

STREAMLINED BEE MONITORING PROTOCOL FOR ASSESSING POLLINATOR HABITAT



The Williams Lab at University of California, Davis, Isaacs Lab at Michigan State University, and Winfree Lab at Rutgers University conduct research into how habitat and habitat restoration projects support and increase the value of wild bees in crop pollination. Working to better understand the ecology of wild pollinators and the pollination services they provide, their research examines pollinator diversity, community ecology of plant-pollinator networks, the ecology and behavior of pollinators, pests and natural enemies within agricultural systems and surrounding landscapes, and the persistence of pollinator populations and communities in the face of global change. They collected and analyzed three field seasons of data on plants and bees at pollinator plantings to develop this streamlined protocol.

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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We are grateful to the many photographers who allowed us to use their wonderful photographs in this monitoring guide. The copyright for all the photographs is retained by the photographers. The photographs may not be reproduced without permission from the photographer.

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Cover Photos

Front: Clockwise from left to right: Eucerine ground-nesting bee, Mace Vaughan, The Xerces Society; Green sweat bee, Rollin Coville; and Bumble bee on red currant, Mace Vaughan, The Xerces Society.

Back: Small carpenter bee, Rollin Coville.

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Section 1

INTRODUCTION

Declines in native bee populations and increased challenges in maintaining sufficient honey bees for pollination in the United States have underscored the need for greater flowering resources in agricultural landscapes. The USDA Natural Resources Conservation Service (NRCS) and the Farm Service Agency (FSA) recognize the value in supporting pollinators and have devoted millions of dollars annually to help farmers and other landowners plant and maintain pollinator habitat on private lands.

Assessing the effectiveness of different habitat restoration practices is a key component of augmenting floral resources for bees, so that conservation strategies can be adapted and improved. A standardized monitoring protocol is presented in this document to allow agency staff, land managers, farmers, and others to evaluate the performance of individual pollinator habitat plantings. This protocol can be used to assess pollinator plantings in three ways. First, it allows users to rank multiple pollinator plantings from least to most diverse in terms of bee communities supported. This may be particularly useful when comparing different management or implementation techniques, or even different seed mixes. Second, by including samples at reference sites, such as old fields or weedy field borders that have not been planted for pollinators, it can indicate whether plantings have increased pollinator populations and species diversity. Third, it can be used to determine whether pollinator diversity and abundance change over time.

This streamlined protocol balances the time and training required to conduct a survey with the need for accurate estimates of the abundance and diversity of pollinators attracted to the pollinator habitat plantings. To develop this streamlined protocol, bee abundance and diversity were observed and recorded at flowers in pollinator habitat plantings and unrestored reference sites over a three-year period in California, Michigan, and New Jersey. These locations represent three important agricultural regions of the United States. Simultaneously, species richness of native bee communities was assessed at the same sites through more thorough sampling with nets followed by species-level identifications. Observation data and net-collection data at each site were compared to determine the sampling effort required to accurately measure the abundance and diversity of bees at pollinator plantings.

This research found that simply observing and recording the **abundance** of native bees on flowers during two site visits of 15 minutes each provide good estimates of both abundance and diversity of bees visiting that site. The best data came from counting native bees in the middle of the growing season (for example May–July in California, and July–August in New Jersey and Michigan), and separating the site visits by two to three weeks. The research also shows that a single 30-minute survey (400 ft of transect) during these same time periods is adequate for assessing bee diversity. However, two 15-minute surveys provide a much more reliable assessment.

Finally, it is important to understand that counting honey bees does not provide a good measure of the value of habitat for bees and other pollinators. The number of honey bees visiting a planting is most heavily influenced by the number of managed bee hives nearby. Seeing abundant honey bees is certainly a sign that a habitat supports bees, but it doesn't indicate how well that planting increases the abundance and diversity of bees.

Therefore, in order to assess changes in the abundance of bees that are using habitat created or enhanced for pollinators, you will need to know how to distinguish native bees from honey bees and other flower-visiting insects. You will also need to understand how to consistently implement a standardized monitoring protocol. In the following pages, we guide you through basic bee identification (Section 2), followed by instructions on the monitoring protocol (Section 3).



