UPPER MIDWEST CITIZEN SCIENCE MONITORING GUIDE

NATIVE BEES

XERCES SOCIETY
for Invertebrate Conservation

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The Xerces® Society for Invertebrate Conservation is a nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. Established in 1971, the Society is at the forefront of invertebrate protection, harnessing the knowledge of scientists and the enthusiasm of citizens to implement conservation programs worldwide. The Society uses advocacy, education, habitat restoration, consulting, and applied research to promote invertebrate conservation.

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Front Cover Photos Clockwise from left: Small carpenter bee (*Ceratina* sp.) on purple prairie clover; long horned bee (*Mellisodes bimaculata*) on basil flower; & green sweat bee (*Augochlora pura*) on butterfly weed, by Sarah Foltz Jordan.

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Getting Started

Introduction

Invertebrates are tremendously diverse and ecologically valuable. They filter water, recycle nutrients, pollinate flowers, and are food for other wildlife. Pollinators are especially vital because of the ecosystem services they provide by pollinating crops and wildflowers. Insect pollinators include bees, wasps, flies, beetles, butterflies, and moths. Of these, bees are the most effective pollinators because (with a few exceptions) they are the only group that actively collects pollen to feed their young and therefore have bodies that are very effective at carrying large amounts of pollen.

This Citizen Science Monitoring Guide will allow you to track bee richness and abundance in a variety of sites including farms, hedgerows, restoration sites, remnant prairies, and almost any habitat where bees occur.

For most people, when they hear the word "bee," a single species comes to mind: the non-native European honey bee. However, North America is home to roughly 4,000 species of native bees. In the Upper Midwest, there are over 400 species of wild native bees that are important for the pollination of the region's specialty crops and wild flowering plants. Roughly one third of crops and about 85% of the earth's flowering plants rely on pollinators to set seed and fruit.

In recent years, research has shown that native bees are valuable crop pollinators, and in many cases they can be more efficient at pollination than honey bees. This is especially relevant today as the honey bee industry continues to struggle with pests, diseases, pesticide exposure, habitat loss, and the phenomenon termed "Colony Collapse Disorder." Together, these threats combine to cause beekeepers to lose 25–35% of their hives each winter since 2006.

The Xerces Society for Invertebrate Conservation has partnered with the Natural Resources Conservation Service (NRCS), Soil and Water Conservation Districts (SWCDs), Bureau of Land Management (BLM), Forest Service (USFS), Port Authorities, and landowners across the country to protect, restore, create, and enhance native bee and butterfly habitat on the lands they manage. Since 2006, we and our university research partners have used professional, standard monitoring protocols to document how bee and butterfly communities respond to restored pollinator habitat. To complement this professional monitoring, we worked with partners at the University of California–Berkeley to develop a simplified bee monitoring protocol for California and trained twenty citizen scientists to observe and identify morpho-groups of bee species (that is, sets of species

Figure 1: Bees are the most important group of pollinators in North America, responsible for pollinating numerous crops and wildflowers. (Photograph by Sarah Foltz Jordan.)

Figure 2: The pollen carried on flower-visiting insects is an essential link to the web of life. Mining bees, shown here, are very efficient pollinators of many specialty fruits produced in the Midwest. (Photograph by Sarah Foltz Jordan.)

that look similar and, in some cases, are closely related). Comparative analysis of the data gathered by these citizen scientists and data gathered by experts suggests that the morpho-groups used by citizen scientists are effective at detecting community level changes in bee abundance and richness.

The majority of the native bee species in the Upper Midwest can only be identified by looking at specimens under a microscope and there are only a handful of taxonomists in North America who can accurately identify all bees to the species level! However, by using the observation protocol and bee identification key found in this guide and by practicing with native bee experts, citizen scientists can learn to identify and monitor some of the most common bee species and morpho-groups found in the Upper Midwest.

Citizen Scientist Monitoring Protocol

The primary purpose of this monitoring protocol is to provide a method the public and land managers can use to measure the relative species richness and abundance of bees in a specific area, and to record changes in their populations over time. This information may be useful if land managers are working to increase the numbers and types of pollinators in an area by enhancing floral resources and/or nesting sites. Monitoring allows for the documentation of how restoration practices are affecting bee communities. Furthermore, if nearby crops need insect pollination to set fruit, monitoring bee visitation on these crops will give valuable information about the pollination service provided by local bee communities.

The monitoring protocol in this guide has been adapted from a standardized method of collecting bee data and setting up monitoring plots that was developed by bee biologists (see Bee Inventory Plot, http://online.sfsu.edu/~beeplot/).

Monitoring Bees

Bee communities vary depending on the quality of the immediate and surrounding habitat. Documenting changes in bee communities using this protocol will allow you to assess the efficacy of best management practices aimed at increasing pollinator abundance and richness. Best management practices may include enhancing floral resources, nest sites and host plants, reducing tillage, changing mowing regimes, and reducing the non-target impact of pesticides. Alternatively, using this protocol to monitor pollinators in field crops or orchards can provide insights into which native species provide farmers with free pollination services.

To develop an accurate picture of how bee communities are changing, however, it is important to keep in mind the following points:

- Because one of the primary goals of monitoring is to get comparative data about changes in bee richness and abundance over time, consistency in using the monitoring protocol is crucial.
- Bee populations vary depending on the time of year, time of day, and weather patterns. Because of this it is important to survey several times in a given season, and gather a few years of data before coming to any conclusions.
- While this approach is geared towards those who are not experts in insect identification, accurate monitoring does require training and practice in identifying the broad morpho-groups of bees detailed in this guide.

Figure 3: Monitoring of pollinators usually requires nothing more than careful observation of what the insects on flowers are doing and what they look like. By following the same procedure each time, you can build up a valuable record of which pollinators are most abundant at your site and changes in their populations over time. (Photograph by Kelly Gill.)

Overview of Techniques and Guidelines

The bee groups addressed in the identification guide are for use in the Upper Midwest from early spring to late summer or early fall. While bee groups in this region overlap significantly with bee groups from other parts of the country, surveys in other regioins may reveal species that do not fit into the categories found in this guide.

Standard monitoring techniques used by the research community to measure bee richness and abundance include collecting floral visitors with nets and using pan traps (bowls of soapy water). In both cases, specimens are collected, pinned, and then identified to species by a taxonomist. While these collection techniques provide the most refined data, they can be labor intensive and expensive. Additionally, if not carried out properly, they can lead to over-collecting. Collecting observational data on floral visitors is an economical and effective alternative way to monitor pollinator populations. This protocol focuses on collecting observational data; however, it can also be useful to build a local reference collection of the species you find at flowers. Building a reference collection will help you learn the floral visitors on-site and will be a useful tool for training future observers.

The Citizen Scientist Pollinator Monitoring Guide can be used to collect consistent observational data on bee communities. Guidelines in this publication include information on: (1) setting up monitoring transects, (2) sample timing, (3) appropriate weather conditions for monitoring, (4) observing bees at flowers, (5) recording data, (6) analyzing data, and (7) identifying groups of floral visitors. A sample step-by-step protocol for native bee monitoring is provided in Appendix E (p.38).

This monitoring tool is designed to be used after training with Xerces Society staff or professional scientists familiar with this monitoring guide. Training is important because consistently and accurately identifying even broad categories of bees based on their appearance takes some practice and feedback from experienced people..

Setting up Transects in Bee Monitoring Plots

The goal of this monitoring protocol is to identify specific associations between pollinators and their habitat. Therefore, monitoring transects should be located within a relatively uniform habitat type, such as a meadow, restored prairie, hedgerow, or crop.

Transects should be equally spaced throughout the study area. For areas less than two acres in size, a single transect through the middle of the site should be sufficient. A transect lenght of at least 250′ is ideal, although in smaller areas this may not be possible. For areas that are greater than two acres in size, two to three transects should be used for a total length between 600–750′ (for example, three transects 200–250' long, or two transects 300–350' long). If multiple transects are use, they should be positioned 100' apart, or as far apart as possible while still being in the interior of the plot (ideally at least 10 to 25′ from edge)

For monitoring linear habitats like hedgerows or roadsides, transects should be at least 200' long and spaced evenly along the length of the habitat. If sampling both sides of a hedgerow, transects should be at least 25' apart.

It is important to map the study area and transect points. This will allow other researchers to monitor that area in the future. If possible, take coordinates using a GPS unit or phone. If no GPS is available, mark the study area and transects on a topographic map, aerial photo, or Google Earth. It is also helpful to stake and flag monitoring transect points before monitoring to ensure a consistent and efficient monitoring scheme. Tall stakes (e.g., bamboo) with bright flagging are more visible as vegetation grows, and will help observers walk in a straight line a long the transect.

Sample Timing

Many bee species only forage for pollen and nectar for a limited number of weeks every year. As a result, bee communities vary greatly depending on what time of day or what time of year you sample. While some bee groups appear consistently during every sample round, other groups are abundant only at certain times of the year. For this reason, it is ideal to monitor a study site monthly (or even more frequently). At a minimum, monitoring should occur at least three times throughout the course of the year, in the late spring/early summer, mid summer, and late summer (the specific months for these seasons vary depending upon where you are in the region). Early spring monitoring may also be important, particularly if you are monitoring a hedgerow or other sites with early blooming shrubs present.

Whichever method you choose for your site, consistency is very important. Once dates and frequency of monitoring are selected, they should be repeated as closely as possible from one year to the next.

Appropriate Weather Conditions and Time of Day

Weather conditions strongly affect bee behavior. Generally speaking, bees avoid cold, windy, or overcast weather. To optimize bee sightings, conduct observations when the temperature is at least 15.5° C (60° F), wind speeds are less than 6 mph, and when there is enough sunlight to see your shadow. These conditions usually exist between 10 am and 3 pm. In order to monitor during optimal and consistent conditions, the time of day when monitoring occurs can be adjusted for the season and daily weather patterns.

To determine wind speed, you can use an anemometer for a precise measure (available at some outdoor outfitters), check the nearest weather station on your phone, or you can use the Beaufort Wind Scale (Table 1, below) to come up with an estimate.

Table 1 **Beaufort Wind Scale**

WIND (MPH)	CLASSIFICATION	APPEARANCE OF WIND EFFECTS
0	Calm	Smoke rises vertically
1–3	Light air	Smoke drift indicates wind direction, still wind vanes
4–6	Light breeze	Feel the wind on your face, leaves rustle, and wind vanes begin to move
7–10	Gentle breeze	Leaves and small twigs will be in constant motion, light flags extended

Observing Bees at Flowers

It is important to keep the following points in mind when collecting observational data on floral visitors:

Only collect data on insects visiting the reproductive parts of the flower:

These insects likely will be collecting either pollen or nectar, and may include bees and non-bees (Figure 4). During the sampling period, don't focus on insects sitting on leaves, petals, stems, etc. (Figure 5) or visitors flying around the area.

Look at all flower types:

Pollinators may visit flowers that are less noticeable to people—such as flowers that are quite small or green. They may also forage in deep flowers (Figure 6). For example, many small bees forage on wild columbine (*Aquilegia canadensis*), a plant with very long nectar spurs. Avoid focusing on only one or a few flower types.

Be careful not to disturb insects visiting flowers before you get a chance to observe them well:

Walk slowly, avoid sudden movements, and do not stand too close to the flower you are observing. Also, insects respond to shadows passing overhead; if possible walk so that your shadow trails you, rather than advances in front of you. If two people are monitoring together, it may be best for one person to observe and the other to record, with the recorder lagging behind so as not to further disturb pollinators.

Figure 4: Green sweat bee and soldier beetle feeding on rigid goldenrod. Non-bee floral visitors can help provide a picture of insect diversity at the site, and should be recorded if possible. Record bees first, then others. (Photograph by Sarah Foltz Jordan.)

Figure 5: Pollinators that are not visiting flowers during the sampling period should not be recorded. However, if the insect is a unique pollinator, like this Bombyliid bee fly, and not yet seen at the site, it could be noted in the additional data for your site. (Photograph by Sarah Foltz Jordan.)

Observe and identify insects as best you can and only to a level at which you are confident:

Pollinator groups and especially bee groups can be difficult to discern. Even noting whether a visitor is a honey bee, native bee, fly, wasp, butterfly or moth, is useful information. If you are particularly interested in monitoring native bees, it will be important for you to learn to distinguish, at minimum, honey bees from native bees.

Be patient:

If you are monitoring a newly planted area be aware that it may take a few years for the plants to get established before you see an increase in pollinator activity.

Recording Data

This monitoring protocol can be implemented with either a one- or two-person observer team. When using two observers, one person should make observations while the other records those observations. At the beginning of data collection, record all of the required information on the datasheet found at the back of this guide (pages 37 and 38, please photocopy the datasheet as needed; we recommend doing double-sided copies). This information includes the location, time, and date, as well as weather conditions.

When monitoring a transect, citizen scientists should pace themselves so that they move along a transect at an average rate of about 10' per minute. For example, a 250' transect should take about 25 minutes to monitor. Floral density may affect the pace of monitoring within a transect. For example, although the average recommended pace is 10' per minute, observers may slow the pace in portions of a transect with particularly high floral density and increase it where blooming plants are absent. Use a timer to help keep track of how quickly you are moving through the site (and how much time you have left). Do not stop the timer when you are looking at the floral visitors you are identifying and counting.

