

# The Adapted Streamlined Bee Monitoring Protocol: Evaluating Pollinator Habitat Plantings Using Bee Abundance and Floral Resource Selection



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# The Adapted Streamlined Bee Monitoring Protocol: Evaluating Pollinator Habitat Plantings Using Bee Abundance and Floral Resource Selection

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Point Blue Conservation Science

## Acknowledgements

This protocol is an adaptation of the [Streamlined Bee Monitoring Protocol](#) (SBMP), developed by The Xerces Society for Invertebrate Conservation, University of California-Davis, Rutgers University, and Michigan State University (Ward et al. 2014). Additional elements were adapted from the California Pollinator Project's [Citizen Scientist Pollinator Monitoring Guide](#) (Ullmann et al. 2011), developed by the Xerces Society and University of California at Berkeley. We are indebted to the individuals and organizations who developed these foundational protocols, as well as staff from Xerces Society and UC Davis who provided training, technical guidance, and feedback during the development of this adapted protocol.

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**Cover photo:** Photo by Alicia Herrera, 2025. Point Blue biologists practicing bee counts on a polygonal wildflower plot.

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## INTRODUCTION

Native pollinators, particularly bees, play a critical role in supporting ecosystem function and agricultural productivity. However, many native bee populations have declined in recent decades due to habitat loss, pesticide exposure, climate change, and other stressors. In response, substantial investments have been made to restore and enhance pollinator habitat across working and natural landscapes, including the establishment of pollinator plantings designed to increase floral resource availability.

As these efforts expand, there is a growing need for standardized, field-based methods to evaluate their effectiveness. Monitoring bee visitation and community composition at restoration sites provides a practical way to assess return on investment, compare outcomes across projects, and inform adaptive management. In particular, identifying which plant species and planting designs most effectively support native bees can help improve restoration practices and maximize ecological benefits.

This protocol—*Evaluating Pollinator Habitat Plantings Using and Floral Resource Selection: The Adapted Streamlined Bee Monitoring Protocol*—provides a standardized approach for assessing bee use of pollinator habitat plantings. It builds on methods developed by The Xerces Society for Invertebrate Conservation, University of California, Davis, Rutgers University, and Michigan State University and described in the *Streamlined Bee Monitoring Protocol* (hereafter SBMP; Ward et al. 2014), while incorporating additional data collection to differentiate native bee diversity by “morphogroups”, identify and quantify floral resource abundance, and better understand how bees use floral resources within habitat plantings.

Specifically, this protocol is intended to: 1) evaluate how floral area and plant species richness influences native bee abundance and morphogroup diversity, (2) identify which blooming plant species are disproportionately used by foraging bees relative to their availability, and (3) compare bee abundance and diversity between habitat plantings and unrestored reference areas. The protocol can also be used to assess changes in bee communities over time.

This protocol was developed to support monitoring of habitat restoration projects implemented through Point Blue Conservation Science’s Roots Program and the California Association of Resource Conservation Districts’ (CARCD) Wildlife and Pollinator Habitat block grants, funded by the California Wildlife Conservation Board. While tailored to these programs, the methods are broadly applicable for evaluating pollinator habitat projects across California and similar systems. Additional background on the development of the SBMP and the rationale for modifications included in this protocol are provided in Appendix A.

This document does not provide detailed guidance on bee identification. Users should refer to external resources, including the original SBMP (Ward et al. 2014) and the California Pollinator Project’s Citizen Scientist Pollinator Monitoring Guide (Ullmann et al. 2011), for identification support.

## METHODS

### Sampling Design

Our goals with this sampling design are (1) to sample enough transects in planting areas to capture a sense of the variability in bee and floral abundance, (2) to sample a similar amount of transects in reference sites on the same property as the plantings, and (3) complete a full round of bee counts and plant observations in both planted and reference sites on a single site in one day.

The sampling design is based on SBMP project data, which suggests that at least 15 minutes of bee counting in a pollinator habitat planting yielded an adequately high correlation between bee abundance estimates using net collection compared to visual counts of bee visitation (Ward et al. 2014). This protocol calls for surveying at least two, and up to five, 30-meter x 1-meter transects with count durations of 7.5 minutes each. This ensures that each project site is surveyed for at least 15 minutes, and up to 37.5 minutes.