Bees are the most important group of pollinators in North America, responsible for pollinating crops and wildflowers.

Section 2

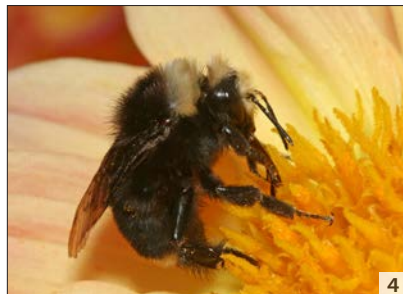
BEE IDENTIFICATION

There are approximately 4,000 species of bees native to North America, and along with that diversity comes great variation in appearance (see Box 1, p.7). One feature all bees share is their dependence on pollen for rearing young. Their adaptations for carrying pollen often make them easy to distinguish from other insects. Usually, bees are quite hairy, allowing pollen grains to stick to them, and females have special pollen carrying structures on their legs or bellies. The location of these pollen-carrying structures and the appearance of obvious pollen loads (dry powder vs. moist balls) can be helpful in identifying bees from wasps or flies, and can even help distinguish between groups of bees.

The size and location of bees' eyes and antennae also help distinguish them from other similar-looking insects, such as flower flies. Specifically, bees' eyes are positioned at the sides of their heads, giving their heads a somewhat heart-shaped appearance, and their antennae are long and straight. In contrast, bee-mimicking flies tend to have large eyes that take up most of their heads, and short, stubby antennae that are often hard to see. Bees also have four wings, whereas flies have two, but this can be hard to see unless they are at rest on a flower or leaf.

To help separate bees from wasps, it is useful to know that bee bodies tend to be rounder than many wasps. Wasps often have a more pointed abdomen and a thinner waist.

Is It a Bee?

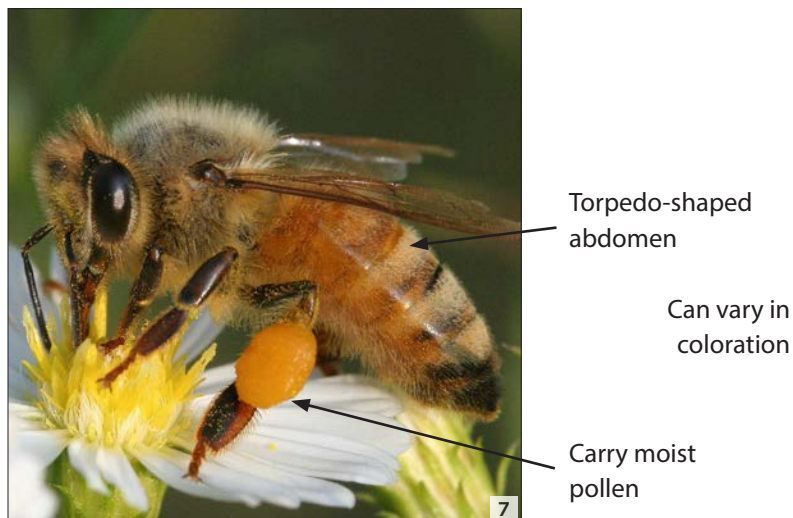


HONEY BEES

For this protocol, it is important to distinguish native bees from European honey bees. While support of honey bees is one goal of providing pollinator habitat, honey bees can be an unreliable indicator of the planting's ability to attract pollinators because their numbers depend on the location of honey bee hives or apiaries.

