Prioritizing Spatial Configuration of Pollinator Gardens to Increase Pollinator Biodiversity Within the Greater Minneapolis Area

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Executive Summary

Although pollinators are an important economic and ecological resource, their numbers are declining rapidly due to urbanization, habitat loss, and habitat fragmentation. The creation of pollinator gardens, which are plots of foraging and nesting habitat designed for pollinator benefit, can help to mitigate these threats. To aid in this effort, the Mississippi Watershed Management Organization (MWMO) offers funding for the construction of rain gardens/pollinator gardens, and they are interested in determining whether spatial distribution of pollinator gardens should be a factor in funding decisions. In this report, we explore how the spatial distribution of available foraging area affects pollinator species diversity and overall success. We examined whether areas with few pollinator gardens effectively create “pollinator deserts”. We compared the distribution of known rain gardens and pollinator gardens with the foraging ranges of different bee species. We found that gaps in these gardens are large relative to the foraging ranges of bumblebees and wild bees, but not honeybees. Increasing the density of pollinator gardens in areas where they are currently sparse is likely to lead to increases in pollinator diversity. We are planning follow-up experiments for the summer of 2016 to test this hypothesis.
Introduction

Pollinators are animals that carry pollen from one plant source to another to initiate fruit and seed production. Pollinators are crucial for processes such as flowering plant reproduction and production of fruits and seeds that serve as an important food source for humans and other wildlife\(^1\). Having a healthy and diverse pollinator population has significant ecologic and economic benefits. For example, native and domesticated bees are responsible for pollinating around 30% of crops in the U.S. every year, which is about $23 billion in value\(^2\).

Making efforts to provide suitable habitat is especially important in urbanized areas, where pollinator habitats are often very fragmented and may lack the sources of food and shelter that are key to pollinator survival\(^3\). This can be accomplished by planting native flowers and grasses in buffer areas like along roadsides, forest edges, hedgerows, and medians. Ultimately, pollinators have been harmed by our rapid urbanization and agricultural practices, extensive use of harmful pesticides, disease, the rapidly changing climate, loss of habitat due to agriculture and (sub)urban developments, degradation, and resource extraction\(^4\) and certain species are declining rapidly due to almost total loss of habitat. Providing pollinator gardens can help to mitigate the effects of the threats named above (Table 1). A pollinator garden is an area of restored habitat filled with key plant species that not only attract specific types of pollinators but also assist in the survival of these vital pollinators by providing food and resources.

Minnesota Pollinator Diversity

Minnesota has over 400 species of bees. The MN department of Natural Resources has yet to list the number and name of specific MN native pollinators and to determine which ones are endangered\(^5\). However, we do know that Minnesota has about twenty species of bumblebees (\textit{Bombus} spp.), six of which researchers think are declining\(^6\). Minnesota also has about 146 different species

\(^1\) U.S. Fish and wildlife services (March 1, 2016). "Why pollinators are important." Accessed:


of butterflies, and 2,000-2,500 different species of moths, eight of which are endangered, one of which is threatened and 10 are listed as special concern. In addition, unlike Honey Bees and Bumble Bees (most commonly known pollinators) who only make up about 2% of bee species in Minnesota, the remaining species are solitary bees; they don't live in colony systems. Examples of solitary bees include leafcutter bees, yellow-faced bees, and small carpenter bees. The importance of bee diversity would be that there is a positive correlation between species richness and the density and diversity of links within species interaction webs. It can also stabilize ecosystem services, like pollination, during disturbance and variability in the environment. Bee diversity is also important for agricultural purposes and can benefit pollination services by increasing the production of fruits and seeds, enhancing the per-visit efficiency of individual pollinators, and hedging against declines in managed pollinators.

**Pollinator Habitat Degradation**

One of the main reasons for pollinator population decline is loss of habitat due to growth and development of urban cities and expansion of agriculture. Within cities, pollinator gardens can be found clumped together forming isolated islands of habitat. For these pollinator gardens to be useful to bees and other pollinators, they have be located within the foraging distances of the pollinator species. Pollinators have specific foraging ranges, or the distance that they tend

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to travel to access food and resources. Because of this, we hypothesize that areas where pollinator gardens are sparse may effectively be "pollinator deserts". We define a pollinator desert as a region where there are limited or no pollinator habitats, which hinders proper pollinator foraging behavior. Studies have shown that pollinators will avoid traveling to small or isolated patches of garden, as the benefit of these areas apparently does not outweigh the energy required to reach them\textsuperscript{14}. The term pollinator desert can also describe a region with little to no connectivity between pollinator habitats. Corridors or links connecting gardens or habitats have been demonstrated to increase pollinator visitation and movement and thus to mitigate the effects of habitat fragmentation\textsuperscript{15}. However, many urban and suburban pollinator gardens are isolated and disconnected from other pollinator habitats, creating the theoretical pollinator desert. To be beneficial to pollinators, not only does the distance between gardens matter but so does the density of the garden. Pollinators need a certain density of decent foraging habitat within a certain radius to support the colony. In cities as well as rural areas there are regions where pollinator gardens have large gaps that go beyond foraging ranges of pollinators, limiting access to resources pollinators need to survive. If the density becomes spares enough, this area becomes a pollinator desert.