To assess the difference between bee foraging habitat quality between planted areas and other vegetated areas that have not been restored, our protocol provides the option of establishing “reference sites” that occur on the same property in the same landscape. These will not serve as true “control” sites, because they may be too geographically close to planted areas to sample independent populations of bees. However, we do expect that they will have different plant communities and thus, their bee visitation counts will differ from planted areas due to the abundance and species composition of the floral resources they contain. See criteria for selecting reference sites in the *Transect Locations* section below.

### **Sample sizes**

Bee visitation counts and plant observations will be surveyed along no fewer than two 30-m x 1-m transects at any given habitat planting area. Additionally, aim to monitor two transects in nearby reference sites. However, if the site is large enough to allow more than two transects, we recommend sampling at least three and up to five 30-m x 1-m transects in the habitat planting area and three transects in nearby reference sites to better account for variability of bee counts, floral area, and blooming plant distribution in each area.

We anticipate that completing a full bee and plant survey at one transect could take at a minimum 20 minutes and maximum around 1 hour, depending on the abundance of blooms in the transect. Based on this and our goal to complete the observations of one planting at one site in one day, we recommend a baseline number of transects to establish with estimated field time in Table 1 below. In cases where blooming plants are sparse or highly variable within the baseline transects, consider adding 1 or 2 more planting area transects in the field. Given the time constraints of bee surveys (see *Timing and Duration for Counts*), we estimate a maximum 6 transects could be surveyed within a day (e.g. 3 planting area transects and 3 reference transects) per 1 observer. The recommended number of transects is based on practical field constraints rather than formal statistical power analyses; others who wish to implement this protocol may adjust sample size based on project goals, including increasing the number of

transects to improve the ability to detect differences between planting and reference sites where variability is high.

**Table 1.** Based on a planting area, recommended number of 30-m x 1-m bee count transects in planting and reference areas and the estimated time required to complete observations.

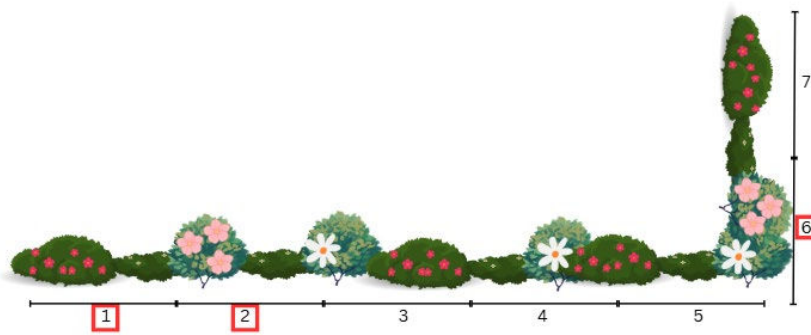
Planting area (acres)	Baseline # of transects	# of reference transects	Estimated field time (hrs)	Reasons for adding 1 or 2 transects above baseline, if total transects can be finished within time and temperature limitations
0.05 - 0.1	2-3	2-3	1.5 - 4.5	- Amount of blooming plants is low in baseline transects (<1m <sup>2</sup> cover within total transect) - Baseline transects fail to capture blooming plant diversity at planting site
0.1 - 0.5	3	3	2.0 - 4.5	
0.5 - 1.0	4	3	2.5 - 5.5	
1.0 +	5	3	3.5 - 5.5	

### ***Establishing Transects in Restored and Reference Sites***

To gather data from random and spatially balanced locations within the planting and reference areas, randomize the locations of each transect within these areas. To determine the transect locations, you will need a map of the planting area where the scale to the nearest meter can be determined (or GIS software, e.g. Google Earth). Random transect locations are selected based on the design and shape of each planting area. Transects should be a standard 30-meters in length. If the planting area is not large enough to accommodate 30-meter transects, slightly shorter transects may be used; in such instances transect length should be recorded on the datasheet and count time should be adjusted accordingly (see *Timing and Duration of Counts* below).

### ***Hedgerows***

If monitoring a linear single-row or multi-row planting like a hedgerow, divide the planting's total length in meters by 30 to get a total number of 30-meter-long segments from which to sample the transects. For a single-row hedgerow, number each segment and use a random number generator (e.g., [random.org](https://www.random.org)) or some other randomization method to select five to seven segments that will serve as potential transect locations, keeping track of their selection order from one to seven. See Figure 1 as an example.