Transect width may vary depending on the site characterstics and plant community, but should be about 2.5′ to 3′ on each side of the observer. The goal is to establish a standard sampling duration and effort for each transect based on the size of the sampling area. This sample duration stays the same for each site and for each sample period and year, regardless of floral or insect density, in order to standardize a consistent level of effort. This could mean that the observers won't cover the whole transect (although, every effort should be made to cover the whole designated area at least once), or may need to backtrack if they complete the plot or transect before the allotted time is up.

For each floral visitor observed, the citizen scientist should record the following data (as outlined in the data sheets on p.40–42): an identification of each floral visitor (only to the level at which the observer is confident), a description of the insect or pollinator group, and the number of times an individual of this insect or pollinator group was seen during the monitoring period. If the observer is comfortable with plant identification, it is also important to note which flower species each pollinator is visiting (see Additional Data to Collect, below). If using a two person team, the observer dictates the floral visitors and their descriptions, while the observer's partner records this information on the datasheet.

Figure 6: Look inside deep flowers for small insects, such as this small sweat bee feeding on the nectar of wild columbine. (Photograph by Sarah Foltz Jordan.)

Figure 7: Transects should be marked at each end with a tall stake and colorful flagging. High visibility, even as the vegetation grows, will help observers find the transect and move in a straight line through the transect. (Photograph by Sarah Foltz Jordan.)

Additional Data to Collect

As noted above, it is also valuable to collect data on the floral associations of pollinators at your site. This information will be help improve your understanding of which plants are important for each pollinator group; which plants are visited in each season; and how pollinator preferences may change over the years as a restoration project progresses. For restoration sites, the lists of species that were planted on site should be available. You may also need to bring plant identification guides with you. Keep in mind that it is important to document blooming plants that are not being visited, as well as those that are. All plants (native or non-native) blooming in the transect during the time of the survey should be recorded.

It can also valuable to collect site specific data such as changes in land management techniques, additions to habitat structure, extreme climatic events, and anything else of ecological importance that might shed light on changing site conditions and animal richness and abundance.

Plotting Your Data

In order to draw meaningful conclusions about the effects of habitat on bee abundance and richness, data should be collected in a consistent manner over several years. To determine changes in abundance over time, tally the number of individual specimens observed during each monitoring event. These numbers could be averaged for each year (for example, combine results from the early spring, late spring/ early summer, mid-summer, and late summer sampling periods into a single average figure for the year) and plotted on a graph or table to show change between years (for example, see Table 2(a) and Figure 8; p.11). Alternatively, you could total the number of individual specimens observed during each monitoring event or period, and look at each sampling period individually (for example, you could examine changes in the total number of bees observed during the mid-summer sampling from year 1 to year 2, etc.). Note: For an analysis of bee abundance, you may want to exclude honey bees because the placement of even a couple of hives within a few miles radius of the study site could dramatically increase the overall number of bees observed.

Similarly, to calculate a measure of species richness for each sample period or year, you could tally the total number of the ten different bee morpho-groups represented in the Monitoring Guide (e.g., striped sweat bees, metallic sweat bees, bumble bees, etc.) that were observed. Once again, the richness could be plotted to record changes over time, either comparing the average or total number of groups observed across all sample periods for each year, or comparing the total number of groups observed during the same sample period from year to year (e.g., see Table 2(b) and Figure 8, p.11).

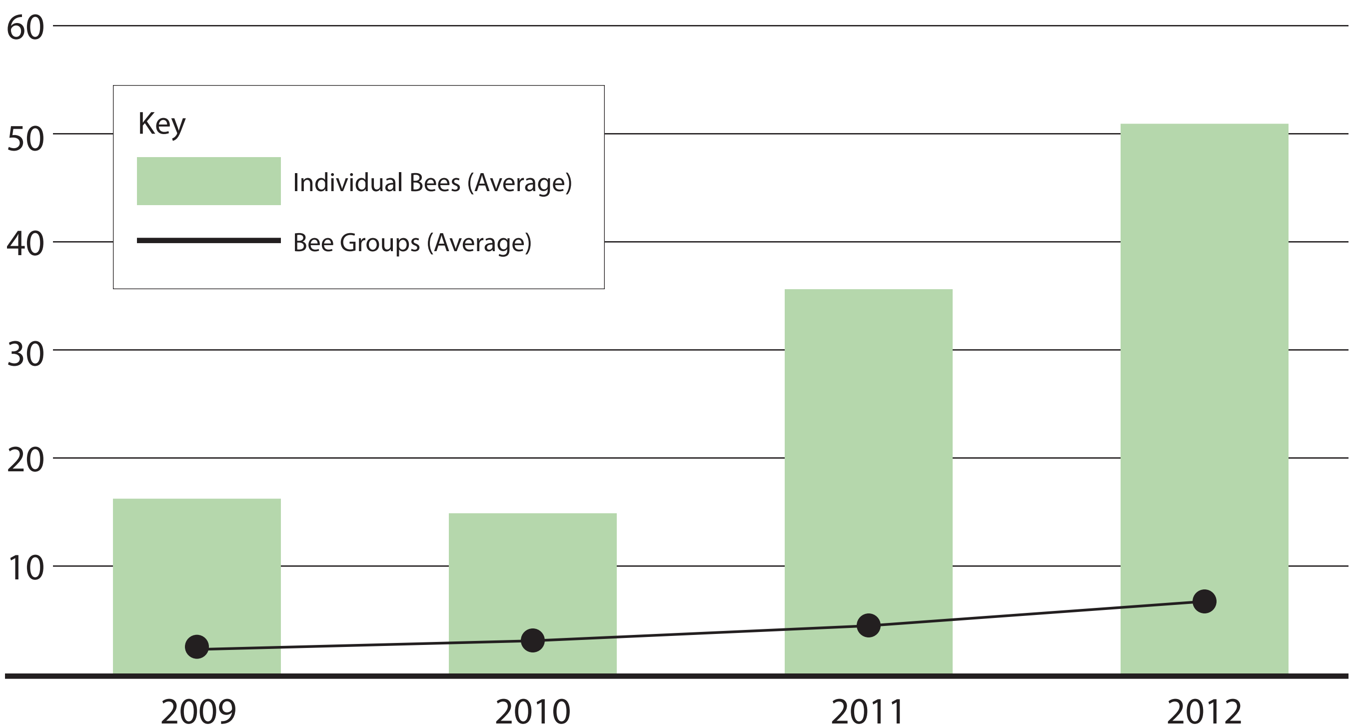
It is important to note that bee populations can vary greatly from season to season as well as from year to year, even in areas where the habitat is essentially unaltered. Thus, the number of species represented and the number of individual pollinators observed within a study area are likely to be highly variable. It is for this reason that monitoring should be conducted for many years in a row in order to draw any substantial conclusions. Sites should be monitored for a minimum of three years, and ideally five. The longer surveys are conducted, the more meaningful the results. In areas where specific habitat and management improvements have been made to attract and protect pollinators, there should be an upward trend in both pollinator abundance and richness over the course of several years. If possible, when habitat improvements are planned, it is useful to acquire baseline data on the pollinator community on site. before enhancing the habitat.

Table 2 **Example Data Spreadsheets**

(A) INDIVIDUAL BEES OBSERVED				
YEAR	LATE SPRING	MID-SUMMER	LATE SUMMER	AVG
2009	Date: 5/1	Date: 6/27	Date: 8/9	15.3
	Bees: 4	Bees: 14	Bees: 28	
2010	Date: 5/3	Date: 7/4	Date: 8/8	13
	Bees: 8	Bees 16	Bees: 15	
2011	Date: 4/30	Date: 6/30	Date: 8/11	35.7
	Bees: 22	Bees: 43	Bees: 42	
2012	Date: 5/6	Date: 6/29	Date: 8/14	51
	Bees: 28	Bees: 58	Bees: 67	

(B) BEE GROUPS OBSERVED				
YEAR	LATE SPRING	MID-SUMMER	LATE SUMMER	AVG
2009	Date: 5/1	Date: 6/27	Date: 8/9	3.3
	Groups: 2	Groups: 3	Groups: 5	
2010	Date: 5/3	Date: 7/4	Date: 8/8	4
	Groups: 4	Groups: 3	Groups: 5	
2011	Date: 4/30	Date: 6/30	Date: 8/11	5.3
	Groups: 4	Groups: 6	Groups: 6	
2012	Date: 5/6	Date: 6/29	Date: 8/14	7.3
	Groups: 6	Groups: 9	Groups: 7	

Figure 8 **Example Graph Showing Bee Community Changes**



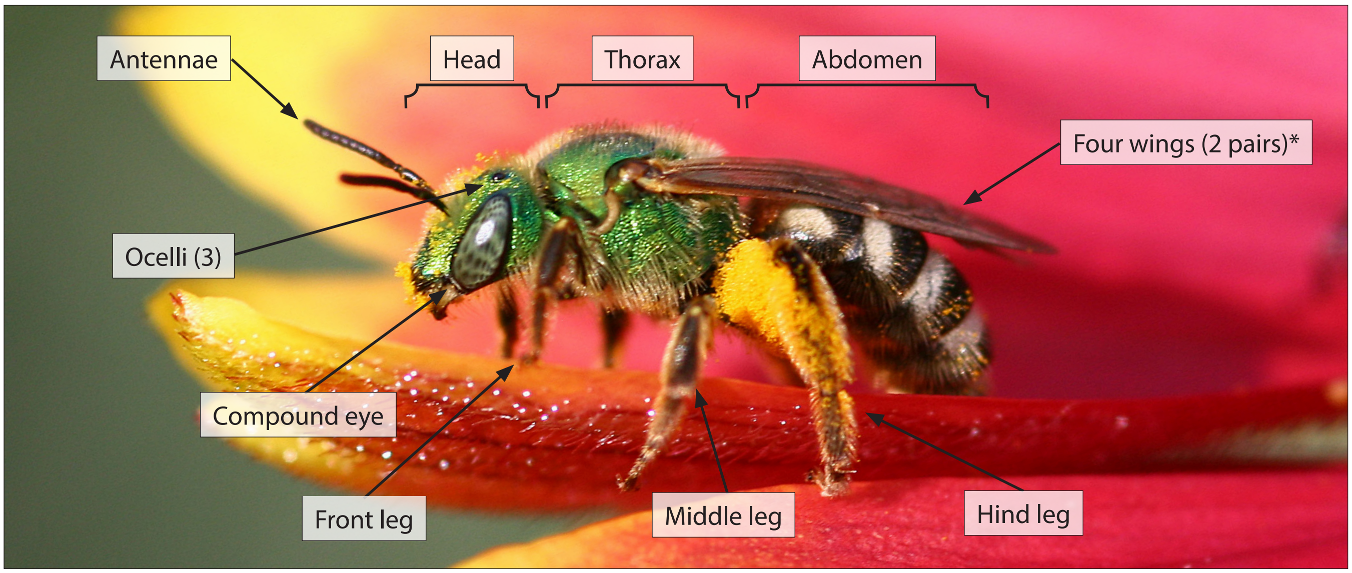
In order to analyze how bee communities change over time it is important to standardize the monitoring protocol, sampling effort, and weather conditions. Specifically, monitoring should occur at roughly the same time every year, for the same amount of time, over the same area, and under similar conditions using a standardized protocol. Once a protocol has been established for a site, it should be clearly written out so that it may be referenced in future years or easily replicated by a different trained observer.

Section 2

IDENTIFYING FLORAL VISITORS

Distinguishing butterflies, moths, or spiders from bees is simple. Separating bees from wasps or flies—especially those that mimic bees—can be harder. The following pages provide more information on how to identify the principal groups of bees and key characteristics to look for when identifying specific bee groups.

Basic Bee Anatomy

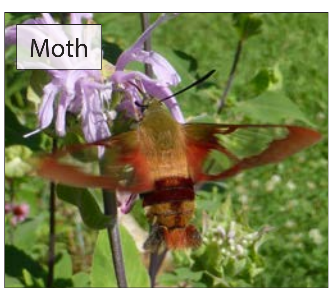


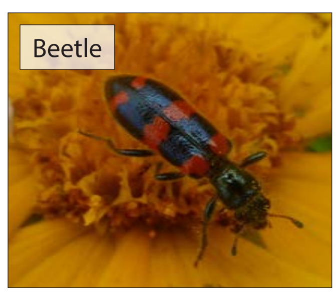
*Note: it can be difficult to see all four wings because sometimes the wings are folded on top of each other.

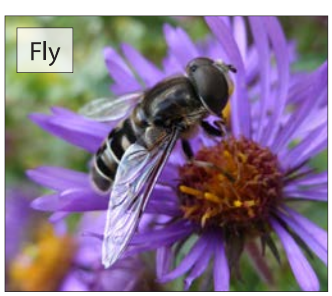
Photograph courtesy of sankax.

Non-Bee Quick Reference

Bees, in general, have evolved to be the most efficient pollen transporters. However, many other animals that visit flowers have the potential to pollinate as well, and may also be indicators of a healthy ecosystem. For this reason, you may wish to note all floral visitors.







Insect and spider photographs by Sarah Foltz Jordan; hummingbird photo courtesy of Bill Buchanan.