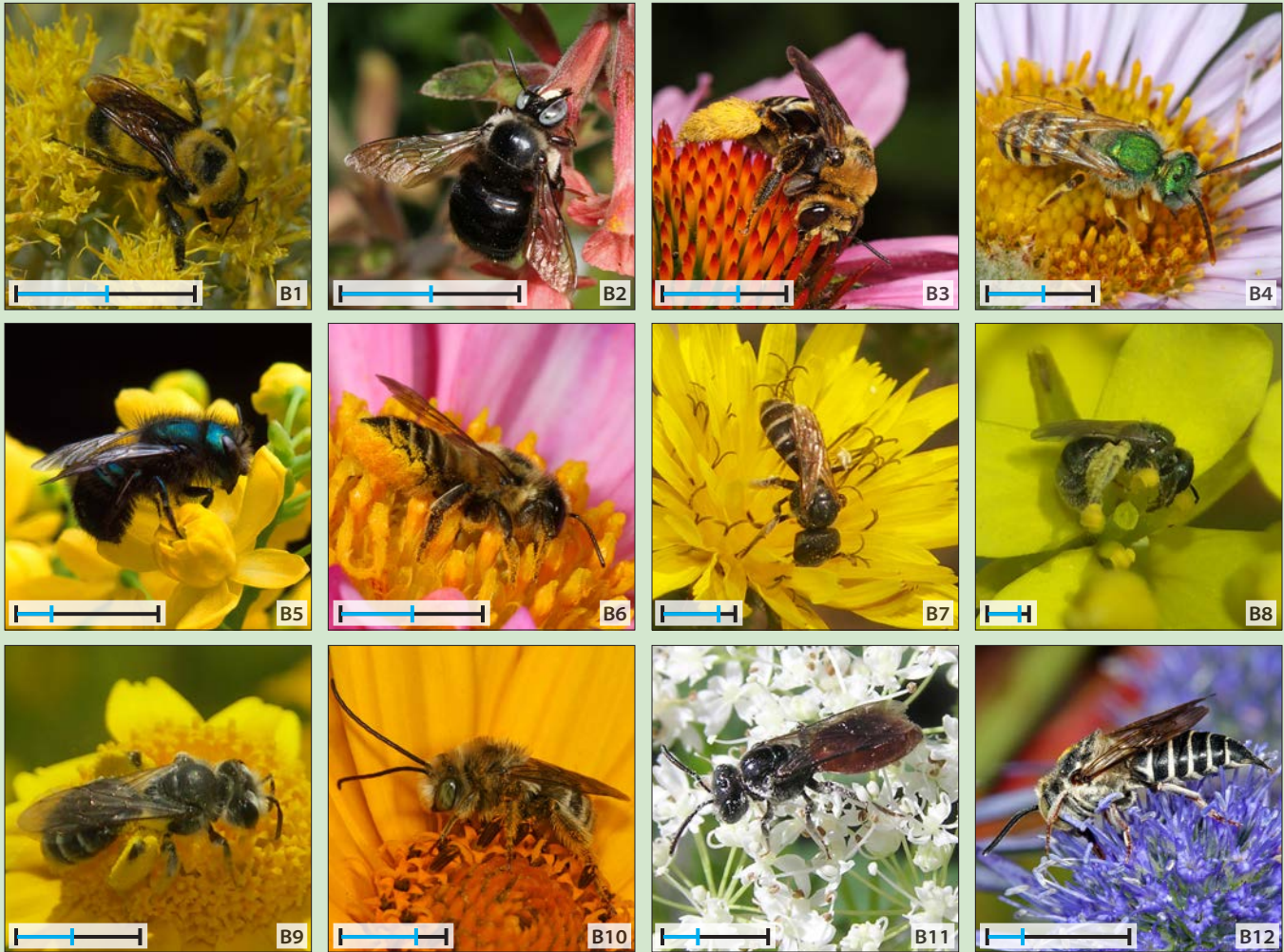
Honey bees vary in coloration from orange-brown to a very dark brown. They always have stripes on their distinctive “torpedo” shaped abdomen. They will always have a thorax covered in light brown hair. Honey bees, like bumble bees, carry pollen in baskets on their hind legs. These pollen baskets are slight indentations surrounded by long, hooked hairs. If the pollen baskets are empty you can see the flattened wide shape of the middle of the hind legs, and if they are full, you see the pollen is carried in moistened clumps, unlike the powdery dry pollen loads of many native bees.

Honey Bees



BOX 1: THE VARIETY OF NATIVE BEES

Pictured here are examples of the wide diversity of native bees you might observe on flowers. Look for some of the features described below.



Size: Native bees can range in size from tiny, dark-colored sweat and mining bees that are 1/8th to 1/4 inch long (e.g., B4, B7, B8), to bumble bees (B1) and large carpenter bees (B2) that are more than 1 inch long.

Shape: Native bees can be relatively slender, as in some of the small carpenter bees. They can be moderately wide, similar to European honey bees. Or they can be quite stocky and robust, as in the bumble bees or large carpenter bees.