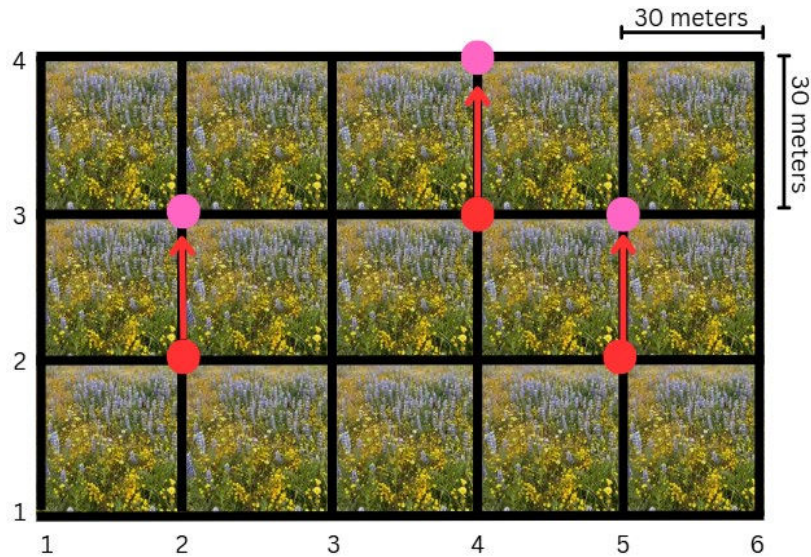
**Figure 1.** Example of how to identify count transects on a hedgerow, in which a 210-meter long hedgerow is divided into seven 30-meter segments. Here, segments 1, 2, and 6 are the randomly selected segments to be survey transects.

Based on the guidelines for number of transects (Table 1) and adjustments in the field (see *In-field Set Up* below), you will use only some of the potential transects that were preliminarily selected, starting with the first transect selected. Selecting five to seven potential transect locations in advance will allow you to adjust in the field, including discarding some transects to use alternates when you encounter unexpected circumstances that would make sampling an area problematic (e.g., appears regularly disturbed by vehicle or foot traffic, terrain or other conditions make it too difficult to access). However, a lack of blooming plants within a transect is NOT a reason to throw out transect locations to use alternates. Transects without blooming plants will help us determine when planting designs don't adequately and consistently provide relatively dense blooming plant cover in the seasons we are counting, just as having survey data with no bee detections is providing valuable information. However, establishing one or two additional transects elsewhere may be warranted if blooming plants are sparse or absent in the initial baseline transects.

#### Polygonal planting areas

If monitoring a polygonal planting area (e.g., a seeded wildflower plot) that is wider than five meters in its narrowest dimension, you will generate random transect locations by creating a grid overlaying the planting area. On a satellite image and/or a schematic drawing of your project area boundaries with an interpretable scale, draw a two-dimensional grid with gridlines approximately 30 meters apart along the longest dimension and between five to 30 meters apart along the narrower dimension (see Figure 2). Number the gridlines in each dimension as an x, y coordinate system. From that numbered grid system, randomly select a set of five to seven coordinates that will serve as the approximate starting point of each 30-meter x 1-meter transects.

Use an online random number generator or method to select numbers (e.g., [random.org](https://www.random.org)). If possible, orient all transects in the same direction so they are parallel to one another. However, orienting transects in different directions to fit them in the area is appropriate for smaller polygonal planting plots. Drop and select a new transect if a randomly generated coordinate is located where a transect has already been selected or if a transect cannot fit given the layout of the polygonal planting area. To help distribute the points throughout the planting area somewhat, we recommend not repeating the number selected from one dimension. If your planting area is only big enough to fit two or three transects, simply situate them where you can, as you will be sampling almost the entire planting regardless.



**Figure 2.** Example of how to identify count transects on a polygonal planting area. This example transect is 180-meters by 90-meters and has an x,y grid overlaid at 30-meter intervals. A random number generator selected grid intersections at (2,2), (4,3), and (5,2) and all transects extend northward to the next grid intersection.

### Reference transects

To determine transect locations in reference areas, consult with the restoration project manager or conduct a site visit to identify suitable reference areas and map their locations.