Bees

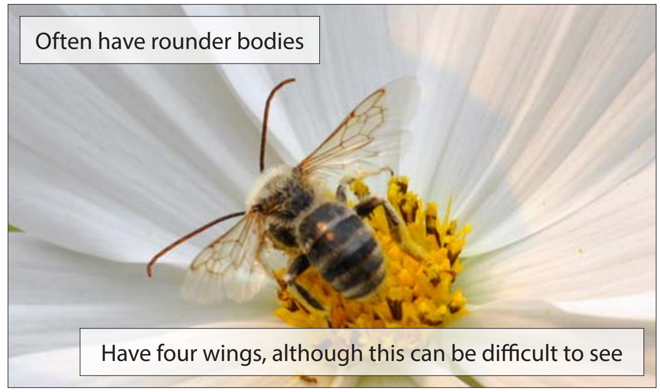
KEY CHARACTERISTICS:

- Bees have four wings (two pairs, difficult to see when folded over the body).
- Bees have large eyes located to the side of their heads.
- Bees are typically more robust (i.e., rounder bodies) than wasps and flies. Abdomen usually looks broad near thorax compared with wasps.
- Bees have antennae that are long and elbowed.
- Most bees are hairy, especially on their legs and/ or on their abdomen.
- Female bees can carry large loads of pollen, either on their legs or on their abdomen in a “scopa” or “corbicula.”

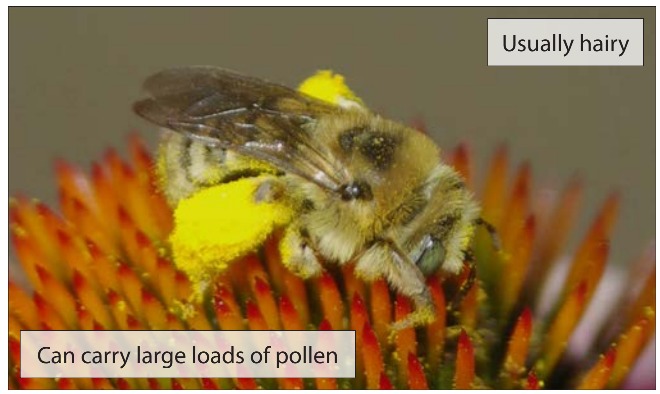
SIZE: Can range from less than ⅛" to 1" or more: tiny, medium, large, or extra large.

COLOR: Can be black, brown, grey, orange, red, silver, or metallic blue, green, or copper-colored and sometimes yellow.

STRIPES: Stripes can be formed by the hair color (e.g. yellow, orange, white, black, or brown) as well as the color of the exoskeletcon (body covering).

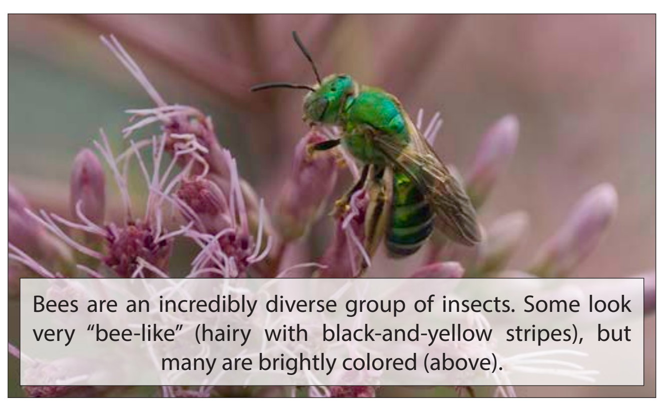


Photograph by Sara Morris.



Photograph by Mace Vaughan.

Photograph courtesy of Joel Gardner.



Photograph courtesy of Debbie Roos.

A NOTE ABOUT STINGS:

When working around bees (and wasps) there is always a risk of getting stung. Most bees are not aggressive and will not sting unless handled improperly. Bees are very docile when visiting flowers. Most wild native bees are far less defensive than the European honey bee or social wasps. Should you be stung by any bee (or wasp) while out in the field, try to identify the type of bee (or wasp) that stung you and let someone know so they can help watch for symptoms. Most people have mild reactions to bee stings and exhibit a reaction only at the site of the sting (mild swelling, redness, itchiness, and/ or mild pain). However, it is important to monitor yourself after a sting for signs of a more severe reaction. Symptoms of a serious reaction include swelling elsewhere on the body, vomiting, dizziness, hoarseness, thickened speech, or difficulty breathing, and should receive prompt medical attention from a physician.

Flies vs. Bees

KEY CHARACTERISTICS:

- Flies often have short thick antennae (sometimes difficult to see).
- Flies often have very large eyes near the front of their head, usually converging on the top of the head.
- Flies only have two wings (one pair).
- Flies are usually less hairy than bees.
- Many flies can hover (most bees are not able to hover, except for carder bees where hovering is common).
- Flies do not carry large loads of pollen although some grains may stick to their bodies.

SIZE: Range similar to bees: from ⅛" to 1".

COLOR: Can be black, brown, yellow, or metallic blue or green.

STRIPES: Can have stripes, usually from exoskeleton color.

NOTE: Many hover flies, bee flies, and robber flies are convincing mimics of bees and wasps (Figure 9). Look carefully at the eyes, legs, wings, antennae, and behavior to distinguish these look-alikes.

Photograph by Mace Vaughan.

Photograph by Sarah Foltz Jordan.

There are numerous species of flies that mimic bees. This drone fly (*Eristalis tenax*) is a honey bee mimic—and, like the honey bee, it is an introduced species from Europe.

Photograph by Sarah Foltz Jordan.

Photograph by Sara Morris.

Wasps vs. Bees

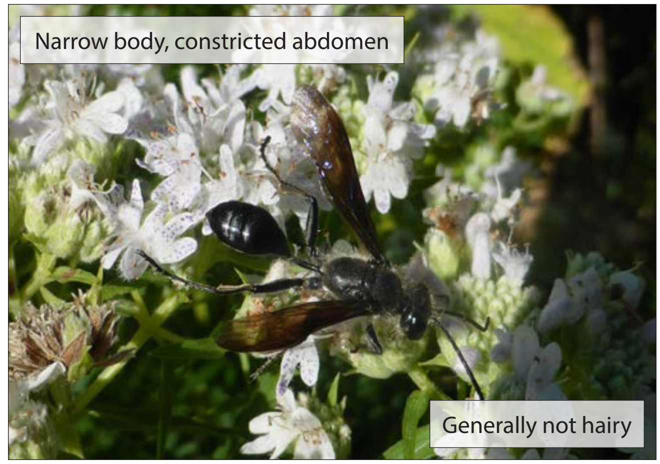
KEY CHARACTERISTICS:

- Wasps, like bees, have four wings (two pairs; often folded lengthways), but it can be hard to see them
- Wasps usually have narrower bodies and a very constricted (pinched) abdomen where it connects to the thorax (more obvious than in bees)
- Wasps tend to have more extensive and obvious coloration and patterns on their exoskeleton (bee markings are usually colored hairs)
- Wasps are generally not hairy
- Wasps do not carry pollen loads, although some pollen grains may stick to their bodies
- Some female wasps have long, obvious ovipositors

SIZE: Can be very tiny to ~1".

COLOR: Can be black, brown, red, orange, yellow, white, or metallic blue, green, or copper.

STRIPES: Can have body stripes or coloration patterns on their exoskeleton that closely resemble a bee. Stripes and markings are usually not from hair patterns.



Grass-carrying wasp (*Isodontia*). Photograph by Sarah Foltz Jordan.

Braconid wasp. Photograph by Sarah Foltz Jordan.

Thynnid wasp (*Myzinum*). Photograph by Sarah Foltz Jordan.

Paper wasp (*Polistes*). Photograph by Sarah Foltz Jordan.

Section 3

UNDERSTANDING BEES

This section describes the key characteristics that identify different bees. You can then use these to help you navigate the key found on p.23.

If you see that a floral visitor is carrying loads of pollen on its hind legs or abdomen, this visitor is likely a bee. Female bees collect pollen from flowers to bring back to their nests, where they use it to feed their offspring. For this reason, they have evolved to be very efficient pollen transporters. All bees have branched ("feathery") hairs to which pollen easily sticks. In addition, bees also have dense hairy patches or other structures for storing pollen for transportation. Depending on the family, these hairs will be on the hind legs or the underside of the abdomen. Some bees, such as honey bees and bumble bees, will add nectar to pollen that they have collected so that it is moist. This moist pollen is then packed onto "pollen baskets," flat areas edged with hairs on the middle part of the hind legs. However, some bees lack pollen carrying structures altoghter—namely, the yellow-faced bees (p.29), who carry pollen internally in their crop; and cuckoo bees (p.31), who do not construct or provision their own nests. To confuse things slightly, males do not collect and transport pollen, and so are usually less hairy than females, and in some species both males and females have few hairs.

HAIR—KEY CHARACTERISTICS:

- Is the bee **hairy**?
- If so, **where**?

Photograph by Sarah Foltz Jordan.

Photograph by Nancy Lee Adamson.

Photograph by Sara Morris.

Photograph by Nancy Lee Adamson.

Photograph by Mace Vaughan.

Photograph by Sarah Foltz Jordan.

POLLEN—KEY CHARACTERISTICS:

- Does the bee have **pollen** on its body?
- If so, **where?**
- Does the pollen look **moist and packed**, or **dry and loose**?

Photograph courtesy of Tom Koerner.

Photograph by Sara Morris.

Photograph courtesy of Debbie Roos.

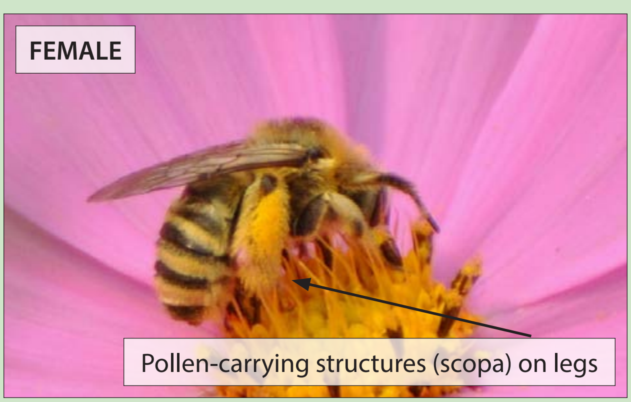
Photograph by Mace Vaughan.

Photograph by Sara Morris.

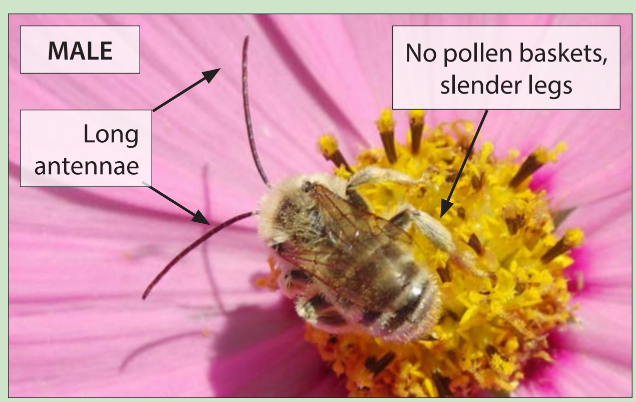
Photograph courtesy of Anne Reeves.

Gender Differences in Bees

Females bees typically carry pollen in a specialized structure called a scopa (cluster of hair) or corbicula (cup-shaped disc fringed with hair) on the hind legs or abdomen. Male bees lack pollen-carrying structures and have longer antennae (this is more noticeable in some groups). Within a given species, females are usually larger than males.



Photograph by Sara Morris.



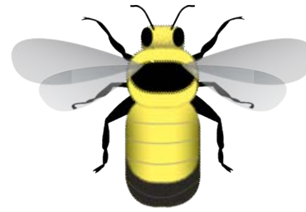
Photograph by Mace Vaughan.

SIZE AND SHAPE

WHAT SIZE IS THE BEE?

Tiny and extra-large: *Perdita minima*, the smallest bee in North America, placed on the face of one of the largest, *Xylocopa varipuncta*.

Photograph courtesy of Stephen L. Buchmann.



EXTRA-LARGE
(16–25mm)

LARGE
(13–16mm)

MEDIUM
(9–13mm)

SMALL
(7–9mm)

TINY
(≤7mm)

WHAT SHAPE IS THE BEE?

Photograph by Sarah Foltz Jordan.

Photograph by Mace Vaughan.

ANTENNAE—KEY CHARACTERISTICS:

- Does the bee have long or short antennae relative to the size of its body?

Photograph by Matthew Shepherd.

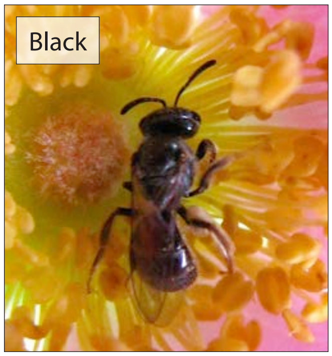
Photograph courtesy of Justin Meissen.

COLOR—KEY CHARACTERISTICS:

- What are the predominant color(s) of the bee? *(Note: predominant colors could come from either the hair or the exoskeleton)*
- Are the head, thorax, or abdomen different colors?
- Is it metallic?

Photograph courtesy of Heather Holm.

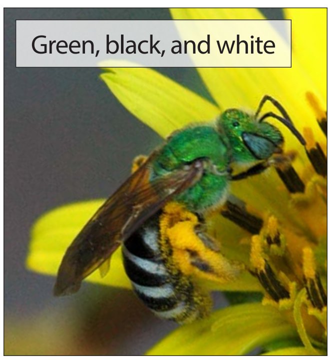
Photograph courtesy of Laura Hubers.