Color: Bees vary greatly in color on their body surface (exoskeleton) and in the color of their hairs. Their exoskeleton can range from black, yellow, or red to metallic green and blue. Hair colors found on bees include black, grey, brown, yellow, orange, and white, and frequently create striped patterns.

Distribution of Hair: The patterns and locations of hair can make some bees look very "fuzzy" (e.g., bumble bees) while other species are hairy only in certain areas (e.g., legs) and, overall, may look quite shiny or bald.

Pollen Transport: Honey bees and bumble bees carry a mixture of pollen and nectar located on a flattened area on the hind leg called the pollen basket. Other bees carry pollen in a dense mass of stiff, branched hairs called the scopae. The scopae are often located on the hind legs, but in some species they are located on the underside of the abdomen. Note: only female bees have pollen-carrying structures.

Pollen: Bees can carry moistened pollen loads (mixture of pollen and nectar) or dry pollen. The wet pollen balls in the pollen baskets of European honey bees helps set them apart from all of the native bees in North America except bumble bees.

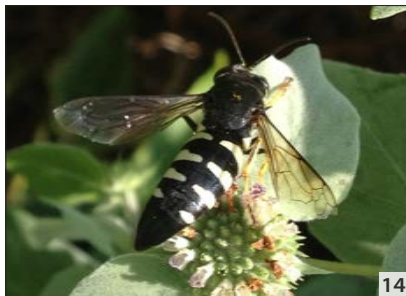
Approximate size:  smallest (blue) / largest (black)

WASPS

Wasps are close relatives of bees and share many features, including 4 wings, stripes, and heart-shaped heads with the eyes on the sides. However, wasps are carnivores and do not have adaptations to collect and carry pollen. They are not very hairy and have little or no pollen on their bodies when visiting flowers. Wasp coloration results from patterns in their exoskeleton, giving them a shiny appearance compared to bees, which usually—but not always—get their stripes from colored hairs. Wasps have been described as having a “tough” or “mean” look with their more slender pointed bodies compared to the more rounded shape of bees. One very common family of wasps folds their forewings lengthwise when at rest, making them look more narrow.

DO NOT COUNT WASPS WHEN USING THIS BEE PROTOCOL.

Wasps

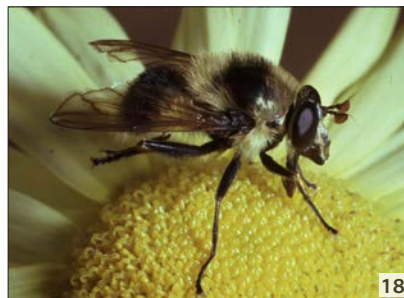


FLIES

Although many flies look very similar to bees, several features make them easy to distinguish. First, the flies that look like bees have eyes that are large and round, often making up the bulk of their head and sometimes giving the head a helmet-like appearance. Their antennae are short and thick, coming out like a 'V' from the middle of their face. Although they may be visiting flowers for nectar, they are not carrying pollen back to their young, so in general they are not as hairy as bees (although some species mimic bumble bees), and they never have hairy pollen-carrying structures on their legs. Flies also have two wings, rather than four wings like bees and wasps. However, it is often difficult to see this feature unless the insects are at rest.

DO NOT COUNT FLIES WHEN USING THIS BEE PROTOCOL.

Flies



Section 3

MONITORING PROTOCOL

The goal of this streamlined bee monitoring protocol is to efficiently document bee diversity and abundance on pollinator habitat plantings in order to measure their success in supporting pollinators, or to document changes in the bee community over the years after seeding. Plantings can include meadows, hedgerows, cover crops, or field trials of pollinator plant seed mixes.

During two separate site visits per year, you will conduct timed assessments, observing and counting bees visiting flowers along transects. Your two site visits should be separated by two to three weeks. In California, you can survey bees anytime between May and July. In the Great Lakes or Mid-Atlantic regions you should survey between early July and late August.

