossRef] [PubMed]
31. Xerces.org. Available online: https://xerces.org/publications/guidelines/pollinator-friendly-parks (accessed on 23 May 2023).
32. Aronson, M.F.; Lepczyk, C.A.; Evans, K.L.; Goddard, M.A.; Lerman, S.B.; MacIvor, J.S.; Nilon, C.H.; Vargo, T. Biodiversity in the City: Key Challenges for Urban Green Space Management. *Front. Ecol. Environ.* **2017**, *15*, 189–196. [CrossRef]
33. Llodrà-Llabrés, J.; Cariñanos, P. Enhancing Pollination Ecosystem Service in Urban Green Areas: An Opportunity for the Conservation of Pollinators. *Urban For. Urban Green.* **2022**, *74*, 127621. [CrossRef]
34. Davis, A.Y.; Lonsdorf, E.V.; Shierk, C.R.; Matteson, K.C.; Taylor, J.R.; Lovell, S.T.; Minor, E.S. Enhancing Pollination Supply in an Urban Ecosystem through Landscape Modifications. *Landsc. Urban Plan.* **2017**, *162*, 157–166. [CrossRef]
35. Bertuol-Garcia, D.; Morsello, C.; El-Hani, C.N.; Pardini, R. A Conceptual Framework for Understanding the Perspectives on the Causes of the Science–Practice Gap in Ecology and Conservation. *Biol. Rev.* **2018**, *93*, 1032–1055. [CrossRef]
36. Enquist, C.A.; Jackson, S.T.; Garfin, G.M.; Davis, F.W.; Gerber, L.R.; Littell, J.A.; Tank, J.L.; Terando, A.J.; Wall, T.U.; Halpern, B.; et al. Foundations of Translational Ecology. *Front. Ecol. Environ.* **2017**, *15*, 541–550. [CrossRef]
37. Toomey, A.H.; Knight, A.T.; Barlow, J. Navigating the Space between Research and Implementation in Conservation. *Conserv. Lett.* **2017**, *10*, 619–625. [CrossRef]
38. Nascimento, V.T.; Agostini, K.; Souza, C.S.; Maruyama, P.K. Tropical Urban Areas Support Highly Diverse Plant-Pollinator Interactions: An Assessment from Brazil. *Landsc. Urban. Plan.* **2020**, *198*, 103801. [CrossRef]
39. Maruyama, P.K.; Bonizário, C.; Marcon, A.P.; D'Angelo, G.; da Silva, M.M.; da Silva Neto, E.N.; Oliveira, P.E.; Sazima, I.; Sazima, M.; Vizentin-Bugoni, J.; et al. Plant-Hummingbird Interaction Networks in Urban Areas: Generalization and the Importance of Trees with Specialized Flowers as a Nectar Resource for Pollinator Conservation. *Biol. Conserv.* **2019**, *230*, 187–194. [CrossRef]
40. Diniz, U.M.; Lima, S.A.; Machado, I.C.S. Short-Distance Pollen Dispersal by Bats in an Urban Setting: Monitoring the Movement of a Vertebrate Pollinator through Fluorescent Dyes. *Urban Ecosyst.* **2019**, *22*, 281–291. [CrossRef]
41. Smith, T.J.; Saunders, M.E. Honey Bees: The Queens of Mass Media, despite Minority Rule among Insect Pollinators. *Insect Conserv. Divers.* **2016**, *9*, 384–390. [CrossRef]

42. Adamson, N.; Roulston, T.; Fell, R.; Mullins, D. From April to August—Wild Bees Pollinating Crops through the Growing Season in Virginia, USA. *Environ. Entomol.* **2012**, *41*, 813–821. [CrossRef]
43. Paini, D.R. Impact of the Introduced Honey Bee (*Apis mellifera*) (Hymenoptera: Apidae) on Native Bees: A Review. *Austral. Ecol.* **2004**, *29*, 399–407. [CrossRef]
44. MacInnis, G.; Normandin, E.; Ziter, C.D. Decline in Wild Bee Species Richness Associated with Honey Bee (*Apis mellifera* L.) Abundance in an Urban Ecosystem. *PeerJ* **2023**, *11*, e14699. [CrossRef]
45. Senapathi, D.; Biesmeijer, J.C.; Breeze, T.D.; Kleijn, D.; Potts, S.G.; Carvalheiro, L.G. Pollinator Conservation—The Difference between Managing for Pollination Services and Preserving Pollinator Diversity. *Curr. Opin. Insect Sci.* **2015**, *12*, 93–101. [CrossRef]
46. Senapathi, D.; Goddard, M.A.; Kunin, W.E.; Baldock, K.C.R. Landscape Impacts on Pollinator Communities in Temperate Systems: Evidence and Knowledge Gaps. *Funct. Ecol.* **2017**, *31*, 26–37. [CrossRef]