Photograph by Nancy Lee Adamson.

Photograph by Sarah Foltz Jordan.

Photograph by Sarah Foltz Jordan.



Photograph by Nancy Lee Adamson.

Photograph courtesy of Susan Ellis.

Photograph courtesy of Jack Dykinga.

Photograph courtesy of Dan Mullen.

STRIPES—KEY CHARACTERISTICS:

- Does the bee have stripes on its body?
- If so, where?

Photograph by Sarah Foltz Jordan.

Photograph by Nancy Lee Adamson.

Section 4

GUIDE TO 10 GROUPS OF BEES

There are roughly 400 species of bees in the Upper Midwest. This guide will help you identify some of the most common bee morpho-groups. The photos on this p.illustrate some of the diversity of these bees.

Remember, this guide is not exhaustive, so if you observe a bee that does not fall into an identified morpho-group, note the bee as "Other bee" and describe the it thoroughly in the observational notes. Even if you can't identify the bee precisely, it is important to document that it was observed.

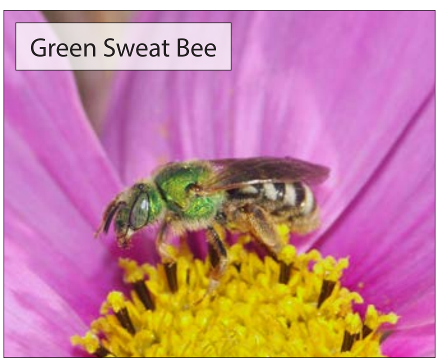
In particular, it is important to distinguish the honey bees, which are non-native, from native bees. Whenever possible, attempt at minimum to distinguish honey bees from the rest of the bee categories. Before monitoring, study the "honey bee" page carefully.

Photograph by Sarah Foltz Jordan.

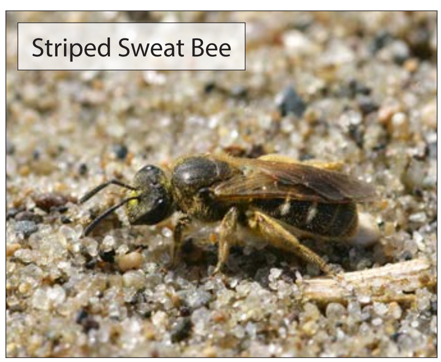
Photograph by Sarah Foltz Jordan.

Photograph courtesy of Debbie Roos.

Photograph courtesy of Ilona Loser.

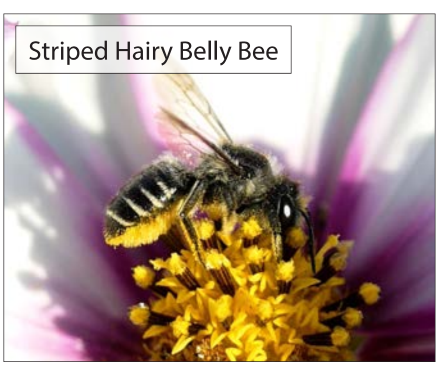


Photograph by Mace Vaughan.



Photograph courtesy of sankax.

Photograph by Debbie Roos.



Photograph courtesy of Ilona Loser.

Photograph courtesy of Heather Holm.

Photograph courtesy of Heather Holm.

Key to Identifying Floral Visitors

- **Non-Bee**
  - Bird (*p. 12*)
  - Butterfly (*p. 12*)
  - Moth (*p. 12*)
  - Fly (*p. 12, 14*)
  - Wasp (*p. 12, 15*)
  - Spider (*p. 12*)
  - Beetle (*p. 12*)
  - True Bug (*p. 12*)

- **Bee**
  - Pollen carrying structures on legs (except for yellow-faced bees which are mostly hairless)
    - Honey Bee (*p. 22*)
    - Bumble Bee (*p. 23*)
    - Chap Leg Bee (*p. 24*)
    - Medium Dark Bee (*p. 25*)
    - Green Sweat Bee (*p. 26*)
    - Striped Sweat Bee (*p. 27*)
    - Tiny Bee (*p. 28*)
  - Thick pollen-carrying hair on underside of abdomen
    - Striped Hairy Belly Bee (*p. 29*)
    - Metallic Hairy Belly Bee (*p. 30*)
  - Mostly hairless
    - Cuckoo Bee (*p. 31*)

Identify bees to the most specific group possible. For example, if you do not know what type of bee you see, but you know that it is not a honey bee, note only that "it is not a honey bee." In some cases (e.g., bumble bees) it will be possible to distinguish species within a bee group.

Honey Bees

FAMILY: Apidae
GENUS SPECIES: *Apis mellifera*

For most people, it is the honey bee that comes to mind when they hear the word "bee."

IDENTIFICATION:

- **Size and shape:** Medium to large with torpedo shaped bodies.
- **Color and hair:** Amber-brown to nearly black; moderately fuzzy thorax and head, legs and abdomen less hairy.
- **Stripes:** Abdomen tri-toned with black, pale and orange-brown stripes.
- **Corbicula:** Enlarged, flattened plates on hind legs to carry moist pollen.

NOTE: Makes buzzing sound when flying and often flies methodically from flower the flower.

IMPORTANT: Honey bees are not native to North America, whereas most other wild bees are. During monitoring, distinguishing between honey bees and the rest of the bee categories is the most important observation you can make.

CAUTION: There are some flies that mimic honey bees (Figure 11, pg. 14). To distinguish flies, look for two wings (one pair), short stubby antennae, large eyes that meet in the middle, and skinny hind legs. These flies will also hover, whereas honey bees do not.

SIZE RANGE: 12–16 mm (shown: 15 mm)

Photograph courtesy of David Cappaert.

Photograph by Sarah Foltz Jordan.

Photograph courtesy of Scott Bauer.

Bumble Bees

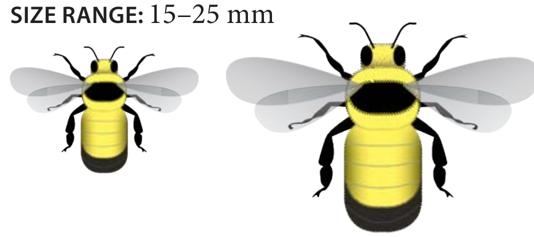
FAMILY: Apidae
GENUS: *Bombus*

IDENTIFICATION:

- **Size and shape:** Medium to very large, robust (workers & males are smaller than queens).
- **Color and hair:** Mostly black with yellow, orange, or brown markings. Entire body is fuzzy.
- **Stripes:** Hair can form yellow, black, orange, or brown stripes or markings.
- **Corbicula:** Females have flattened plate on upper hind leg for carrying moist clumps of pollen.

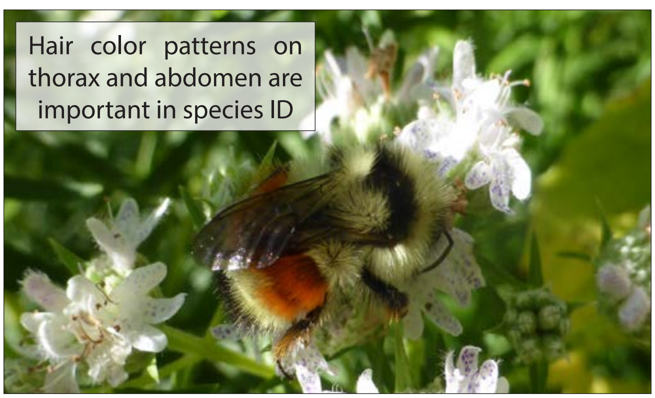
NOTES: Make a low buzzing sound when flying. Several flies are excellent bumble bee mimics (see p.14), but they only have two wings (one pair). Large carpenter bees (not included in this guide) look very similar to bumble bees, but they are shinier (less hairy), especially on the abdomen. Large carpenter bees are rare in the Upper Midwest, but occur regularly in the southern parts of the Midwest.

SIZE RANGE: 15–25 mm



Moist clumps of pollen on upper hind leg

Photograph courtesy of Jim Nelson.



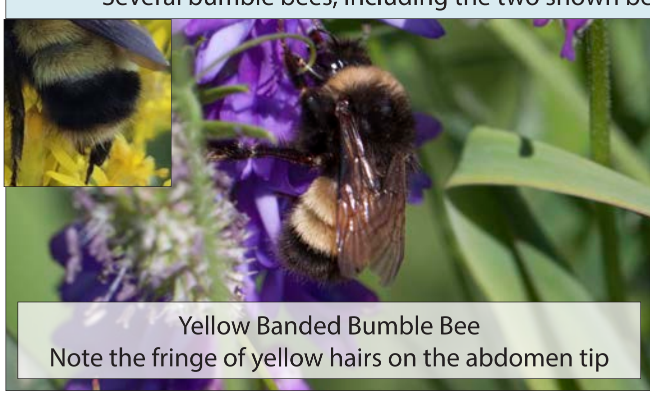
Hair color patterns on thorax and abdomen are important in species ID

Photograph by Sarah Foltz Jordan.

Color of hairs on head can be important in species ID

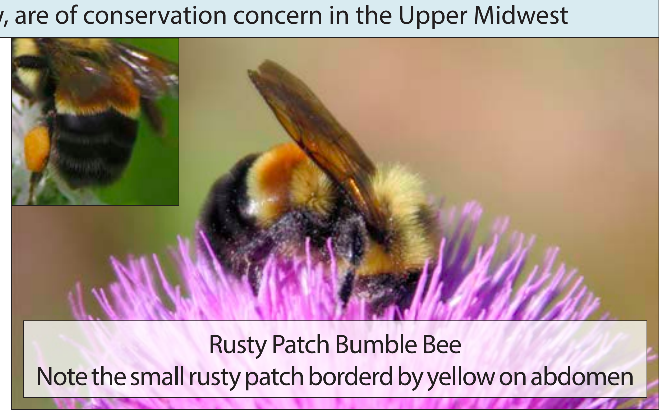
Photograph by Sarah Foltz Jordan.

Several bumble bees, including the two shown below, are of conservation concern in the Upper Midwest



Yellow Banded Bumble Bee
Note the fringe of yellow hairs on the abdomen tip

Photograph by Sarah Foltz Jordan(left), and courtesy of Kent McFarland (main).



Rusty Patch Bumble Bee
Note the small rusty patch borderd by yellow on abdomen

Photographs courtesy of Dan Mullen.

Chap Leg Bees

FAMILY: Apidae
GENERA: *Melissodes* (Long-horned bees), *Peponapis* (Squash bees) , and others

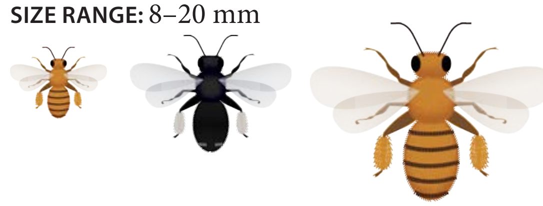
FAMILY: Apidae
GENUS: *Anthophora* (Digger bees) and others

KEY CHARACTERISTICS:

- **Size and shape:** Medium to large, robust.
- **Color and hair:** Dark with white, yellow or brown hairs; often hairy—especially on thorax—with short, dense, velvety hair.
- **Stripes:** Often with bands of pale hair on abdomen
- **Scopa:** Carries dry pollen on noticeably dense hairs on lower hind legs, but pollen is often on the whole body.

NOTES: Antennae are typically longer than most other bees, especially on males. The legs of males are not as hairy as the legs of females because males do not transport pollen. Some fly fast (usually in smooth motions that almost look like they are tracing a figure 8) and can visit flowers rapidly.

SIZE RANGE: 8–20 mm



Photograph courtesy of Heather Holm.

Photograph courtesy of Heather Holm.

Photograph by Sara Morris.

Photograph by Sarah Foltz Jordan.

Photograph by Mace Vaughan.

Medium Dark Bees

FAMILY: Andrenidae (Mining bees)
GENUS: *Andrena* and others

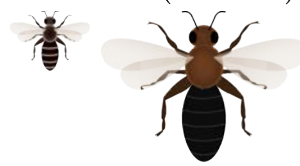
FAMILY: Colletidae (Polyester bees)
GENUS: *Colletes*

KEY CHARACTERISTICS:

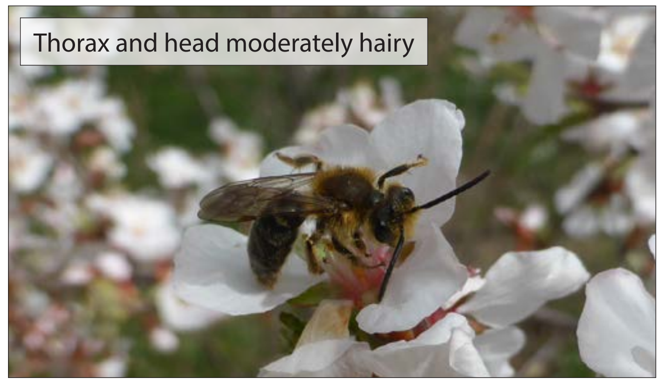
- **Size and shape:** Small to large; relatively narrow to moderately robust.
- **Color and hair:** Dull, dark-bodied; thorax and face are moderately hairy.
- **Stripes:** May have bands of pale hair on abdomen.
- **Scopa:** Carries pollen on upper hind legs and back of thorax (armpits).
- **Face** may have two hairy depressions between the eyes (*Andrena*) or be heart-shaped (*Colletes*)

NOTES: Among the first to emerge in early spring. Nest in the ground, often in large aggregations.