Bees are most active when weather conditions are good, so you must survey your site when it is warm, sunny, and calm. Ambient temperatures should be greater than 60°F, wind speeds ideally should be less than 8 mph, and skies should be mostly clear (partly cloudy or overcast skies are OK if you can still see your shadow). You will get the best data during an afternoon visit, so conduct surveys between noon and 4 pm. For each site or planting that you survey, allow enough time to mark or find the transects, collect two 7.5-minute samples, and walk between transects. We estimate about 30 minutes per site will be needed for each visit.

Each time you visit a site, you will survey two 100 ft transects (or the equivalent length split into smaller sections). Keep the transects in full sun because bee activity declines in the shade. Each 100 ft transect should be sampled for 7.5 minutes, and only count bees on flowers in a 3 ft wide strip. If you are sampling a relatively large meadow or cover crop that will easily fit a 100 ft transect, one of the transects should be 10–20 ft from the planting edge (running parallel with the edge) and the other should be either 250 ft from the edge, or in the center of the habitat, whichever is shorter (Figure 1). If sampling a small planting, do your best to set up 200 ft of transects through each plot. For example, this may be four 50 ft transects (Figure 2). If you are sampling a hedgerow, then run one transect along each side of the hedgerow, only counting bees in a 3 ft wide strip (Figure 3).

Select and photocopy the appropriate data sheet for your site (p.12–14). Record the site name, the date and your name at the top of the data sheet, as well as whether this is your first or second visit to the site. Note the weather conditions to show that the sample was conducted during optimal conditions for bees. Also note the type of planting (e.g., hedgerow, meadow, cover crop, etc.).

When sampling each transect, record the time of day you start, then start the timer and begin walking down the transect. Plan your transect walk so that your shadow does not move in front of you or across where you are counting bees. As you slowly walk, survey three feet to one side of the line you are walking, trying to watch all the open flowers. Record each bee you see visiting a flower (visiting = landing on the reproductive structures of a flower for more than 0.5 seconds). Pause the timer if you need time to record an insect or to shift over to another subsection of the transect you are surveying. Then start the timer again when you are ready to resume observations. Tally native bees and honey bees separately on your data sheet.

- ⇒ Try to pace yourself so you reach the end of the 100 ft transect when the 7.5 minutes are up.
- ⇒ If the timer goes off before you have reached the end of the transect, quickly walk to the end of the transect and take a rough count of the native bees and honey bees visiting flowers.
- ⇒ Don't count the same bee twice even if it visits several flowers—the goal is to count the number of bees using the site, not the rate of flower visitation.

SUPPLIES NEEDED FOR MONITORING

During your site visit you will need:

- A stopwatch, wristwatch, or timer on your phone
- Thermometer
- Data sheets
- Monitoring protocol
- Clipboard
- Pencils/ pens
- Long measuring tape (eg. 100–150 ft)
- Flags or stakes to mark transect start and end
- Permits (if necessary)
- Optional: camera or phone with high quality camera
- Suggested: sunscreen, hat, water, first aid kit, and plant list/ identification guide

In the notes section of the data sheet, record important site information, such as the dominant flowers in bloom and which species seem to be attracting the most native bees or honey bees.

Interpretation of results: The number of native bees counted by this streamlined survey protocol is positively correlated with the diversity of bees at a site. If multiple sites are surveyed, the differences in diversity of the bee community likely will reflect differences in habitat quality among sites. Thus, native bee counts can be used to rank the quality of sites or the quality of a pollinator seed mix. If data are collected over several years, these bee counts can also assess the change in the bee community at a site over time.

LAYOUT OF SAMPLING TRANSECTS



Figure 1. For larger habitat plantings, survey bees on two 100 ft transects parallel to the edge of the habitat. One transect should be 10–20 ft from the edge, and the other should be 250 ft from the edge or at the center of the habitat, whichever is shorter.