Reference sites:

- (1) should ideally be on the same property as the planted area (for practical purposes of not having to work with other landowners/managers),
- (2) should contain plant cover that is representative of or similar to what the planting area was before planting. If the planted area was previously bare soil, it should contain plant cover typical of unrestored but vegetated areas on the property (i.e., should not be in a crop field or over bare soil, but it is okay if the area doesn't contain plants blooming during count periods),
- (3) should be large enough in size to contain at least two and preferably three 30-meter x 1-meter transects,
- (4) should not be located directly adjacent to or near plots in restored sites. This reduces the likelihood that bee activity in reference transects is elevated due to spillover from nearby planting areas. The distance that bees may travel from their nests to forage varies widely by species. Usually, it is relative to their body size, where the smallest bees may only travel a few hundred meters, bumble bees may travel up to 1-2 km, and honeybees from 5-10 km (Mader et al. 2011). With this variability and the practical limitations of staying within a single property, this criterion should be applied flexibly. On smaller properties where suitable distant reference areas are not available, nearby reference sites may be used.
- (5) where possible, avoid areas that are intensively managed in ways that substantially reduce or eliminate flowering vegetation (e.g., frequent low mowing, repeated disking, heavy grazing, or broad-leaf herbicide application). If such conditions are present across the entire property and no alternative areas are available, these areas may still be used as reference sites.

Reference transects are recommended and are helpful for comparative analyses of habitats but are not required if reference criteria cannot be met. Once suitable reference areas are delineated, use the same randomization methods described above for planting areas to determine a random sample of five potential transect locations.

### ***Transect Naming Conventions***

Site-transect codes will follow the following naming convention:

(A four-letter combination that reflects the site name)–hyphen–(P or R for planting or reference area)(Numbers 1, 2, 3, 4, etc., consecutively)

For example, for a site in Yolo County called “Putah Creek Fishing Access” with 4 planted transects and 3 reference transects, the site-transect codes follow as:

PUFA-P1, PUFA-P2, PUFA-P3, PUFA-P4, PUFA-R1, PUFA-R2, PUFA-R3

## In-field Set Up

### ***Set-up Materials and Equipment List***

- Measuring tape (at least 30 meters)
- Rubber or metal mallet (for pounding in stakes)
- Wooden stakes, 3-5 ft long by ½-1¾ ” thick (for 2-3 years of study) OR rebar stakes, 3-5 ft. long (for >3 years of study) OR if stakes are hazards or ground difficult to drive stakes into, consider ground-marking fluorescent pink or white whiskers with 6” steel stakes.
- Orange fluorescent spray paint
- Permanent marker (e.g., Sharpie, to mark Site Code - Transect names on stakes)
- Project site data sheet
- GPS for marking transect start and end points (phone apps like Avenza, Gaia, and Google Maps, etc., should be fine)

### ***Transect Set-up and Site Data***

Because transects will be surveyed twice per year and potentially across multiple years, transect endpoints should be marked with stakes or other durable markers that remain in place for the duration of the monitoring period. This ensures that surveys are conducted at the same locations during each visit, allowing for consistent measurement of bee visitation and floral abundance over time.

For monitoring periods of ~ two to three years, 3-4 ft wooden stakes are generally sufficient to mark transect endpoints. For longer-term monitoring, more durable materials such as rebar or metal stakes are recommended. Because project sites may be actively managed (e.g. mowing, trimming, or other equipment use), markers should be made highly visible to reduce the risk of damage or safety hazards. Use fluorescent orange spray paint and bright flagging tape on the top of each stake to ensure visibility.

After mapping five to seven randomly selected potential transect locations for both planting and reference areas in the office (see ***Establishing Transects***, above), visit the site to set up transects. This is

best completed on a day prior to the first survey, as setup can be time-intensive and a full day is needed for bee counts. At each site, go to the mapped locations in the order they were randomly selected. Use a measuring tape to install two end stakes 30 meters apart. The end stakes will mark the centerline of a 1-meter-wide transect.

If a transect location is unsuitable (see *Establishing Transects*, above), discard it and move to the next location in the randomized selection order. After establishing the baseline number of transects and assessing plant composition for issues identified in Table 1, you may add one or two additional transects, not to exceed five transects for a planting area.

For linear plantings (e.g., single-row or multi-row hedgerows), center the 30-meter x 1-meter transect on the center of the planting. Where drip irrigation lines run along the centers of plantings, these lines can be used as the transect centerline (with 0.5 meters sampled on each side), particularly on recently planted sites with low-stature vegetation. In more mature plantings with tall, shrubby vegetation, shift the transects to a 1-meter-wide swath along the edge of the planting that captures their blooming stems. This adjustment improves visibility and ensures that bee observations can be made reliably from a standing position.