ANDRENIDAE (7–18 mm)



COLLETIDAE (7–18 mm)



Thorax and head moderately hairy

Photograph by Sarah Foltz Jordan.

Pollen collecting hairs on upper hind legs

May have two hairy depressions on face (*Andrena*)

Photograph courtesy of Heather Holm.

May have smooth black abdomen

Photograph courtesy of Heather Holm.

May have heart-shaped face (*Colletes*)

Photograph courtesy of Heather Holm.

May have striped abdomen

Photograph courtesy of Heather Holm.

Green Sweat Bees

FAMILY: Halictidae
GENERA: *Augochlora*, *Augochlorella*, *Augochloropsis*, *Agapostemon*

KEY CHARACTERISTICS:

- **Size and shape:** Medium sized, narrow bodied.
- **Color and hair:** Bright metallic green; abdomen can be green like the thorax, or dark with stripes; body covered in pale hairs that are less noticeable.
- **Stripes:** Some with yellow and black striped abdomen.
- **Scopa:** Carries dry pollen on hairs on hind legs, less noticeable than other bees, unless covered in dry pollen.

NOTES: Relatively fast flying and numerous. Antennae are short on females and longer on males.

CAUTION: Some cuckoo wasps (Chrysididae) are metallic green and very easy to confuse with green sweat bees (see below). Mason bees can also be metallic green. Look to see whether the green visitor is a bee or not, and also check where it is carrying pollen or where it is hairy. Sweat bees carry pollen on their hind legs; mason bees carry pollen on the underside of their abdomens, and also tend to be darker, almost green-blue. In addition, it is important to note if the green visitor has stripes on abdomen (characteristic of *some* green sweat bees, but not chrisid wasps or mason bees)

AUGOCHLORA (5–11 mm)

AGAPOSTEMON (9–11 mm)

Photograph courtesy of Heather Holm.

Photograph courtesy of Heather Holm.

Photograph courtesy of Vengolis.

Photograph by Sarah Foltz Jordan.

Striped Sweat Bees

FAMILY: Halictidae
GENERA: *Halictus*, *Lasioglossum* (in part)

KEY CHARACTERISTICS:

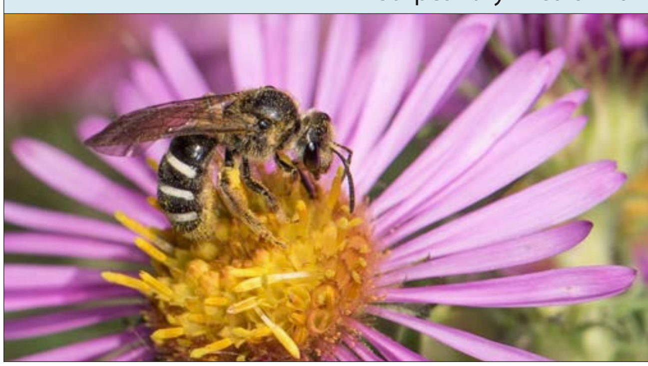
- **Size and shape:** Small to medium, narrow bodied.
- **Color and hair:** Usually dark with bands of pale hairs on abdomen.
- **Stripes:** Stripes on abdomen may appear faint and vary in color from creamy to dark gray.
- **Scopa:** Brush of hair on upper part of hind legs, sometimes loaded with pollen.

NOTES: May crawl around the base of flowers or inside flowers. Fast moving; sometimes with jagged movements.

SIZE RANGE: 7–15 mm

Photograph courtesy of Elizabeth Sellers.

Stripes vary in color from cream to yellow or dark grey



Photograph courtesy of Heather Holm.

Photograph by Joseph Berger.

Photograph courtesy of Scott Bauer.

Photographs courtesy of Heather Holm.

Tiny Dark Bees

FAMILIES Halictidae, Apidae, Colletidae
GENERA: *Lasioglossum* (Small sweat bees), *Ceratina* (Small carpenter bees), *Hylaeus* (Yellow-faced bees)

KEY CHARACTERISTICS:

- **Size and shape:** Tiny and narrow bodied.
- **Color and hair:** Can be dull black/brown, pale golden, metallic black/brown or blue/green. Sometimes with white or yellow markings on face. Body sparsely covered in pale hairs that are less noticeable, but some with dense patches of hair on abdomen.
- **Stripes:** Faint stripes on abdomen, if any.
- **Scopa:** Small carpenter bees and sweat bees have brushes of pollen collecting hairs on hind leg. Yellow-faced bees carry pollen in a crop, and lack external scopa.

NOTES: Often crawl deep into flowers. Can move fast—some with jagged movements. Members of this morphological group are not closely related and have different life histories and habitat needs (e.g., Ceratina and Hylaeus are stem nesting, whereas Lasioglossum is ground nesting). As such, if you are comfortable distinguishing these genera, you may wish to record them separately in your data sheet.

LASIOGLOSSUM (4–7 mm)

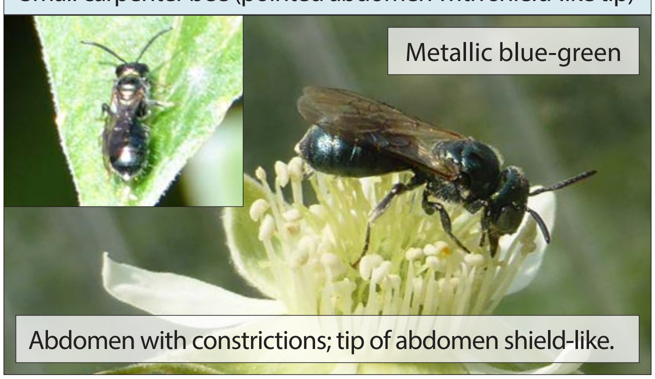
HYLAEUS (5 mm)

CERATINA (6–8 mm)

Small sweat bee (tip of abdomen rounded)

Top: photograph by Sarah Foltz Jordan. *Bottom*: photographs by Sara Morris.

Small carpenter bee (pointed abdomen with shield-like tip)



Metallic blue-green

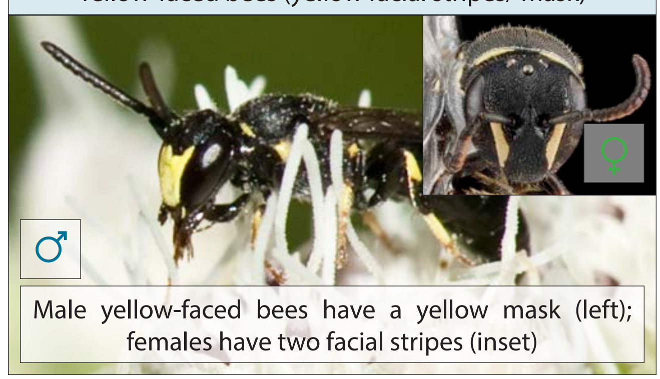
Abdomen with constrictions; tip of abdomen shield-like.

♀ ♂

Female small carpenter bees have a narrow white facial stripe (left); males have a larger white "nose" (inset).

Top: photograph by Sarah Foltz Jordan (main) and Sara Morris (inset). *Bottom:* photograph by Sarah Foltz Jordan (main) and courtesy of Erin Maxson (inset).

Yellow-faced bees (yellow facial stripes/ mask)



♂ ♀

Male yellow-faced bees have a yellow mask (left); females have two facial stripes (inset)

Slender, few hairs, wasp-like

Top: photographs courtesy of Heather Holm (main) and Jacabo Werther (inset). *Bottom:* photograph courtesy of Rob Cruickshank.

Striped Hairy Belly Bees

FAMILY: Megachilidae
GENERA: *Megachile* (Leafcutter bees), *Heriades* (Small resin bees), *Anthidium* (Carder bees), *Hoplitis* (Mason bees)

KEY CHARACTERISTICS:

- **Size and shape:** Small to medium and typically very robust. Often with a broad head and strong jaws used to cut leaves for nesting materials.
- **Color and hair:** Black with thorax and head covered in silver, white, or yellow hairs OR black with yellow markings on exoskeleton
- **Stripes:** Abdomen has light hairs that create stripes, or markings are on exoskeleton.
- **Scopa:** Females carry dry pollen on thick hairs on underside of abdomen.

NOTES: When visiting flowers, these bees often elevate abdomen, revealing pollen underneath.

APPROXIMATE SIZE RANGE: 8–12 mm

Pollen carried on the underside of its abdomen

Photograph courtesy of Debbie Roos.

Thick brushes of hair on underside of abdomen

Photograph courtesy of Whitney Cranshaw.

Abdomen often elevated

Often with pale stripes on abdomen

Photograph by Sarah Foltz Jordan.

May be black with yellow on abdomen (*Anthidium*)

Photograph courtesy of Heather Holm.

May be very small

Photograph courtesy of Heather Holm.

Metallic Hairy Belly Bees

FAMILY: Megachilidae
GENUS: *Osmia* (Mason Bees)

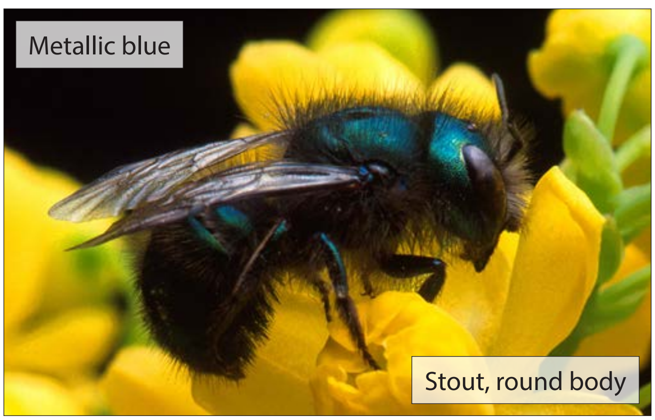
KEY CHARACTERISTICS:

- **Size and shape:** Small to medium, stout, robust bodies.
- **Color and hair:** Metallic green, blue or bluish black. Brushes of hair beneath abdomen – no prominent hair bands.
- **Stripes:** None.
- **Scopa:** Females carry dry pollen loads on underside of abdomen.

NOTES: Among the first bees seen during the pollinating season. Most are observed in early spring and summer. As their name suggests, some species of Mason Bees gather mud and pebbles to construct their nests. These bees are also often called Orchard Bees, due to their frequent pollination of fruit tree blossoms.

APPROXIMATE SIZE RANGE: 8–12 mm

Photograph courtesy of Heather Holm.



Photograph courtesy of Jack Dykinga.

Photograph courtesy of Heather Holm.

O. bucephala—our largest mason bee—is dark blue-green with bronze overtones under dense hair

Photograph courtesy of Ilona Loser.

Male *O. lignaria* have a dense tuft of pale facial hair (inset), females have pale hair all over head and thorax (main)

Photographs courtesy of Seabrooke Leckie (inset) and Elizabeth Sellers (main).

Cuckoo Bees

FAMILIES: Halictidae, Megachilidae, Apidae
GENERA: *Sphecodes*, *Coelioxys*, *Nomada*, *Epieolus*, *Triepeolus*, and others

Cuckoo bees are a very diverse group of bees united by similar life histories--they lay their eggs in other bees' nests. Because they do not provision their own nests, they lack pollen-carrying structures.

SPHECODES (7–10 mm)

NOMADA (9–12 mm)

KEY CHARACTERISTICS:

- **Size and shape:** Small to large, often narrow bodied.
- **Color and hair:** Variable, can be shiny black, cream, red, or yellowish. Can have red or black legs. Usually not very hairy.
- **Stripes:** Can have wasp-like markings made from short, thick hairs.
- **Scopa:** Lack pollen carrying structures.

NOTE: These bees are not key pollinators, since they do not actively collect pollen and are generally not very hairy. However, their presence can indicate healthy populations of native bees. During the day, they fly low to the ground searching for nests to parasitize. They are also often seen on flowers, looking for nectar in the evening when their hosts have stopped foraging and returned to their nests.

Cuckoo bees tend to look very wasp-like and may be difficult to identify in the field. Generally, when comparing with wasps, look for shorter legs, elbowed antennae, and more bee like body stature. It may also be wise to learn the patterns and shapes of some of the most common cuckoo bees in your region (e.g., those shown here). If still unsure, mark in the "other" category and report your suspicion of a cuckoo bee.

Red abdomen (*Sphecodes*)

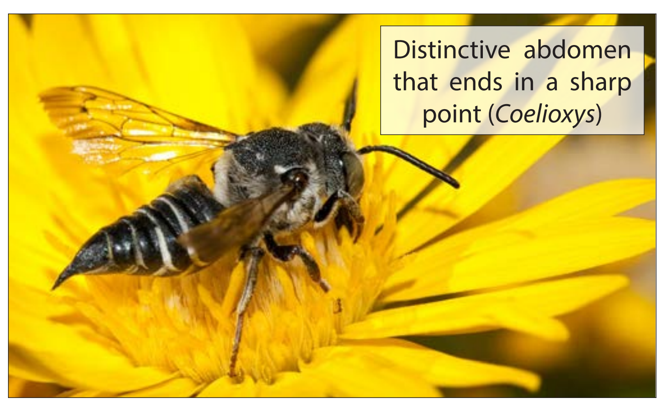
Photograph by Sarah Foltz Jordan.