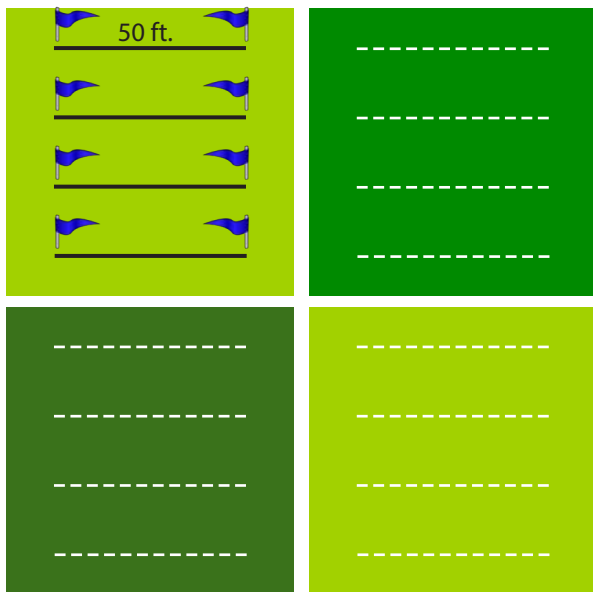


Figure 2. For smaller habitat plantings, such as field trials of pollinator seed mixes, you can work to fit 200 ft of transect into each block. For example, the upper left block demonstrates establishing four parallel 50-foot-long transects. When walking each transect, you are only observing bees in a 3 ft wide strip along the transect path. The dotted lines in the other blocks in this figure indicate similar sampling efforts.

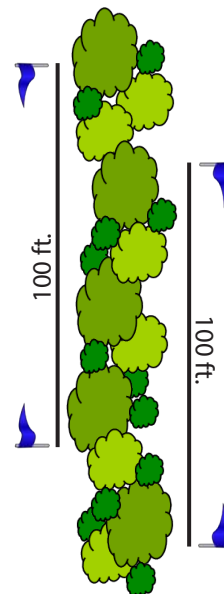


Figure 3. For hedgerows, survey bees on two 100 ft transects on opposite sides of the hedgerow. If the two sides are difficult to access, sample a single transect that is 200 ft long. You will observe bees in a 3 ft wide strip along each transect.

Bee Monitoring Data Sheet: Large Habitat (See Figure 1)

please remember to photocopy

Site Name: _____ Date: ____ / ____ / ____ Observer: _____

Visit #: ____ of 2 Skies (circle): Clear / Partly Cloudy / Bright Overcast Temp: ____ °F

Type of planting (circle): Meadow / Range / Cover Crop / Other (describe): _____

Conduct observations in the afternoon (noon–4 pm), when temperatures are over 60°F, skies are clear (partly cloudy or bright overcast is OK as long as you can see your shadow) and wind speed is low (a gentle breeze or less). **Conduct observations on two 100 ft transects in open areas of the planting.** One transect should be 10–20 ft from the edge, and the other should be 250 ft from the edge or at the center of the habitat, whichever is shorter. Observe plants in each transect for 7.5 minutes. For each transect, record the number of native bees and honey bees visiting flowers (touching reproductive structures of flowers) within 3 ft of one side of your transect line. You can note flies, wasps, or other floral visitors in the notes.

Transect	Start Time	End Time	# Native Bees	# Honey Bees	Notes
Transect 1 (10–20 feet from edge of planting)					
Transect 2 (center of planting)					

Site notes (e.g. details of the planting, dominant plants in bloom, proximity of honey bee hives, etc.): _____

Bee Monitoring Data Sheet: Small Planting Blocks (See Figure 2)

please remember
to photocopy

Site Name: _____ Date: ____ / ____ / ____ Observer: _____

Visit #: ____ of 2 Skies (circle): Clear / Partly Cloudy / Bright Overcast Temp: _____ °F

Type of planting (circle): Field Trials / Meadow / Cover Crop / Other (describe): _____

Conduct observations in the afternoon (noon–4 pm), when temperatures are over 60°F, skies are clear (partly cloudy or bright overcast is OK as long as you can see your shadow) and wind speed is low (a gentle breeze or less). **Conduct observations on 200 ft of transects, evenly spaced through the planting.** Observe plants in all combined transects for a total of 15 minutes. For each transect, record the number of native bees and honey bees visiting flowers (touching reproductive structures of flowers) within 3 ft of one side of your transect line. You can note flies, wasps, or other floral visitors in the notes.