47. Holm, H. *Pollinators of Native Plants*; Pollination Press LLC: Minnetonka, MN, USA, 2014; ISBN 97809913563001.
48. Geslin, B.; Le Féon, V.; Folschweiller, M.; Flacher, F.; Carmignac, D.; Motard, E.; Perret, S.; Dajoz, I. The Proportion of Impervious Surfaces at the Landscape Scale Structures Wild Bee Assemblages in a Densely Populated Region. *Ecol. Evol.* **2016**, *6*, 6599–6615. [CrossRef] [PubMed]
49. Hinners, S.J.; Kearns, C.A.; Wessman, C.A. Roles of Scale, Matrix, and Native Habitat in Supporting a Diverse Suburban Pollinator Assemblage. *Ecol. Appl.* **2012**, *22*, 1923–1935. [CrossRef] [PubMed]
50. Vaughan, M.; Black, S.H. *Enhancing Nest Sites For Native Bee Crop Pollinators. Agroforestry note 34*; USDA National Agroforestry Center: Lincoln, NE, USA, 2007.
51. Bates, A.J.; Sadler, J.P.; Fairbrass, A.J.; Falk, S.J.; Hale, J.D.; Matthews, T.J. Changing Bee and Hoverfly Pollinator Assemblages along an Urban-Rural Gradient. *PLoS ONE* **2011**, *6*, e23459. [CrossRef]
52. Daniels, B.; Jedamski, J.; Ottermanns, R.; Ross-Nickoll, M. A "Plan Bee" for Cities: Pollinator Diversity and Plant-Pollinator Interactions in Urban Green Spaces. *PLoS ONE* **2020**, *15*, e0235492. [CrossRef]
53. Persson, A.S.; Ekroos, J.; Olsson, P.; Smith, H.G. Wild Bees and Hoverflies Respond Differently to Urbanisation, Human Population Density and Urban Form. Landsc. *Urban Plan.* **2020**, *204*, 103901. [CrossRef]
54. Chong, K.Y.; Teo, S.; Kurukulasuriya, B.; Chung, Y.F.; Rajathurai, S.; Tan, H.T.W. Not All Green Is as Good: Different Effects of the Natural and Cultivated Components of Urban Vegetation on Bird and Butterfly Diversity. *Biol. Conserv.* **2014**, *171*, 299–309. [CrossRef]
55. Dylewski, Ł.; Maćkowiak, Ł.; Banaszak-Cibicka, W. Are All Urban Green Spaces a Favourable Habitat for Pollinator Communities? Bees, Butterflies and Hoverflies in Different Urban Green Areas. *Ecol. Entomol.* **2019**, *44*, 678–689. [CrossRef]
56. Pardee, G.L.; Philpott, S.M. Native Plants Are the Bee's Knees: Local and Landscape Predictors of Bee Richness and Abundance in Backyard Gardens. *Urban Ecosyst.* **2014**, *17*, 641–659. [CrossRef]
57. Salisbury, A.; Armitage, J.; Bostock, H.; Perry, J.; Tatchell, M.; Thompson, K. Editor's Choice: Enhancing Gardens as Habitats for Flower-Visiting Aerial Insects (Pollinators): Should We Plant Native or Exotic Species? *J. Appl. Ecol.* **2015**, *52*, 1156–1164. [CrossRef]
58. Wojcik, V.A.; McBride, J.R. Common Factors Influence Bee Foraging in Urban and Wildland Landscapes. *Urban Ecosyst.* **2012**, *15*, 581–598. [CrossRef]
59. Tonietto, R.; Fant, J.; Ascher, J.; Ellis, K.; Larkin, D. A Comparison of Bee Communities of Chicago Green Roofs, Parks and Prairies. *Landsc. Urban Plan.* **2011**, *103*, 102–108. [CrossRef]
60. Tallamy, D.W.; Narango, D.L.; Mitchell, A.B. Do Non-Native Plants Contribute to Insect Declines? *Ecol. Entomol.* **2020**, *46*, 729–742. [CrossRef]