Thick antennae (*Nomada*)

Photograph by Sarah Foltz Jordan.

Can be brightly colored (*Epeolus*)

Photograph courtesy of Heather Holm.



Distinctive abdomen that ends in a sharp point (*Coelioxys*)

Photograph courtesy of Heather Holm.

Appendix A: ADDITIONAL RESOURCES

Bee Conservation Resources

Black, S. H., N. Hodges, M. Vaughan, and M. Shepherd. 2007. *Pollinators in Natural Areas. A Primer on Habitat Management*. Portland: The Xerces Society. www.xerces.org/guidelines/.

Hatfield, R., Jepsen, S., Mäder, E., Black, S.H., and M. Shepherd. 2012. *Conserving Bumble Bees*. www.xerces.org/bumblebees/guidelines/

Mäder, E., M. Shepherd, M. Vaughan, S. H. Black, and G. LeBuhn. 2011. *Atttracting Native Pollinators: Protecting North America's Bees and Butterflies*. North Adams, MA: Storey Publishing.

Vaughan, M., Hopwood, J., Lee-Mäder, E., Shepherd, M., Kremen, C., Stine, A., and S. Hoffman Black. 2015. *Farming for Bees*. Portland: The Xerces Society. www.xerces.org/wp-content/uploads/2008/11/farming_for_bees_guidelines_xerces_society.pdf.

Xerces Society Pollinator Habitat Assessment Guides: www.xerces.org/pollinator-conservation/habitat-assessment-guides/

Xerces Society Pollinator Plant Lists: www.xerces.org/pollinator-conservation/plant-lists

Xerces Society Pollinator Conservation Resource Center: www.xerces.org/pollinator-resource-center/

Bee Biology and Identification Resources

BugGuide. An online resource devoted to North American insects, spiders and their kin, offering identification, images, and information.

Colla, S., Richardson, L., and Williams, P. 2012. *Bumble bees of the Eastern United States*. USDA Forest Service.

Discover Life Bee Species Guide, World Checklist, and Keys: www.discoverlife.org/mp/20q?search=Apoidea.

Holm, H. 2014. *Pollinators of Native Plants: Attract, Observe, and Identify Pollinators and Beneficial Insects with Native Plants*. Minnetonka, MN: Pollination Press.

Evans, E. 2015. *Keys to Male and Female Bumble Bees of Minnesota*. www.befriendingbumblebees.com/survey.html.

Michener, C.D., R.J. McGinley, and B.N. Danforth. 1994. *The Bee Genera of North and Central America.* Washington: Smithsonian Institution Press.

Michener, C.D. 2000. *The Bees of the World*. Baltimore: The Johns Hopkins University Press.

Pollinators on Native Plants- Midwest, Great Lakes, and Northeast. A Facebook group to post and share images of pollinators on native plants. www.facebook.com/groups/PollinatorsNativePlants/

Rykken, J. Bee Observer Cards. *Encyclopedia of Life and the National Park Service*. Edited by Holmes, J.

Williams, P., Richardson, L.L., Thorp, R.W., and S. Colla. *Bumble bees of North America: an Identification Guide*. Princeton, NJ: Princeton University Press.

More Citizen Science Opportunities

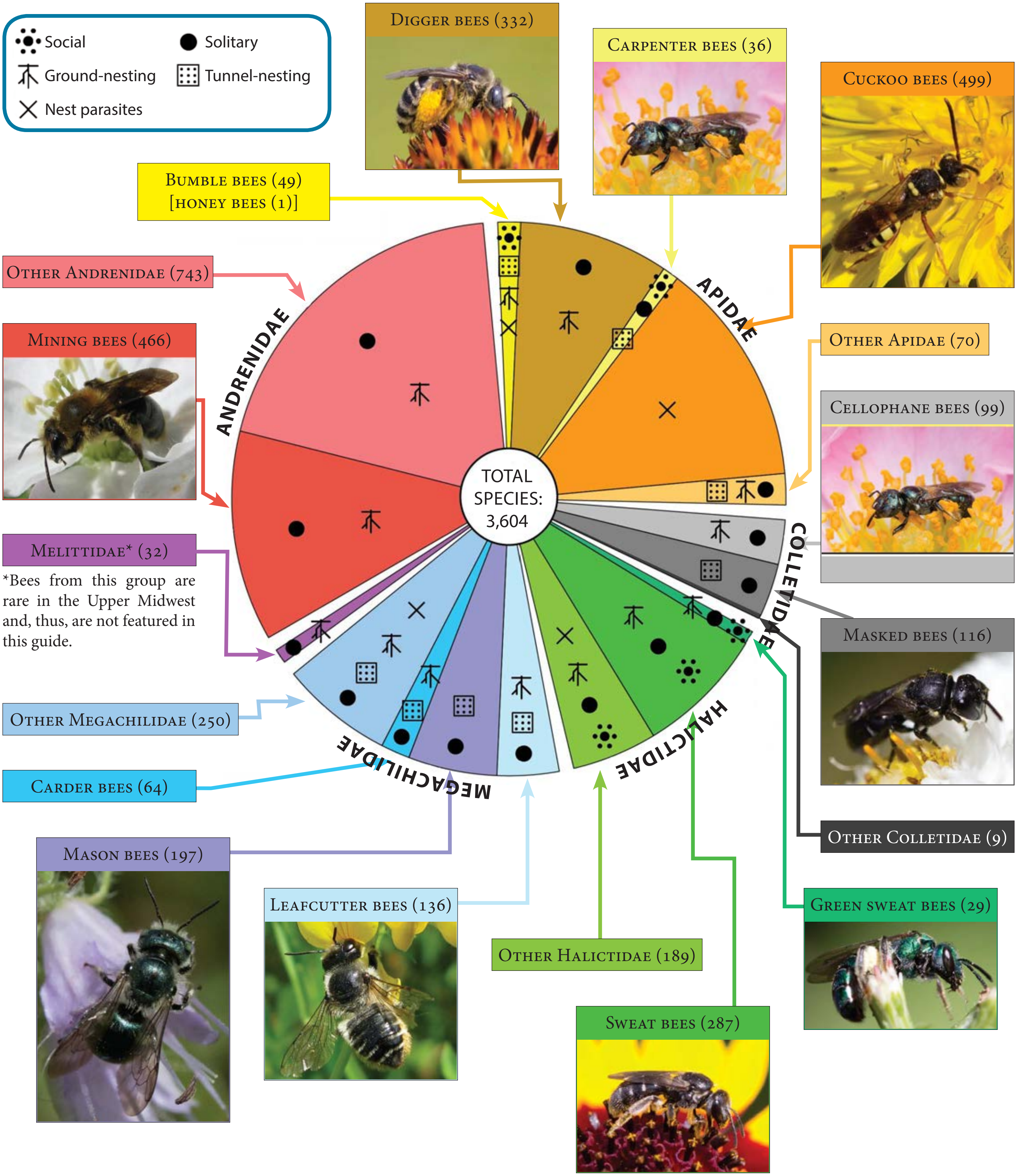
Bumble Bee Watch. Citizen science database for reporting bumble bee observations in North America. Photos required with each submission. www.bumblebeewatch.org.

MN Bumble Bee Survey. Volunteer to help with long-term bumble bee monitoring in the metro area, examining changes in local bee communities over time. www.befriendingbumblebees.com/survey.html.

Streamlined Bee Monitoring. Guidelines for monitoring bees using a simplified yet research-based approach in which just two categories are used: honey bees vs. native bees. www.xerces.org/streamlined-bee-monitoring-protocol/.

The Great Sunflower Project. Citizen science – ID and report bees that visit sunflowers. www.greatsunflower.org.

Appendix B: BEE SPECIES DIVERSITY IN THE UNITED STATES



Chart, content, and photographs* courtesy of Joel Gardner, University of Minnesota/ Bee Squad. (*Cellophane bee photo courtesy of Heather Holm.)
Data source: Ascher, J. S., and J. Pickering. 2015.Discover Life bee species guide and world checklist. (Available at: www.discoverlife.org/mp/20q?guide=Apoidea_species)

Appendix C: UPPER MIDWEST BEE GROUPS QUICK GUIDE

HONEY BEES

COLORS:

» **15 mm**/ 0.59″

12–16 mm / 0.47–0.63″

- Torpedo-shaped; fuzzy head and thorax; tri-tone striped abdomen
- Moist pollen on hind legs

CHAP LEG BEES

COLORS: W

8–20 mm / 0.31–0.79″

- Robust; velvety all over; pale bands on abdomen
- Dry pollen on hind legs
- Males are less hairy, often have longer antennae

STRIPED SWEAT BEES

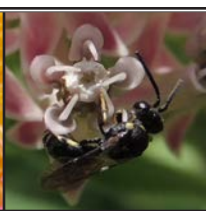
COLORS: W

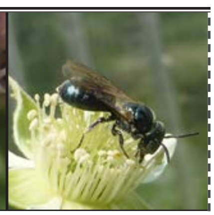
7–15 mm / 0.28–0.59″

- Narrow; fuzzy head & thorax; pale stripes on abdomen
- Dry pollen on hind legs and thorax
- May be found inside or at base of flowers; move very fast

TINY DARK BEES

COLORS: W





4–7 mm / 0.16–0.28″

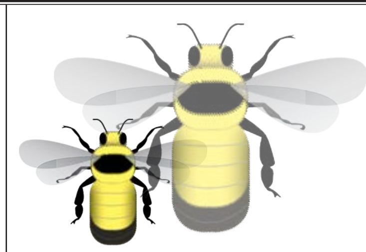
5 mm / 0.2″

6–8 mm / 0.24–0.31″

- Narrow; sparse hair; faint or no stripes on abdomen
- Dry pollen on hind legs or in stomach
- May have yellow or white markings on face, often metallic green or blue-green in bright light (also black, brown, or pale gold)

BUMBLE BEES

COLORS: W

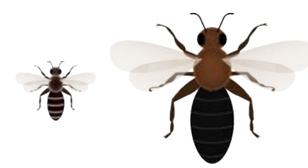


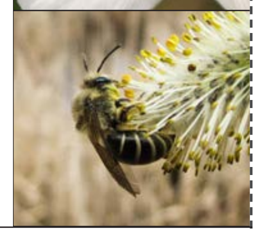
15–25 mm / 0.59–0.98″

- Robust; fuzzy all over, markings vary by species
- Moist pollen on hind legs
- Workers & males are smaller than queens

MEDIUM DARK BEES

COLORS: W





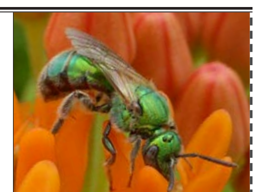
7–18 mm / 0.28–0.71″

- Narrow–robust; fuzzy head & thorax; some species have striped abdomen
- Dry pollen on hind legs and under thorax arm pits
- Some species nest in large aggregations in the ground

GREEN SWEAT BEES

COLORS: W

5–11 mm / 0.2–0.35″



9–11 mm / 0.35–0.43″

- Narrow; fuzzy head & thorax; striped abdomen
- Dry pollen on hind legs
- Coloration varies—may have a blue-violet or coppery cast, or have a light-and-dark striped abdomen

KEY

W White/light	Yellow	Amber	Orange	Red
Green	Blue-green	Blue	Brown	Black

STRIPED HAIRY BELLY BEES

COLORS: W

8–12 mm / 0.31–0.47″

- Very robust; fuzzy all over, pale hair stripes on abdomen
- Dry pollen on belly (under abdomen)
- When visiting flowers, females bees often elevate abdomen

METALLIC HAIRY BELLY BEES

COLORS: W

8–12 mm / 0.31–0.47″

- Robust; fuzzy all over, no stripes on abdomen
- Dry pollen on belly
- Among the first bees seen in early spring

CUCKOO BEES

COLORS: W

7–10 mm / 0.28–0.39″

9–12 mm / 0.35–0.47″

- Small–large, very narrow; usually not hairy; wasp-like stripes
- Lack pollen-carrying structures—very narrow legs
- Look similar to wasps; often seen flying low to the ground or on flowers