Transect	Start Time	End Time	# Native Bees	# Honey Bees	Notes
Transect 1 length: _____					
Transect 2 length: _____					
Transect 3 length: _____					
Transect 4 length: _____					

Site notes (e.g. details of the planting, dominant plants in bloom, proximity of honey bee hives, etc.): _____

Bee Monitoring Data Sheet: Linear Planting (See Figure 3)

*please remember
to photocopy*

Site Name: _____ Date: ____ / ____ / ____ Observer: _____

Visit #: ____ of 2 Skies (circle): Clear / Partly Cloudy / Bright Overcast Temp: ____ °F

Type of planting (circle): Hedgerow / Windbreak / Insectary Strip / Other (describe): _____

Conduct observations in the afternoon (noon–4 pm), when temperatures are over 60°F, skies are clear (partly cloudy or bright overcast is OK as long as you can see your shadow) and wind speed is low (a gentle breeze or less). **Conduct observations on two 100 ft transects along either side of the planting.** Observe plants in each 100 ft transect for 7.5 minutes. For each transect, record the number of native bees and honey bees visiting flowers (touching reproductive structures of flowers) within 3 ft of one side of your transect line. You can note flies, wasps, or other floral visitors in the notes. If it is less than 6 ft wide, consider using a single 200 ft transect.

Transect	Start Time	End Time	# Native Bees	# Honey Bees	Notes (Describe where transect is located)
Transect 1 (side A) length: _____					
Transect 2 (side B) length: _____					

Site notes (e.g. details of the planting, dominant plants in bloom, proximity of honey bee hives, etc.): _____

Appendix A

ADDITIONAL RESOURCES

Bee Conservation Publications

Buchmann, S. L. and G. P. Nabhan. 1996. *The Forgotten Pollinators*. 292 pp. Washington, D.C.: Island Press.

National Research Council. 2006. *Status of Pollinators in North America*. 307 pp. Washington, D.C.: National Academies Press. (Available at: <http://www.nap.edu/catalog/11761.html>.)

Mader, E., M. Shepherd, M. Vaughan, S. H. Black, and G. LeBuhn. 2011. *Attracting Native Pollinators. Protecting North America's Bees and Butterflies*. 384 pp. North Adams, MA: Storey Publishing.

Bee Biology and Identification Publications

Michener, C. D., R. J. McGinley, and B. N. Danforth. 1994. *The Bee Genera of North and Central America*. 209 pp. Washington, D.C.: Smithsonian Institution Press.

Michener, C. D. 2000. *The Bees of the World*. 913 pp. Baltimore, MD: The Johns Hopkins University Press.

O'Toole, C., and A. Raw. 1999. *Bees of the World*. 192 pp. London, UK: Blandford Press.

Williams, P. H., R. W. Thorp, L. L. Richardson, and S. R. Colla. 2014. *Bumble Bees of North America: An Identification Guide*. 208 pp. Princeton, NJ: Princeton University Press.

Plant Lists & Conservation Resources

Fiedler, A., J. T. Tuell, R. Isaacs, and D. Landis, 2007. *Attracting Beneficial Insects with Native Plants*. 6 pp. Michigan State University Extension Bulletin E-2973.

Rutgers University Outreach:

<http://winfreelab.rutgers.edu/outreach>

<http://winfreelab.rutgers.edu/documents/NativeBeeBenefits2009.pdf>

Michigan State University, Native Plants and Ecosystem Services: www.nativeplants.msu.edu

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

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

Citizen Science Opportunities

Bumble Bee Watch (www.bumblebeewatch.org): Citizen science database for collecting bumble bee observations in North America.

The Great Sunflower Project (www.greatsunflower.org): A citizen science project that identifies bees visiting flowers.

Bug Guide (www.bugguide.net): An online resource devoted to North American insects, spiders, and their kin, offering identification, images, and information.

Partner Websites

University of California, Davis: <http://polleneaters.wordpress.com/>

Rutgers University Outreach: <http://winfreelab.rutgers.edu/>

Michigan State University: www.isaacslab.ent.msu.edu

The Xerces Society: www.xerces.org/pollinator



Some native bees, such as this small carpenter bee, can be tiny and wasp-like.



The Xerces Society's Bring Back the Pollinators campaign is based on four principles: grow pollinator-friendly flowers, protect bee nests and butterfly host plants, avoid pesticides, and spread the word. You can participate by taking the Pollinator Protection Pledge and registering your habitat on our nationwide map of pollinator corridors.

www.bringbackthepollinators.org