Woody Plants for Urban Bee Conservation

Summary of research completed by Bernadette Mach and Daniel Potter, University of Kentucky

Bees

Andrena nigrihirta

Apis mellifera

Hylaeus floridanus

Augochlora pura

Anthidium porterae

Melitta americana

Ctenocolletes smaragdinus

Mention "bees," and most people think of the honey bee (*Apis mellifera*), but thousands of other bee species exist. The bees shown here each belong to a different bee family. For more about bee families, see *Bee Families* box.
Photos by Sam Droege.

Main Findings

Woody plants differ in their attractiveness to bees.
Both native and non-native woody plants can be highly attractive to bees.
To create pollinator-friendly landscapes, incorporate woody plant species that:

1. attract bees and various bee species
2. help landscapes maintain bloom throughout the growing season

Background

There are roughly 4,000 species of native bees in the U.S.A.
Bees are important:

- as pollinators–75% of leading food crops depend on pollinators (mostly bees) to some extent
- as players in the environment–an estimated 78% of all flowering plants have some level of dependency on pollinators

Many bee species can live in urban areas, where they play important roles in:

- pollinating our gardens
- maintaining native plant biodiversity
- pollinating plants whose fruits and seeds support birds and other urban wildlife

To survive, bees need food (nectar and pollen) and nesting sites.
Woody plants can be high-quality food sources (with both nectar and pollen) for bees.

Problem

Despite their importance, honey bees and native bees appear to be in decline.
Bee declines linked to multiple factors:

- habitat loss
- diseases, parasites
- stress from transport of honey bees for commercial pollination
- pesticides

To help bee populations, citizens are encouraged to establish flowering plants for pollinators (e.g. Million Pollinator Garden Challenge), **but** the lists of plants recommended for pollinators are rarely backed with scientific evidence–especially for urban woody plants.

Project Goal

Document which flowering woody plant species (trees & shrubs) attract bees in urban areas, and document the types of bees they attract.

Details of Data Collection

Sampled woody plants in 373 landscaped areas, such as municipal areas, commercial and residential landscapes, urban arboreta, and cemeteries.

Sampling took place in central and northern Kentucky, and southern Ohio, U.S.A.

Data collected between February and November of 2014-2017.

Three modes of data collection:

A. Counted total number of bee visitors

Selected 72 woody plant species.
In most cases, sampled each woody plant species in 5 different sites.
Counted the number of bees visiting each plant in two 30-second sessions.

B. Identified diversity of bee visitors

Selected 45 of the 72 woody plant species tested in section A.
In most cases, sampled each woody plant species in 5 different sites.
Collected 50 bees from each site (generally 250 bees collected for each woody plant species).
Identified each bee to genus, except for bumble bees and honey bees, which were identified to species.
To calculate diversity, used Simpson's D index (see *Measuring Diversity* box).

Measuring Diversity

To compare diversity between samples, scientists often calculate diversity indices. A diversity index is a mathematical measure that takes into account both (i) the number of species in a sample and (ii) how equally represented each species is within the sample.

To give an example, let's say that Plant A attracts:
5 individuals of Bee Species 1
5 individuals of Bee Species 2
Plant B attracts:
1 individual of Bee Species 1
9 individuals of Bee Species 2

In this case, Plant A is considered to attract a higher diversity of bees than Plant B. Why? Because even though the number of bee species found on each plant is the same (2), and the *total* number of bees found on each plant is the same (10), the bee species found on Plant A were more equally represented than the bee species found on Plant B. In other words, Plant A saw equal numbers of each bee species, while Plant B saw many more of one bee species than another.

Simpson's D–the diversity index used in this study–is one type of diversity index, and taking the inverse of the value it produces gives a value between 0 and 1. Values closer to 1 indicate higher levels of diversity, while values closer to 0 indicate lower levels of diversity.

C. Determined if certain characteristics influenced number or diversity of bee visitors:

i. Site characteristics

Compared bees in large v. small natural areas.
Large natural areas refer to park-like sites, such as arboreta, cemeteries, etc.
Small natural areas refer to more residential and commercial sites such as road medians, people's backyards, areas near parking lots or stadiums, etc.

ii. Season

Compared bees found in spring, summer, and fall.

iii. Woody plant characteristics

	Compared bees found on…
Type	trees v. shrubs
Species	different woody plant species
Origin	native v. non-native woody plant species

Several closely-related species were included for additional comparison: four *Hydrangea* species (2 native, 2 non-native), four *Ilex* species (2 native, 2 non-native), and two *Rosa* species (1 native, 1 hybrid).