Because there is a lot of variability in the foraging ranges of different types of pollinators, pollinator deserts may exist for some species but not others. Ultimately, lack of suitable habitat can lead to decline in pollinator populations and to changes in the structure of the pollinator community, which itself can lead to changes in plant species composition of an area\textsuperscript{16}. Since bee species, like bumble bees, forage for pollen within a certain distance from a centralized nest, it is suggested that a larger total garden and or an increase in wild areas of a garden may aid in larva/pupa development\textsuperscript{17}. Although Minnesota has a wide variety of native pollinators including bees, butterflies, moths, beetles, and hummingbirds, we have chosen to focus on bees, as they are one of the most well-known and recognizable pollinators. Bees, because they are not a migratory species, like butterflies and humming birds, they do not have the ability to travel great distances and are more affected by isolation of pollinator gardens.


Additionally, the decline in bee population has become a topic of emerging concern, and there is a great deal of research and literature on bee behavior.

Goals

The main goals of this project are to determine a) if pollinator deserts are a real phenomenon and b) if there are areas of pollinator isolation in the Minneapolis area based upon known pollinator behavioral data. From these, we will make suggestions regarding prioritization of specific areas for pollinator garden grant funding by MWMO. To address our goals we hope to create a map to show where current/possible pollinator deserts are in comparison to the foraging ranges of the three bee species we are focusing on.

Bee Foraging Behavior

The foraging distance for honey bees tends to be the largest of the bees at around a 2-7 mile radius\(^\text{18}\). However, literature values can vary significantly across honeybee species *A. mellifera*, foraging distances have been recorded as small as 150 ft and as large as 3.7 miles, and the mean distance was 0.5 miles\(^\text{19}\). Based upon the literature we consulted, we will use 4 miles for our range\(^\text{20}\).

Bumblebees tend to forage less widely than honeybees; the general consensus is within a 0.3-1 mile radius\(^\text{21}\). Again, this varies between species. *B. terrestris* forages largely within 330 feet of its nest, but has been observed foraging as far as 0.4 miles\(^\text{22,23}\). Similarly, *B. pascuorum* tends to forage within 0.2 miles of its nest\(^\text{20}\). Conservatively, we will assume a range of about 0.5 miles.

The foraging distance for wild bees can vary significantly as well. According to the UMN Bee Lab, wild bees generally have a much smaller


foraging range than honey bees, perhaps because wild bees tend to be solitary. This range tends to be around 0.3 miles\textsuperscript{24}. However, some native wild bees may have ranges larger or smaller than this estimate; literature values are limited. For our purposes, we will assume a range of 0.3 miles.

**Existing Pollinator Gardens and Identification of Pollinator Deserts**

Pollinator gardens registered through share.pollinator.org are mapped in Figure 1 below. While these data provide some indication of the spatial distribution of pollinator gardens around Minneapolis, this is an incomplete dataset. Because rain gardens also typically provide foraging habitat for bees and other pollinators, we have used a map of rain gardens from metroblooms.org as a better indicator of the spatial distribution of pollinator gardens in the Twin Cities (Figure 2).

![Figure 1. Pollinator gardens in or near the MWMO watershed, that are registered through share.pollinator.org.](image)

Figure 2. Rain Gardens surrounding Minneapolis, with average foraging ranges for honey bees, bumble bees, and wild bees overlaid. A few gardens, some in highly concentrated areas and some isolated, were chosen for example. This illustrates the concept of a pollinator desert, particularly in regards to bumble and wild bees versus honey bees. Map from Metroblooms.org.

Analysis

Based on the known distribution of pollinator and rain gardens in the Minneapolis area and surrounding suburbs and information gathered from the literature, pollinator deserts are a real issue, particularly downtown Minneapolis. Additionally, these deserts exist for some species and not others; for example, wild bees and bumble bees forage much less widely than honey bees, so these pollinators are much more prone to being stranded than others may be. Because honey bees will forage four miles or more for pollen, the density of gardens throughout the twin cities is high enough to support their foraging; thus, pollinator
deserts largely do not exist for them. However, this may have negative effects on overall pollinator diversity\textsuperscript{25}, particularly in urban areas with more distance between gardens. The honey bee \textit{Apis mellifera} is technically nonnative. These bees have quickly become dominant over other species, and they will continue to outcompete native and solitary bees in an environment where their success is favored\textsuperscript{26}. Thus, addressing the issue of pollinator deserts in regards to smaller solitary wild bees may help to support their population growth and overall species diversity, and increase the functional diversity of pollinators so that this important ecosystem service will continue even if honey bees decline.

**Identifying Knowledge Gaps**

Due to limited information on this subject, we’ve been able to identify knowledge gaps including the following:

- What are the species of native pollinators found in MN?
- How does pollinator species diversity change in rural areas compared to urban areas?
- How many pollinator gardens do you need within a certain radius to support pollinators?
- How does the location of gardens affect the diversity of pollinators, specifically in urban settings?

Further research is being done to address some of these questions. The DNR is working on collecting more complete data to identify the species of native pollinators found in Minnesota and to better understand their behavior. In addition, one of our team members will be conducting research this summer following up on this report, to examine whether isolation of pollinator gardens is associated with decreased diversity of pollinator species.

After determining that spatial distribution of gardens does affect pollinator survival, the next step would be to determine the area or size of garden needed for maximum pollinator benefit for each species. For example, is one or two gardens sufficient to sustain a colony of honey bees? Our preliminary investigation yielded mixed results – for nested bees, a bigger garden is more beneficial, while for butterflies, smaller, more widely distributed gardens are more beneficial.\textsuperscript{27} As with our other findings, the best garden size for maximum benefit varies across species.