HOME PRINT SCALE CHECK

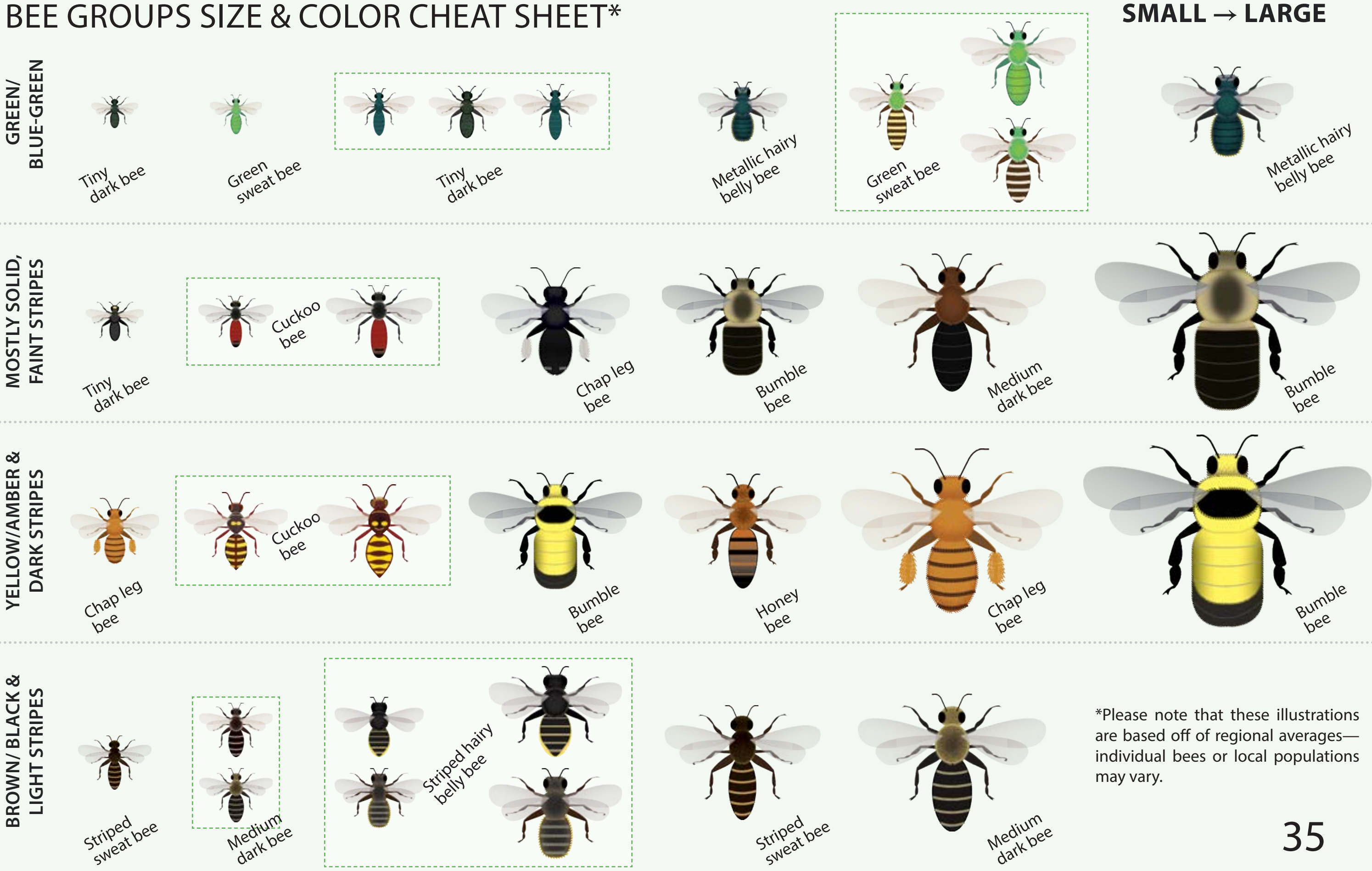
This bar should be **25.4 mm/ 1″ long** at 100% scale.

If it is not, check your printer's scale settings.

CREDITS: Photographs by Sara Morris (honey bee, chap leg bee, striped sweat bee), Sarah Foltz Jordan (bumble bee, *right* tiny dark bee, *top* green sweat bee, *bottom* striped hairy belly bee, *top* and *bottom* cuckoo bees), Mace Vaughan (*top* medium dark bee, *bottom* green sweat bee), Nancy Lee Adamson (*left* tiny dark bee, *top* striped hairy belly bee), courtesy of Jason King (*bottom* medium dark bee), Anita Gould (*middle* tiny dark bee), and Heather Holm (metallic hairy belly bee). Bee group icons created by Sara Morris.

BEE GROUPS SIZE & COLOR CHEAT SHEET*

SMALL → LARGE



*Please note that these illustrations are based off of regional averages—individual bees or local populations may vary.

Appendix D: BUMBLE BEES OF THE UPPER MIDWEST

All insects have three main body parts: the head (H), thorax (TH) and abdomen (AB). Bumble bee keys often refer to the coloration of the hairs on a particular abdominal segment, such as T2 ('T' refers to 'tergite', or the top of the abdominal segment). Note in the figure to the right that numbering of the abdominal segments always begins at the point where the abdomen meets the thorax.

IS YOUR BUMBLE BEE MALE OR FEMALE?

There are three types of bumble bees you will encounter: queens (♛), workers (♀), and males (♂). Both queens and workers are female and usually have similar color patterns, but queens are much larger. Males, on the other hand, may have different coloration from females of the same species, in addition to other important physical characteristics:

- Males have 7 abdominal segments vs. 6 in females
- Males have 13 antennal segments vs. 12 in females
- Males do not have Corbiculae (pollen baskets)
- Males of some species have larger eyes or longer hair than females

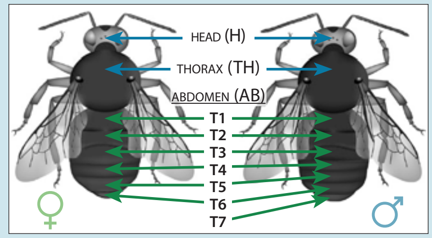
Bumble bee species in this guide are organized in three groups by their **most common female color patterns**. In most cases (but not all), this grouping system will work for both sexes. See illustrations for further details.

- A **YELLOW THORAX USUALLY* WITH BLACK SPOT**
- B **YELLOW THORAX WITH BLACK STRIPE**
- C **THORAX MOSTLY BLACK**

Please note that many species are variable in coloration. The illustrations and text below highlight some of the most common morphs, but further study may be needed for rarer morphs (see next page).

BUMBLE BEE SEXUAL DIMORPHISM

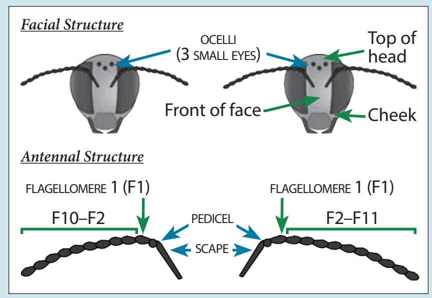
Bumble bees exhibit strong sexual dimorphism that extends beyond color and size differences—males actually have one more abdominal segment than females (explained below).



Females have 6 abdominal segments (T1–T6).

Males have 7 abdominal segments (T1–T7).

Males also have longer antennae than females, with an additional antennal segment ('flagellomere').



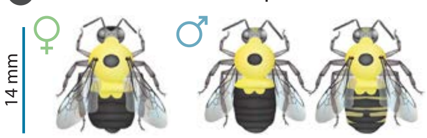
Females have a total of 12 antennal segments—scape, pedicel, and F1–10.

Males have a total of 13 antennal segments*—scape, pedicel, and F1–11.

**Males of some species can be identified by unique antennal segment features—such as a long F3.*

GROUP A: YELLOW THORAX USUALLY* WITH BLACK SPOT

1 *B. bimaculatus* (Two-spotted)



TH: Usually with black spot
AB— T1: yellow; T2: black with yellow center (often W-shaped); T3(+): black

♛ 18–22 mm ♀ 10–16 mm ♂ 12–15 mm

2 *B. griseocollis* (Brown-belted)

TH: Usually with black spot
AB—T1: yellow; T2: black with yellow center (bordered by rusty swoop); T3(+): black
♂—Large eyes

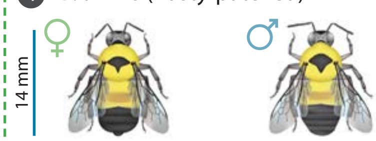
♛ 18–23 mm ♀ 10–16 mm ♂ 12–18 mm

3 *B. impatiens* (Common eastern)

TH: Usually with black spot (may be faint)
AB—T1: yellow; T2(+): black

♛ 21–23 mm ♀ 9–14 mm ♂ 12–14 mm

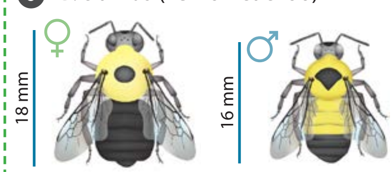
4 *B. affinis* (Rusty-patched)



TH—Spot sometimes with faint V-shaped extension
AB—T1: yellow; T2: central brown patch bordered by yellow; T3(+): black
Note: Queens do not have T2 brown patch

♛ 19–23 mm ♀ 9–16 mm ♂ 14–17 mm

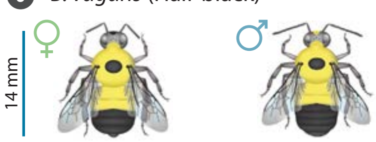
5 *B. citrinus* (Lemon cuckoo)



AB—Sparse hair; coloration varies
♀—No pollen baskets
♂—Very short cheek

♀ 18–22 mm ♂ 12–16 mm

6 *B. vagans* (Half-black)

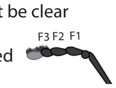


TH: Usually with black spot
AB—T1 & T2: yellow; T3(+): black
♀—Slightly elongate cheek
♂—Black hair limited to center spot; F3 long

♛ 17–21 mm ♀ 11–14 mm ♂ 11–14 mm

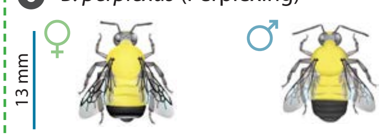
7 *B. sandersoni* (Sanderson's)

AB—T1 & T2: yellow; T3(+): black
♀—Black on top of head; square cheek; sparse yellow hairs on T5; TH spot may not be clear
♂—F3 short; F3–F4 with short hair; spot or stripe on thorax well-defined
Note: Smaller than *B. vagans*



♛ 15–17 mm ♀ 10–14 mm ♂ 12–15 mm

8 *B. perplexus* (Perplexing) V



TH—No obvious spot, often brown on sides
AB—T1–3: yellow; T4(+): variable coloration

♛ 18–20 mm ♀ 11–14 mm ♂ 13–14 mm

**Many of the species in Group A usually have a black spot on their thorax, but some morphs may be missing this spot or have a stripe instead.*

GROUP B: YELLOW THORAX WITH BLACK STRIPE

9 *B. rufocinctus* (Red-belted) V

TH—Black stripe (rarely) may appear more like a spot
AB—T1 & T2: yellow; T3(+): variable colors
♀—Cheek shorter than width of mandible
♂—Eyes slightly enlarged
Note: Smaller than many other species

♛ 17–18 mm ♀ 9–13 mm ♂ 11–15 mm

10 *B. huntii* (Hunt's)

H—Yellow on top and front of face
TH—Black stripe, sparse black hairs on rear half
AB—T1: yellow; T2 & 3: orange or red; T4(+): yellow or black
Note: Only occurs as far east as western MN

♛ 19–20 mm ♀ 11–14 mm ♂ 9–13 mm

11 *B. ternarius* (Tri-colored)

TH—Yellow with black stripe, often thumbtack-shaped
AB—T1: yellow; T2 & 3: orange or red; T4(+): yellow or black
♀—Distinct V-shape extension from TH stripe

♛ 17–19 mm ♀ 9–13 mm ♂ 10–14 mm

12 *B. fervidus* (Yellow)

H—Black on top and front of face
TH—Sides yellow around black stripe
AB—T1–4: yellow; T5(+): black

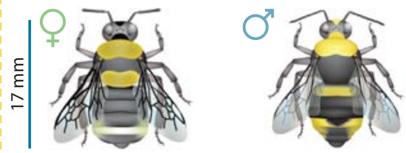
♛ 18–21 mm ♀ 11–17 mm ♂ 13–16 mm

13 *B. borealis* (Boreal)

H—Yellow on top and front of face
TH—Sides with brown hairs around black stripe
AB—T1–4: yellow; T5(+): may be black or yellow

♛ 18–22 mm ♀ 13–15 mm ♂ 14–16 mm

14 *B. bohemicus* (Ashton's cuckoo)

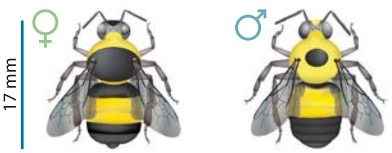


TH—May have black stripe or be mostly black
AB—Sparse hair; T1: yellow; T2(+): may be black, yellow, or white
♀—No pollen baskets; T4 & T5 frequently white
♂—Head yellow on top and front of face

♀ 17–19 mm ♂ 11–17 mm

GROUP C: THORAX MOSTLY BLACK

15 *B. auricomus* (Black-and-gold)



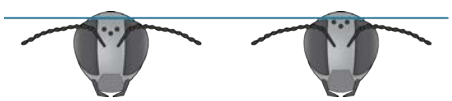
H—Ocelli (three small eyes) lower on face (see right)
TH—Predominantly black with yellow towards the front; often with yellow around rear edge
AB—T1:black or mostly black; T2 & 3: yellow; T4(+): black
♂—Large eyes

♛ 22–26 mm ♀ 16–19 mm ♂ 13–21 mm

16 *B. pensylvanicus* (American)

H—Usually black on top; ocelli higher on face (see right)
TH—Predominantly black; often with dark hair at sides
AB—T1: may be black or yellow; T2–4: yellow; T5(+): black
♂—T7 often orange

♛ 22–26 mm ♀ 13–19 mm ♂ 15–21 mm



B. auricomus
Ocelli are lower on the face, visibly below the supraorbital line

B. pensylvanicus
Ocelli are higher on the face, equidistant from the eyes and each other

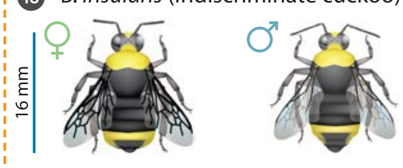
Female *B. auricomus* and *B. pensylvanicus* can be very similar in appearance. When in doubt, the location of the subject's ocelli can help determine species.