Findings

Bee Families

Bees are found on every continent except Antarctica, and over 20,000 bee species have been identified worldwide.

Although honey bees are the most widely recognized bee species, their characteristics do not reflect that of most bee species. Honey bees live in social colonies with a queen and workers, for instance, but most other bee species live solitary lives, where one female bee is responsible for building her nest, laying her eggs, and finding food for her young. In other words, she is both a queen and a worker. Also, most bee species build a nest in the ground, unlike honey bees who nest in hives.

Below are short descriptions of the bee families found in this study.

Apidae
This family contains the most widely known bees, such as honey bees, bumble bees and carpenter bees. Bees within this family often appear hairy or fluffy.

Andrenidae
One of the largest of all bee families, Andrenidae includes a wide diversity of bee species that vary in both size and color. These bees are often called mining bees, and all species within this family line their nests with a substance that makes their nests waterproof.

Colletidae
Within the U.S.A., all bees from this family are solitary, meaning they live and work alone. Like bees in the Andrenidae family, many Colletid species also line their nest with a special substance for protection.

Halictidae
Often called sweat bees, this family of bees is often widespread and common. Halictids are characterized by an intriguing amount of diversity in their social structures. For example, some species can switch between living solitary lives in some environmental conditions, and living in a social hierarchy with queens and workers in others.

Megachilidae
This group includes leaf-cutter bees, mason bees, blue orchard bees, and blueberry bees.

Source: *The Bees in Your Backyard: A Guide to North America's Bees*, by Joseph S. Wilson and Olivia Messinger Carril.

A. Number of bee visitors:

Certain woody plant species attract many more bees than others.

Table A1. Top flowering woody plants attracting highest number of bee visitors.

Woody Plant Type	Woody Plant Species	Common Name	Average Number of Bees Counted in 30-seconds
 Flowering Trees	*Rhus copallinum*	Winged sumac	**65.3**
	Tetradium daniellii	Bee bee tree	**50.1**
	Maackia amurensis	Amur maackia	**42.2**
	Heptacodium miconioides	Seven-son flower	**33.2**
	Malus spp.	Flowering crabapple	**30.7**
 Flowering Shrubs	*Hydrangea paniculata*	PG Hydrangea	**31.4**
	Hypericum frondosum	St.John's wort	**28.2**
	Ilex verticillate	Common winterberry	**28.0**
	Clethra alnifolia '16 candles'	Summersweet	**26.3**
	Aesculus parviflora	Bottlebrush buckeye	**20.5**

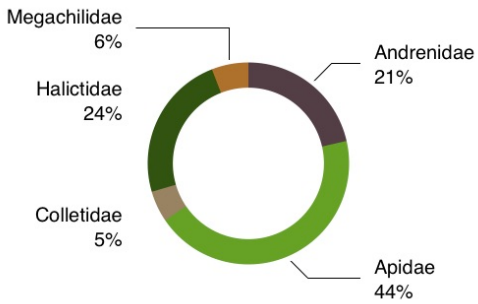
Table A2. Bottom flowering woody plants attracting lowest number of bee visitors.

Woody Plant Type	Woody Plant Species	Common Name	Average Number of Bees Counted in 30-seconds
 Flowering Trees	*Magnolia stellata*	Star magnolia	**0.6**
	Chionanthus virginicus	White fringetree	**0.3**
	Prunus 'kanzan'	Japanese cherry	**0.1**
	Magnolia liliiflora	Mulan magnolia	**0.0**
	Sassafras albidum	Sassafras	**0.0**
 Flowering Shrubs	*Forsythia* spp.	Forsythia	**0.1**
	Rosa spp.	Hybrid tea rose	**0.1**
	Calycanthus floridus	Carolina allspice	**0.0**
	Hydrangea arborescens	Smooth hydrangea	**0.0**
	Hydrangea macrophylla	Bigleaf hydrangea	**0.0**

B. Diversity of bee visitors:

Similar to the findings for number of bee visitors, some woody plant species attract a more diverse set of bees than others.

Figure B1. Identity of all sampled bees, grouped by bee family.



For more about each family, see *Bee Families* box on the left.

Table B1. Top 5 plants attracting highest bee diversity.