61. Erickson, E.; Adam, S.; Russo, L.; Wojcik, V.; Patch, H.M.; Grozinger, C.M. More Than Meets the Eye? The Role of Annual Ornamental Flowers in Supporting Pollinators. *Environ. Entomol.* **2020**, *49*, 178–188. [CrossRef]
62. Fukase, J. Increased Pollinator Activity in Urban Gardens with More Native Flora. *Appl. Ecol. Env. Res.* **2016**, *14*, 297–310. [CrossRef]
63. Rollings, R.; Goulson, D. Quantifying the Attractiveness of Garden Flowers for Pollinators. *J. Insect. Conserv.* **2019**, *23*, 803–817. [CrossRef]
64. Frankie, G.W.; Thorp, R.W.; Schindler, M.; Hernandez, J.; Ertter, B.; Rizzardi, M. Ecological Patterns of Bees and Their Host Ornamental Flowers in Two Northern California Cities. *J. Kans. Entomol. Soc.* **2005**, *78*, 227–246. [CrossRef]
65. Wojcik, V.A.; Frankie, G.W.; Thorp, R.W.; Hernandez, J.L. Seasonality in Bees and Their Floral Resource Plants at a Constructed Urban Bee Habitat in Berkeley, California. *J. Kans. Entomol.* **2008**, *81*, 15–28. [CrossRef]
66. Praz, C.J.; Müller, A.; Dorn, S. Specialized Bees Fail to Develop on Non-Host Pollen: Do Plants Chemically Protect Their Pollen. *Ecology* **2008**, *89*, 795–804. [CrossRef]
67. Winfree, R.; Fox, W.J.; Williams, N.M.; Reilly, J.R.; Cariveau, D.P. Abundance of Common Species, Not Species Richness, Drives Delivery of a Real-World Ecosystem Service. *Ecol. Lett.* **2015**, *18*, 626–635. [CrossRef] [PubMed]
68. Morales, C.L.; Traveset, A. A Meta-Analysis of Impacts of Alien vs. Native Plants on Pollinator Visitation and Reproductive Success of Co-Flowering Native Plants. *Ecol. Lett.* **2009**, *12*, 716–728. [CrossRef]
69. von der Lippe, M.; Kowarik, I. Do Cities Export Biodiversity? Traffic as Dispersal Vector across Urban–Rural Gradients. *Divers. Distrib.* **2008**, *14*, 18–25. [CrossRef]

70. McLean, P.; Gallien, L.; Wilson, J.R.U.; Gaertner, M.; Richardson, D.M. Small Urban Centres as Launching Sites for Plant Invasions in Natural Areas: Insights from South Africa. *Biol. Invasions* **2017**, *19*, 3541–3555. [CrossRef]
71. Garbuzov, M.; Ratnieks, F.L.W. The Strengths and Weaknesses of Lists of Garden Plants to Help Pollinators: The Strengths and Weaknesses of Lists of Garden Plants to Help Pollinators. *BioScience* **2014**, *64*, 1019–1026. [CrossRef]
72. Nassauer, J.I. Messy Ecosystems, Orderly Frames. *Landsc. J.* **1995**, *14*, 161–170. [CrossRef]
73. Somme, L.; Moquet, L.; Quinet, M.; Vanderplanck, M.; Michez, D.; Lognay, G.; Jacquemart, A.-L. Food in a Row: Urban Trees Offer Valuable Floral Resources to Pollinating Insects. *Urban Ecosyst.* **2016**, *19*, 1149–1161. [CrossRef]
74. Lowenstein, D.M.; Matteson, K.C.; Minor, E.S. Evaluating the Dependence of Urban Pollinators on Ornamental, Non-Native, and 'Weedy' Floral Resources. *Urban Ecosyst.* **2019**, *22*, 293–302. [CrossRef]