For polygonal or non-linear planting areas, locate and orient 30-meter x 1-meter transects as described in the *Establishing Transects* section (above). Transects do not need to align precisely with planted rows or individual plant locations.

### ***Project Site Datasheet***

Record project site information on a datasheet, once transects are set up in the field and prior to starting a bee survey. This datasheet can include information about the project location/address, bioregion, county, planting type, planting design description narrative, and a list of all transects and their GPS transect end locations (latitude, longitude or UTM). Ensure that the unique site-transect code (e.g., PUFA-P1, PUFA-R1) is the same as what will be entered on the bee survey datasheet so they can be linked in a relational database such as ArcGIS Field Maps or Microsoft Access. (See *Appendix B for example blank and filled-in data sheets*).

## Bee Survey Protocol

### ***Bee Survey Materials and Equipment List***

- Timer, stopwatch, or watch
- Clipboard
- Pens
- Protocol
- Landowner access permits (if required, e.g., state or municipal parks)
- Data sheets for bee surveys
- List of plants known to be planted or seeded, and their USDA code/symbol
- Bee morphogroup picture guide from the [CSPMG](#) (Ullmann et al. 2011)
- Small ruler with metric (cm and mm preferred, minimum of 15 cm length should suffice)

- ❑ Binoculars for bee ID after counts or during pauses (Close-focusing best, 8x also helpful). 1-3x reading glasses may also be helpful.
- ❑ Hand-held tally counters for bee counts or floral unit counts (optional)
- ❑ Hand-held anemometer to estimate wind speed (e.g., Kestrel wind meter) (optional)
- ❑ GPS for locating transects when necessary (phone or tablet apps may work)
- ❑ Camera or phone with camera
- ❑ Personal items for fieldwork: sunscreen, hat, water, snacks, electrolytes, first aid kit

### ***Timing, Frequency, and Duration of Surveys***

**Surveys should be conducted two times per site between May 1 and August 10**, with the second survey occurring at least two weeks after the first. For sites sampled in consecutive years, schedule surveys on similar dates to previous years ( $\pm$  1-2 weeks). These dates may need to be adjusted to match different climates and the phenological timing of blooms and bee flight seasons in a region. For sites in warmer and more arid climates, starting earlier (March or April) and completing surveys before the end of July is recommended. For northern California coastal sites, where wind and cool weather persist through the summer, extending surveys later into August is acceptable.

**Bee counts should be conducted between 10:00 AM and 4:00 PM, with the optimal window between noon and 4:00 PM.** In very hot locations where daytime high temperatures can exceed 102°F, start promptly at 10:00 AM and conclude counts by 1:00 or 2:00 PM to avoid exceeding the heat limit. If surveys for the planting and reference areas at a site cannot be completed in a single day and postponing is not possible, surveys may be split across two days (ideally consecutive days).

**Bee count duration is 7.5 minutes** for 30-meter transects. The timer may be paused as needed to allow time for identifying insects (e.g. bee, wasp, or fly) or assigning native bees to morphogroups. If no flowering plants are present within a transect, the survey may be concluded before the full count duration, as no bee visitation would be expected. For transects shorter than 30 meters, adjust the count duration proportionally (e.g. 20-meter transect = 5-minute count).

### ***Weather Conditions***

Bee counts should be conducted under warm, sunny, and calm conditions. Counts should only be conducted when air temperatures are between 60°F and 102°F, consistent with the SBMP and guidance from UC Davis and Xerces staff. Clear skies are preferred; however, counts may be conducted under partly cloudy or overcast conditions if you can still cast a shadow.

Wind conditions should be calm, with average speeds below 8 mph (Beaufort scale of  $\leq$  2). At consistently windy sites, use your best judgement to assess whether conditions are suitable for counts (bees at windy sites tend to remain active under windy conditions). During sporadic gusts at otherwise calm sites, it is acceptable to pause a count until a gust subsides. Conducting counts under suboptimal conditions may reduce bee activity and bias count results. Utilizing a handheld anemometer such as a Kestrel can help you estimate and record wind speed.