17 *B. terricola* (Yellow-banded)

TH—Rear half is black
AB—T1: black; T2 & T3: yellow; T4(+): black with fringe of yellow hairs near end of AB
♀—Short cheek
Note: Smaller and stouter than many other species

♛ 19–21 mm ♀ 10–15 mm ♂ 13–15 mm

18 *B. insularis* (Indiscriminate cuckoo)



TH— Rear half is black
AB—Sparse hair; T1–3: black; T4: yellow; T5(+): yellow sides with black center
♀—No pollen baskets

♀ 16–20 mm ♂ 11–16 mm

19 *B. flavidus* (Fernalde cuckoo) V

TH— Rear half is black
AB—Sparse hair; variable coloration; T1–3—black; T4–yellow (may have black spot); T5(+): black
♀—No pollen baskets
♂—TH often with yellow on rear half; T1: may be yellow; T6 & T7: sometimes orange

♀ 17–18 mm ♂ 11–15 mm

ACKNOWLEDGEMENTS & ADDITIONAL RESOURCES

Bumble bee species illustrations by Elaine Evans, University of MN Bee Lab. Bumble bee anatomy illustrations by Sara Morris.
For regional keys to bumble bee males and females, see www.befriendingbumblebees.com.
For a bumble bee citizen scientist project, see www.bumblebeewatch.org.
For more information on bumble bee taxonomy and ID, see *Bumblebees of North America* by Williams et al. 2014.

HOME PRINT SCALE CHECK

This bar should be **25.4 mm/ 1" long** at 100% scale.

If it is not, check your printer's scale settings.

KEY

#	Species	
1	*B. bimaculatus*	GROUP A
2	*B. griseocollis*	GROUP A
3	*B. impatiens*	GROUP A
4	*B. affinis*	GROUP A
5	*B. citrinus*	GROUP A
6	*B. vagans*	GROUP A
7	*B. sandersoni*	GROUP A
8	*B. perplexus*	GROUP A
9	*B. rufocinctus*	GROUP B
10	*B. huntii*	GROUP B
11	*B. ternarius*	GROUP B
12	*B. fervidus*	GROUP B
13	*B. borealis*	GROUP B
14	*B. bohemicus*	GROUP B
15	*B. auricomus*	GROUP C
16	*B. pensylvanicus*	GROUP C
17	*B. terricola*	GROUP C
18	*B. insularis*	GROUP C
19	*B. flavidus*	GROUP C

ANATOMY	AB	Abdomen	F(#)	Flagellomere
	TH	Thorax	T(#)	Tergite (AB segment)
GENDER	♛	Queen	♀	Female or worker
	♂	Male		
NOTES	V	Variable—some species have numerous accepted forms		

Appendix E: BEE MONITORING PROTOCOL AND DATASHEET

This sample pollinator monitoring protocol can be used to collect observational data on the abundance and richness of native bees, and is designed for observers working on their own or in pairs.

EXAMPLE OF APPLYING THE PROTOCOL

- **Note:** This is an example; the exact timing may vary depending upon weather and the size of the site being monitored.

SETTING UP A SITE

- Prior to conducting site monitoring, transects need to be established. It is also important to map the site or take GPS coordinates of transect end and start points. If GPS is not available, mark the transect(s) on an aerial photo or using Google Earth.

Monitoring a site

10:00 AM—ARRIVE AT SITE

- Set up thermometer in the shade, and fill out the site/ date information in the data sheet.

10:10 AM—RECORD START WEATHER DATA AND DETERMINE SAMPLE DURATION

1. **Shade temperature:** should be greater than 15.5° C (60° F)
2. **Wind speed:** average wind speed over one minute (at shoulder height, facing the wind) should ideally be less than 6 mph
3. **Cloud cover:**
   - Clear—clouds rarely/ never cover sun
   - Partly cloudy—clouds cover sun sometimes
   - Bright overcast—even haze/ clouds, but sun or light shadows are visible
   - Overcast—more overcast than bright overcast; no shadows are cast

   NOTE: *Do not sample in overcast, rainy, or windy conditions.*
4. **Sample duration:**
   - To determine the number of minutes you need to sample your site divide the total length (in feet) of the transect(s) by ten.
   - Record this number of minutes on the top of the data sheet.

MATERIALS REQUIRED

- Identification and monitoring guides (*Citizen Science Pollinator Monitoring Guide*)
- Clipboard
- Pencil
- Datasheet(s)
- Permits (if necessary)
- Timer
- Thermometer
- Wind meter (optional)
- Sunscreen
- Hat
- Water
- First aid kit (including an Epi-Pen or other appropriate medicine if allergic to bees)
- Site specific monitoring protocol
- Optional: Plant list for the site or plant identification guide

TO SET UP TRANSECT, BRING:

- Measuring tape or wheel (100–150')
- Stakes and flagging to mark the transect end
- Aerial photo or map to document location of transect
- Optional: GPS or phone to record the start and end points of the transect.

Figure 8: Before monitoring a site, transects need to be established and mapped to maintain consistency for future efforts. If possible, it can be helpful to install long-term markers on the site that can be left in place between visits. (Photograph by Sarah Foltz Jordan.)

10:20 AM–11:20 AM—OBSERVATIONS

1. Set timer to 60 minutes. Note start time and then start timer.
2. Begin walking the transect through your study area. Pace yourself. Try to cover the study area (transects) as evenly as possible—it is important not to rush through the area, but it is also important to keep moving (i.e., do not spend more than a couple of observational minutes at any flower or group of flowers). Remember to look at a diversity of flowers, and not just the showy ones. It is also important to be as consistent as possible each time you visit a site so that you collect data with the same level of effort. This will allow you to more reliably compare data from year to year.
3. When you see an animal visiting the reproductive parts of a flower:
   - Observe, identify and note the animal(s) as best you can until you are satisfied with your identification or until the visitor flies away. The recorder should note your observations, including flower species if that is part of your methods.
   - If you see more than one floral visitor on a single flower, first note the number of visitors and then identify them.
4. Begin walking again and continue with your observations until your sampling time is finished.
5. Note end time.

11:20 AM—RECORD END WEATHER DATA

- See above.

11:25 AM—RECORD ANY ADDITIONAL NOTES ABOUT THE SITE

- After you have finished collecting data on the bees, note each additional flower species that is in bloom but did not have floral visitors during your survey. (This could also be noted by either the observer or reporter during the survey if it does not distract from monitoring). You can also record unique insects seen at the site, the intensity of visitation to specific flowers, vigor of the planting, needs for site maintenance, observer contact information, etc.

NOTE:

- This example is based on a 600' long transect.
- During monitoring, the observer and recorder work together to collect observational data for a total of one hour. The observer and recorder should cover the study area (transect) as evenly as possible.

DURING YOUR OBSERVATION

- Only identify and make notes on the animals visiting the reproductive parts of the flower. You do not need to record animals sitting on petals, leaves, stems, etc., or visitors flying around the area.
- Be careful not to disturb insects visiting flowers before you get a chance to observe them well. Avoid sudden movements. Insects respond to a shadow passing overhead by moving away; if possible walk so that your shadow trails you, rather than advances in front of you. Also, do not stand too close to the flower you are observing.
- If you have walked through the entire study area (transect) before the allotted time has expired (in the case of this example, 60 minutes for the whole plot), you may go back to monitor particularly rewarding areas until the time runs out.
- Bee species can be difficult to tell apart. If you are particularly interested in monitoring the native bees on your property, it will be important for you to distinguish, at minimum, honey bees from native bees.

FIGURE 9: Monitoring in pairs can be highly efficient, allowing the oberserver and recorder to collect data continuously without stopping to take notes. (Photograph by Sarah Foltz Jordan.)

CITIZEN SCIENCE MONITORING DATASHEET: NATIVE BEES

STEP 1—Photocopy or print copies of this datasheet in advance (www.xerces.org/csmdatasheets)

STEP 2—Site Details

SITE NAME: ______________________ **TRANSECT:** ______________________

MONITORING TIME*: ______________________ **DATE:** ______________________

**1 minute per 10' of transect*

OBSERVER: ______________________ **DATA RECORDER:** ______________________

STEP 3—Site Conditions *(Remember to note* Observation End Time *upon completion!)*

OBSERVATION START TIME: ______________________

SHADE TEMP: ______ ºC / °F

Wind: (*circle one*) Calm / light air / light breeze / gentle breeze

Sky: (*circle one*) Clear / partly cloudy / bright overcast

OBSERVATION END TIME: ______________________

STEP 4—Monitoring

Set timer and hit start when ready. Note any floral visitors you see and identify to your confidence level. Pace the transect until the time is up.

FLORAL VISITOR CATEGORIES:

Honey bee	Chap leg bee	Green sweat bee	Tiny dark bee	Metallic hairy belly bee
Bumble bee	Medium dark bee	Striped sweat bee	Striped hairy belly bee	Cuckoo bee

OBSERVATIONS:

Important: Remember to look at a diversity of flowers, stand so that you do not cast a shadow, and only ID floral visitors to the level at which you are confident in your identification. In order to track floral attractiveness, tally individual floral visitors from the same species by floral association.

#	FLORAL VISITOR	DESCRIPTION (GENUS, COLOR, SIZE, ETC.)	TIMES OBSERVED (TALLY)	FLORAL ASSOCIATION
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				

STEP 4—Monitoring, *continued*

FLORAL VISITOR CATEGORIES:

Honey bee	Chap leg bee	Green sweat bee	Tiny dark bee	Metallic hairy belly bee
Bumble bee	Medium dark bee	Striped sweat bee	Striped hairy belly bee	Cuckoo bee

OBSERVATIONS, *continued*: (attach any Additional Monitoring Sheet(s) if necessary, available at: www.xerces.org/csmdatasheets)

#	FLORAL VISITOR	DESCRIPTION (GENUS, COLOR, SIZE, ETC.)	TIMES OBSERVED (TALLY)	FLORAL ASSOCIATION
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				

STEP 5—Notes (include changes in weather or other pertinent details)

Example

CITIZEN SCIENCE MONITORING DATASHEET: NATIVE BEES

STEP 1—Photocopy or print copies of this datasheet in advance (www.xerces.org/csmdatasheets)

STEP 2—Site Details

SITE NAME: S. Wash Cons Corridor

TRANSECT: NE Pollinator Planting Transect 2

MONITORING TIME*: 1 hour

DATE: August 26, 2015

**1 minute per 10' of transect*

OBSERVER: Sarah Foltz Jordan

DATA RECORDER: Pamela Herou

STEP 3—Site Conditions *(Remember to note* Observation End Time *upon completion!)*

OBSERVATION START TIME: 9:43 am

SHADE TEMP: 74 °C / °F

Wind: *(circle one)* Calm / light air / light breeze / gentle breeze

Sky: *(circle one)* Clear / partly cloudy / bright overcast

OBSERVATION END TIME: 10:40 am

STEP 4—Monitoring

Set timer and hit start when ready. Note any floral visitors you see and identify to your confidence level. Pace the transect until the time is up.

FLORAL VISITOR CATEGORIES:

Honey bee	Chap leg bee	Green sweat bee	Tiny dark bee	Metallic hairy belly bee
Bumble bee	Medium dark bee	Striped sweat bee	Striped hairy belly bee	Cuckoo bee

OBSERVATIONS:

Important: Remember to look at a diversity of flowers, stand so that you do not cast a shadow, and only ID floral visitors to the level at which you are confident in your identification. In order to track floral attractiveness, tally individual floral visitors from the same species by floral association.

#	FLORAL VISITOR	DESCRIPTION (GENUS, COLOR, SIZE, ETC.)	TIMES OBSERVED (TALLY)	FLORAL ASSOCIATION
1	Honey		~~IIII~~ ~~IIII~~	Goldenrod–showy
2	Bumble	Bombus impatiens	III	Goldenrod–showy
3	Bumble	not sure what species	I	Liatris ligulistylis
4	Honey		I	Black-eyed Susan
5	Chap	very long antennae, male?	I	Goldenrod–oldfield
6	STR-Hairy	hairs and pollen on underside of Abd.	I	Maximilian sunflower
7	GRN	striped abdomen, green thorax	I	Heath aster
8	Cuckoo	black w/ red abdomen	I	Maximilian sunflower
9	Honey		I	Heath aster
10	Bumble	abdomen mostly yellow	I	Aster–unknown blue flowers
11	Monarch		~~IIII~~	Liatris ligulistylis
12	Hoverfly	large, yellow + black	I	unknown mustard (weed)
13				
14				

Appendix E: Additional Acknowledgements

Photographs

We are grateful to the photographers for allowing us to use their wonderful photographs. The copyright for all photographs is retained by the photographers. None of the photographs may be reproduced without permission from the photographer:

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Yellow bumble bee (*Bombus fervidus*) on bee balm (*Monarda fistulosa*). (Photograph by Sarah Foltz Jordan.)

Native bees can be excellent indicators of biodiversity and functioning ecosystems.

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