75. Staab, M.; Pereira-Peixoto, M.H.; Klein, A.-M. Exotic Garden Plants Partly Substitute for Native Plants as Resources for Pollinators When Native Plants Become Seasonally Scarce. *Oecologia* **2020**, *194*, 465–480. [CrossRef]
76. Davis, M.A.; Chew, M.K.; Hobbs, R.J.; Lugo, A.E.; Ewel, J.J.; Vermeij, G.J.; Brown, J.H.; Rosenzweig, M.L.; Gardener, M.R.; Carroll, S.P.; et al. Don't Judge Species on Their Origins. *Nature* **2011**, *474*, 153–154. [CrossRef] [PubMed]
77. Coombs, G. Monarda Research Report. Available online: https://issuu.com/mtcuba/docs/monarda-report-final/1 (accessed on 17 February 2021).
78. Baisden, E.C.; Tallamy, D.W.; Narango, D.L.; Boyle, E. Do Cultivars of Native Plants Support Insect Herbivores? *HortTechnology* **2018**, *28*, 596–606. [CrossRef]
79. Fenster, C.B.; Armbruster, W.S.; Wilson, P.; Dudash, M.R.; Thomson, J.D. Pollination Syndromes and Floral Specialization. *Annu. Rev. Ecol. Evol. Syst.* **2004**, *35*, 375–403. [CrossRef]
80. Robbins, P.; Birkenholtz, T. Turfgrass Revolution: Measuring the Expansion of the American Lawn. *Land Use Policy* **2003**, *20*, 181–194. [CrossRef]
81. Ignatieva, M.; Ahrné, K.; Wissman, J.; Eriksson, T.; Tidåker, P.; Hedblom, M.; Kätterer, T.; Marstorp, H.; Berg, P.; Eriksson, T. Lawn as a Cultural and Ecological Phenomenon: A Conceptual Framework for Transdisciplinary Research. *Urban For. Urban Green.* **2015**, *14*, 383–387. [CrossRef]
82. Robbins, P. *Lawn People: How Grasses, Weeds, and Chemicals Make Us Who We Are*; Temple University Press: Philadelphia, PA, USA, 2012; ISBN 9781592135806.
83. Jenkins, V. *The Lawn: A History of an American Obsession*; Smithsonian Institution: Washington, DC, USA, 1994; ISBN 9781560984061.
84. Nassauer, J.I.; Wang, Z.; Dayrell, E. What Will the Neighbors Think? Cultural Norms and Ecological Design. *Landsc. Urban Plan.* **2009**, *92*, 282–292. [CrossRef]
85. Sehrt, M.; Bossdorf, O.; Freitag, M.; Bucharova, A. Less Is More! Rapid Increase in Plant Species Richness after Reduced Mowing in Urban Grasslands. *Basic Appl. Ecol.* **2020**, *42*, 47–53. [CrossRef]
86. Fetridge, E.D.; Ascher, J.S.; Langellotto, G.A. The Bee Fauna of Residential Gardens in a Suburb of New York City (Hymenoptera: Apoidea). *Ann. Entomol. Soc. Am.* **2008**, *101*, 1067–1077. [CrossRef]
87. Lerman, S.B.; Contosta, A.R.; Milam, J.; Bang, C. To Mow or to Mow Less: Lawn Mowing Frequency Affects Bee Abundance and Diversity in Suburban Yards. *Biol. Conserv.* **2018**, *221*, 160–174. [CrossRef]
88. Knight, T.M.; Ashman, T.-L.; Bennett, J.M.; Burns, J.H.; Passonneau, S.; Steets, J.A. Reflections on, and Visions for, the Changing Field of Pollination Ecology. *Ecol. Lett.* **2018**, 1282–1295. [CrossRef]
89. Smith, R.M.; Gaston, K.J.; Warren, P.H.; Thompson, K. Urban Domestic Gardens (VIII): Environmental Correlates of Invertebrate Abundance. *Biodivers. Conserv.* **2006**, *15*, 2515–2545. [CrossRef]