### **Collecting Bee Visitation Data by Plant Species**

Record bee visitation separately for **each plant species** blooming within the transect, including both native and introduced species, regardless of whether they were intentionally planted. For each species, count the number of native bees and honey bees visiting flowers. The datasheet is structured to record data on separate lines for each blooming plant species (see example data sheet in Appendix B). Before beginning the bee count, walk the full length of the transect and record all blooming plant species present. Do not include blooming grasses, as they are not likely to attract bees; however, blooming trees, shrubs, and herbaceous plants should be recorded. Record species using USDA plant codes where possible (USDA plant codes can be found using the [USDA Plant Database](https://plants.usda.gov): plants.usda.gov). If codes are unknown in the field, record common or scientific names and update to USDA codes later. If species-level identification is not possible, identify to genus and use the corresponding USDA code for that genus.

**Important:** Bee counts represent a three-dimensional sampling area. Include all bees visiting flowers within the 30 m length and 1 m wide transect, from ground level up to the height of the tallest blooming plant within the transect.

### **Bee Morphogroup Observations**

Most native bees (i.e., non-honey bees) are very difficult to identify to species in the field while visiting flowers. However, they can often be assigned to groups with shared morphological characteristics, referred to as morphogroups. While these groups do not perfectly correspond with taxonomical groupings, they can provide a practical way to estimate bee diversity and characterize which types of bees are visiting different plant species. Thus, record which native bee morphogroups are observed visiting each blooming plant species.

Each morphogroup should be recorded only once per plant species per survey, regardless of the number of individual bees observed. Morphogroups follow the definitions provided in the *California Pollinator Project's Citizen Scientist Pollinator Monitoring Guide* (CSPMG) developed by the Xerces Society and University of California at Berkeley (pgs. 20-31, Ullmann et al. 2011). The datasheet includes a field for each plant species where observers can record the corresponding two-letter morphogroup code:

**BM** - Bumble bees (Genus *Bombus*)

**LC** - Large carpenter bees

**HL** - Hairy leg bees

**GS** - Green sweat bees

**SS** - Striped sweat bees

**SD** - Small dark bees

**SH** - Striped hairy belly bees

**MH** - Metallic hairy belly bees

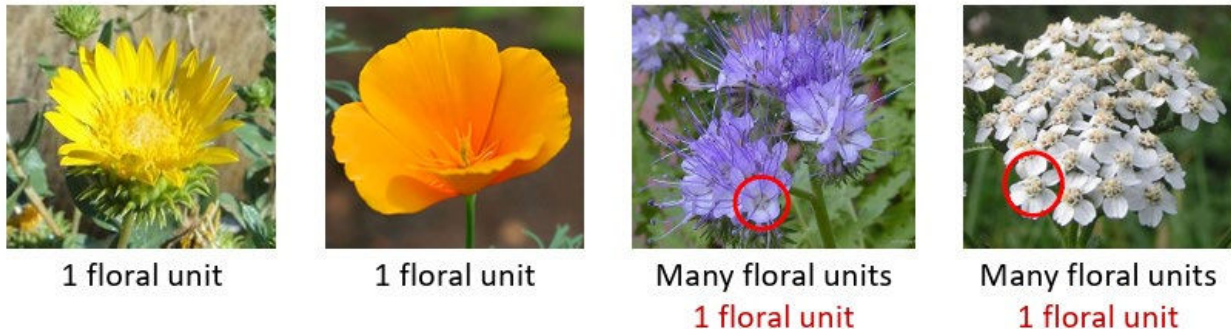
**CU** - Cuckoo bees

**OU** - Other that was undetermined or did not conform with other groups

### Floral Area Estimates

In addition to recording bee visitation by the plant species, this protocol quantifies the abundance of floral resources within each transect by estimating floral area for each blooming species at the time of the survey.

Floral area is calculated as: Floral area = number of floral units x average area per floral unit. A floral unit is defined as a single flower that is open and available to bees for pollen and nectar. For species in the *Asteraceae* family, the entire composite flower head (ray and disk flowers combined) is treated as a single floral unit (see Figure 3).