Woody Plant Type	Woody Plant Species	Common Name	Diversity of Collected Bees*
 Flowering Trees	*Aesculus x carnea*	Red horsechestnut	**0.70**
	Oxydendrum arboreum	Sourwood	**0.69**
	Ilex opaca	American holly	**0.65**
	Vitex agnus-castus	Chaste tree	**0.64**
	Syringa reticulata	Japanese Tree Lilac	**0.64**
 Flowering Shrubs	*Abelia* spp.	Abelia	**0.74**
	Aesculus parviflora	Bottlebrush buckeye	**0.71**
	Rosa setigera	Climbing rose	**0.70**
	Spirea virginiana	Virginia spiraea	**0.67**
	Amorpha fruticosa	False indigo	**0.66**

*Values closer to 1 indicate higher diversity, and values closer to 0 indicate lower diversity. For more information, see *Measuring Diversity* box.

To Use or Not To Use Non-native Plants?

There is an ongoing debate about whether to use non-native plants in landscaping.

The following are often considered reasons to avoid using non-native plants in landscaping:

- Non-native plants can be invasive
- Non-native plants may serve as a pathway for pathogens
- Non-native plants may support fewer wildlife species

Within the context of this study, however, we find sufficient reason to consider using non-native plants in landscaping:

- None of the non-native plants included in this study are considered invasive within the study area
- Supporting wildlife–such as insect herbivores–is not always desirable in urban areas, where increased pest pressure could lead to increased pesticide use
- Non-native plants can bloom early or late in the season, allowing them to fill in important seasonal gaps in the resources available to bees

The results from this study add to a growing body of evidence that both native and non-native plants can be valuable in supporting bees and other pollinators in urbanized habitats.

C. Characteristics influencing number or diversity of bee visitors:

Table C1. Summary table describing effect of additional characteristics on number and diversity of bees.

Factor Tested	Effect on number of bee visitors	Effect on diversity of bee visitors
Site characteristics *large/small natural areas*	NSE	NSE
Season *spring/summer/fall*	Higher number of bees found in late summer.	NSE
Woody plant characteristics		
Type *tree/shrub*	Trees had more bee visitors than shrubs.	NSE
Species	Generally, flowers with double petals or clusters of showy sterile sepals attracted few bees.	NSE
Origin *native/non-native*	NSE	NSE

NSE means No Significant Effect.

i. Site characteristics

Woody plants in smaller natural areas, such as residential and commercial landscapes, were able to attract just as many bees as woody plants in larger natural areas, such as parks and cemeteries.

ii. Season

The number of bees observed on woody plants increased slightly as the growing season progressed, but this varied by bee family.

As the growing season progressed, the number of bees from the Halictidae family and *Bombus* (bumble bee) genus increased, while the number of bees from the Andrenidae and Colletidae families decreased.
In this study, the majority of plants that bloomed very early or late in the growing season (before April or after July) were non-native. These plants were additionally highly attractive to bees.

iii. Woody plant:

Type Trees, in general, had higher numbers of bee visitors than shrubs. This result is likely due to difference in size between trees and shrubs; trees are larger than shrubs and often present more flowers, thereby attracting more bees.

Species Woody plant species can differ drastically in their attractiveness and value to bees.

Origin Both native and non-native plants can be highly attractive and valuable resources to bee visitors.

Of the four *Hydrangea* species, *Hydrangea paniculata* (a non-native) was the only species highly attractive to bees.
Of the four *Ilex* species, native and non-native Ilex species attracted similar number and diversity of bee visitors.
Of the two *Rosa* species, *Rosa setigera*–a native single-petal rose–was highly attractive to bees, whereas all hybrid tea roses were non-attractive.

Find the full study here:

Mach BM, Potter DA (2018) Quantifying bee assemblages and attractiveness of flowering woody landscape plants for urban pollinator conservation. PLoS ONE 13(12): e0208428. https://doi.org/10.1371/journal.pone.0208428

View a full presentation of this study's results in Dr. Daniel Potter's webcast *Woody Plants for Urban Bee Conservation*:
http://www.plantmanagementnetwork.org/edcenter/seminars/outreach/bee/WoodyPlants/

Download the *Plants Bees Like Best* handout, created in conjunction with HRI and using this study's data:
http://growwise.org/wp-content/uploads/2017/02/HRI-Pollinator-BeePlantLists-February2017.pdf

This study was completed as part of a larger project investigating how to protect pollinators in ornamental horticulture. To learn more about this larger project, and to access additional resources for choosing pollinator-friendly plants, see the Protecting Bees site at https://protectingbees.njaes.rutgers.edu/.

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