90. Hülsmann, M.; von Wehrden, H.; Klein, A.-M.; Leonhardt, S.D. Plant Diversity and Composition Compensate for Negative Effects of Urbanization on Foraging Bumble Bees. *Apidologie* **2015**, *46*, 760–770. [CrossRef]
91. Keasar, T. The Spatial Distribution of Nonrewarding Artificial Flowers Affects Pollinator Attraction. *Anim. Behav.* **2000**, *60*, 639–646. [CrossRef] [PubMed]
92. Normandin, É.; Vereecken, N.J.; Buddle, C.M.; Fournier, V. Taxonomic and Functional Trait Diversity of Wild Bees in Different Urban Settings. *PeerJ* **2017**, *5*, e3051. [CrossRef]
93. Plascencia, M.; Philpott, S.M. Floral Abundance, Richness, and Spatial Distribution Drive Urban Garden Bee Communities. *Bull. Entomol. Res.* **2017**, *107*, 658–667. [CrossRef]
94. Quistberg, R.D.; Bichier, P.; Philpott, S.M. Landscape and Local Correlates of Bee Abundance and Species Richness in Urban Gardens. *Environ. Entomol.* **2016**, *45*, 592–601. [CrossRef]
95. O'Toole, C.; Raw, A. *Bees of the World*; Facts on File: New York, NY, USA, 2004; ISBN 9780816057122.
96. Michener, C.D. *The Bees of the World*, 2nd ed.; The Johns Hopkins University Press: Baltimore, MD, USA, 2007; ISBN 9780801885730.
97. MacIvor, J.S.; Packer, L. 'Bee hotels' as tools for native pollinator conservation: A premature verdict? *PLoS ONE* **2015**, *10*, e0122126. [CrossRef]
98. Geslin, B.; Gachet, S.; Deschamps-Cottin, M.; Flacher, F.; Ignace, B.; Knoploch, C.; Meineri, É.; Robles, C.; Ropars, L.; Schurr, L.; et al. Bee Hotels Host a High Abundance of Exotic Bees in an Urban Context. *Acta Oecolog.* **2020**, *105*, 103556. [CrossRef]
99. Neame, L.A.; Griswold, T.; Elle, E. Pollinator Nesting Guilds Respond Differently to Urban Habitat Fragmentation in an Oak-Savannah Ecosystem. *Insect Conserv. Divers.* **2013**, *6*, 57–66. [CrossRef]
100. Fortel, L.; Henry, M.; Guilbaud, L.; Mouret, H.; Vaissière, B.E. Use of human-made nesting structures by wild bees in an urban environment. *J. Insect Conserv.* **2016**, *20*, 239–253. [CrossRef]

101. Cane, J.H. Landscaping pebbles attract nesting by the native ground-nesting bee *Halictus rubicundus* (Hymenoptera: Halictidae). *Apidologie* **2015**, *46*, 728–734. [CrossRef]
102. Baldock, K.C.R.; Goddard, M.A.; Hicks, D.M.; Kunin, W.E.; Mitschunas, N.; Morse, H.; Osgathorpe, L.M.; Potts, S.G.; Robertson, K.M.; Scott, A.V.; et al. A Systems Approach Reveals Urban Pollinator Hotspots and Conservation Opportunities. *Nat. Ecol. Evol.* **2019**, *3*, 363–373. [CrossRef]
103. Majewska, A.A.; Altizer, S. Planting Gardens to Support Insect Pollinators. *Conserv. Biol.* **2020**, *34*, 15–25. [CrossRef] [PubMed]
104. Donald, P.F.; Evans, A.D. Habitat Connectivity and Matrix Restoration: The Wider Implications of Agri-Environment Schemes. *J. Appl. Ecol.* **2006**, *43*, 209–218. [CrossRef]
105. Egerer, M.H.; Arel, C.; Otoshi, M.D.; Quistberg, R.D.; Bichier, P.; Philpott, S.M. Urban Arthropods Respond Variably to Changes in Landscape Context and Spatial Scale. *J. Urban Ecol.* **2017**, *3*, jux001. [CrossRef]