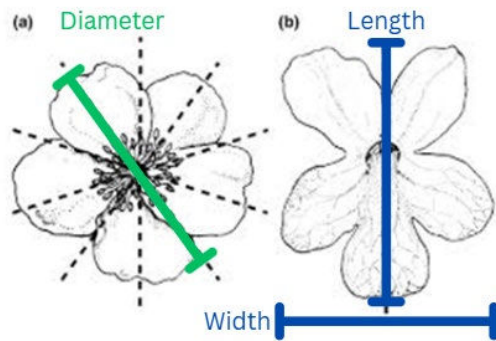


**Figure 3.** Examples of how to designate individual floral units.

Estimating and recording floral area follows a two-step process:

**Step 1:** After completing the bee count, walk the transect again to estimate the number of floral units for each blooming species within the sampled area. If blooms are sparse, tally floral units by species at the bottom of the datasheet as you move along the transect. When flowers are abundant, it is often more efficient to count one species at a time. Hand-held tally counters may be helpful. Estimating counts in grouped increments (e.g., 5s, 10s, or 100s) can improve efficiency and accuracy. For species with very small, densely clustered flowers (e.g., goldenrod, yarrow, buckwheat, elderberry), estimate the number of floral units within a representative area (e.g., 100 or 1,000 flowers) and then count how many such areas occur within the transect. Record the total estimated floral units for each species on the datasheet.

**Step 2:** After completing floral unit counts, estimate the average size of floral units for each species to the nearest tenth of a centimeter (e.g., 2.4 cm). Select at least five representative flowers that reflect the average size within the transect. Measure diameter for flowers with radial symmetry; or length and width for flowers with bilateral symmetry, using the widest dimensions on a one-dimensional plane (Figure 4). Record the average measurement(s) on the datasheet. These values will be used to calculate total floral area by species within each transect.



**Figure 4.** Radially symmetric flower (a) and bilaterally symmetric flower (b) adapted from Donoghue et al. (1998) and how to measure them.

In addition to estimating floral area, record any non-flowering plant species within the transect (excluding grasses). An exhaustive search is not required; include species observed during floral unit counts or during one additional walk of the transect. Record species using USDA plant codes where possible (USDA plant codes can be found using the [USDA Plant Database](#)). If codes are unknown in the field, record common or scientific names and update to USDA codes later. If species-level identification is not possible, identify to genus and use the corresponding USDA code. These data help characterize overall plant diversity and captures species present but not represented in bee visitation observations.

### Protocol Training

This survey method does not require a specialized degree or permit, but does require moderate knowledge development and observational practice for most observers, especially for insect and bee morphogroup identification and floral area estimation. Training and calibrating floral area estimation among observers prior to collecting data is highly recommended. Plant identification may also be an area where training is needed. Ideally, observers would receive a training that combines insect identification information on slides and photos with in-field identification practice in a location and time of year with diverse insect, bee, and plant communities. The training should also include floral area estimation methods with practice sessions on plants with a wide variety of flower inflorescence arrangements, shapes, and sizes. Contact the protocol authors for training resources and opportunities. The Xerces Society for Invertebrate Conservation periodically offers trainings on their *Streamlined Bee Monitoring Protocol*, which are valuable for learning to identify and count bee visitors and how to establish survey transects. For plant identification, local CA Native Plant Society chapters often hold plant walks and are available to assist with plant ID.

### Data Entry and Analysis

#### **Overview**

For pollinator habitat projects monitored by Point Blue Conservation Science, data are entered according to the two different data forms:

1. Site and transect information data form
2. Adapted Streamlined Bee Monitoring Protocol data form (i.e., bee and plant data)

### **Site Information Data Form**

Maintaining consistent and complete site information records is essential for revisiting sites across years and ensuring continuity despite staff turnover. Data from the site data form should be entered into one or more spreadsheets on either Excel or Google Sheets to record general site information and transect locations; a project manager should provide a link or file for inputting site data. If you need to create your own data table to house these data, the site information data field are listed below:

Site data fields (column headers): Observer, Visit Date, RCD Name (if applicable), County, Bioregion, Site Name, Site four-letter code, Landowner, Planting Type, Planting Design

Transect data fields: Site Name, Site four-letter Code, Transect Code, Start Latitude, Start Longitude, Stop Latitude, Stop Longitude

Site metadata fields: Site Name, Stakes/Markers/None, Description of Planting Site Location, Description of Reference Site Location, Where to Park

### **Adapted Streamlined Bee Monitoring Protocol Data Form**

For Point Blue projects, bee and plant data is entered into an ArcGIS Field Maps platform specifically developed for this program. Two forms are used in Field Maps: a **site conditions form**, which captures data from the top portion of the datasheet (Table 2), and a **plant and bee data form** for recording survey observations. Data collected in Field Maps can be exported as a .csv file for analysis. If the Point Blue Field Maps platform is not used, data may be entered into another platform or directly into a spreadsheet (e.g., Excel), with the following data fields found in Tables 2 and 3. To analyze data, create a unique site-transect-visit code to link the site conditions form and plant and bee data form.