106. Steffan-Dewenter, I.; Tscharntke, T. Effects of habitat isolation on pollinator communities and seed set. *Oecologia* **1999**, *121*, 432–440. [CrossRef] [PubMed]
107. Garibaldi, L.A.; Steffan-Dewenter, I.; Kremen, C.; Morales, J.M.; Bommarco, R.; Cunningham, S.A.; Carvalheiro, L.G.; Chacoff, N.P.; Dudenhöffer, J.H.; Greenleaf, S.S.; et al. Stability of Pollination Services Decreases with Isolation from Natural Areas despite Honey Bee Visits. *Ecol. Lett.* **2011**, *14*, 1062–1072. [CrossRef]
108. Kennedy, C.M.; Lonsdorf, E.; Neel, M.C.; Williams, N.M.; Ricketts, T.H.; Winfree, R.; Bommarco, R.; Brittain, C.; Burley, A.L.; Cariveau, D.; et al. A Global Quantitative Synthesis of Local and Landscape Effects on Wild Bee Pollinators in Agroecosystems. *Ecol. Lett.* **2013**, *16*, 584–599. [CrossRef]
109. Fischer, L.K.; Eichfeld, J.; Kowarik, I.; Buchholz, S. Disentangling Urban Habitat and Matrix Effects on Wild Bee Species. *PeerJ* **2016**, *4*, e2729. [CrossRef] [PubMed]
110. Van Rossum, F.; Triest, L. Stepping-Stone Populations in Linear Landscape Elements Increase Pollen Dispersal between Urban Forest Fragments. *Plant Ecol. Evol.* **2012**, *145*, 332–340. [CrossRef]
111. Van Geert, A.; Van Rossum, F.; Triest, L. Do linear landscape elements in farmland act as biological corridors for pollen dispersal? *J. Ecol.* **2010**, *98*, 178–187. [CrossRef]
112. Garratt, M.P.; Senapathi, D.; Coston, D.J.; Mortimer, S.R.; Potts, S.G. The benefits of hedgerows for pollinators and natural enemies depends on hedge quality and landscape context. *Agric. Ecosyst. Environ.* **2017**, *247*, 363–370. [CrossRef]
113. Sattler, T.; Duelli, P.; Obrist, M.K.; Arlettaz, R.; Moretti, M. Response of arthropod species richness and functional groups to urban habitat structure and management. *Landsc. Ecol.* **2010**, *25*, 941–954. [CrossRef]
114. Goddard, M.A.; Dougill, A.J.; Benton, T.G. Scaling up from Gardens: Biodiversity Conservation in Urban Environments. *Trends Ecol. Evol.* **2010**, *25*, 90–98. [CrossRef] [PubMed]
115. Shwartz, A.; Muratet, A.; Simon, L.; Julliard, R. Local and Management Variables Outweigh Landscape Effects in Enhancing the Diversity of Different Taxa in a Big Metropolis. *Biol. Conserv.* **2013**, *157*, 285–292. [CrossRef]
116. Rudolph, M.; Velbert, F.; Schwenzfeier, S.; Kleinebecker, T.; Klaus, V.H. Patterns and Potentials of Plant Species Richness in High-and Low-maintenance Urban Grasslands. *Appl. Veg. Sci.* **2017**, *20*, 18–27. [CrossRef]
117. Blaauw, B.R.; Isaacs, R. Larger patches of diverse floral resources increase insect pollinator density, diversity, and their pollination of native wildflowers. *Basic Appl. Ecol.* **2014**, *15*, 701–711. [CrossRef]
118. Turo, K.J.; Gardiner, M.M. Effects of urban greenspace configuration and native vegetation on bee and wasp reproduction. *Conserv. Biol.* **2021**, *35*, 1755–1765. [CrossRef]