**Table 2.** Data entry fields for the site conditions ArcGIS Field Maps form for a single bee monitoring transect visit. This can also be entered into a spreadsheet program.

<b>Data entry field</b>	<b>Data type (examples or comments)</b>
Monitoring Date	Date (MO-DAY-YEAR, e.g., 06-11-2025)
Observer Name	Text (first name, last name)
Project type or number	Text, numeric or alphanumeric code (optional)
Site four-letter code	Alphanumeric code unique to the site
Transect number	Alphanumeric (P1, P2, R1, R2, etc.)
Visit number	Numeric (1, 2, 3, etc.)
Start time	Numeric (24-hour clock)
Duration of the survey	Numeric (minutes)
Bioregion	Dropdown; applies to EPA bioregion categories
Transect length (m)	Numeric (m)
Type of planting	Dropdown (hedgerow, pollinator transplants, etc.)
Describe other planting type	Text (optional)
Site notes	Text (can pertain to access, changes from previous visit, etc.)
Plant species not in bloom	Alphanumeric (USDA codes)
Temperature (F)	Numeric (degrees Fahrenheit)
Skies	Dropdown (Clear, partly cloudy, bright overcast)
Windspeed	Numeric (mph utilizing anemometer)

**Table 3.** Data entry fields for the bee and plant ArcGIS Field Maps form for a single bee monitoring transect visit. This can also be entered into a spreadsheet program.

<b>Data entry field</b>	<b>Data type (examples or comments)</b>
Site four-letter code	Alphanumeric code unique to the site
Transect number	Alphanumeric (P1, P2, R1, R2, etc.)
Visit number	Numeric (1, 2, 3, etc.)
Plant species (in bloom)	USDA code
Floral units	Numeric
Floral symmetry	Dropdown (Radial or Bilateral)
Diameter (cm)	Numeric (cm, to the nearest tenth of cm, e.g., 1.4 cm)
Length (cm)	Numeric (cm, to the nearest tenth of a cm)
Width (cm)	Numeric (cm, to the nearest tenth of a cm)
Native bee total	Numeric
Honey bee total	Numeric
Cuckoo	Binary (0 – absent, 1 - present)
Metallic hairy belly	Binary (0 – absent, 1 - present)
Striped hairy belly	Binary (0 – absent, 1 - present)
Small dark bee	Binary (0 – absent, 1 - present)
Striped sweat bee	Binary (0 – absent, 1 - present)
Green sweat bee	Binary (0 – absent, 1 - present)
Hairy leg bee	Binary (0 – absent, 1 - present)
Large carpenter bee	Binary (0 – absent, 1 - present)
Bumble bee	Binary (0 – absent, 1 - present)
Other/unknown	Binary (0 – absent, 1 - present)

### ***Data Analysis***

The data collected can be used to look at bee floral preference. A description of the analysis, including the R code, will be published in a final report or manuscript. Please reach out to the authors of this protocol for more information. Native and honey bee data, as well as number of morphogroups can be summarized for each visit to determine seasonal and annual trends in bee numbers, as well as native and exotic plant visits. These can be summarized for a site or across sites within a particular bioregion. Appendix E includes an example of a data summary for a particular bee monitoring location.

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## APPENDICES

### Appendix A: Protocol Development and Rationale

**SBMP Foundation:** This protocol builds on and was adapted from the [Streamlined Bee Monitoring Protocol](#) (SBMP), developed by The Xerces Society for Invertebrate Conservation, University of California-Davis, Rutgers University, and Michigan State University (Ward et al. 2014). The **SBMP** was designed to provide a standardized, rigorous, yet efficient method for evaluating pollinator habitat plantings that allows for:

- (1) ranking pollinator plantings from least to most diverse in terms bee communities supported,
- (2) evaluating differences between planted and reference areas, and
- (3) assessing changes over time.

The SBMP sampling framework is based on a three-year field study in California, Michigan, and New Jersey that compared visual observations of bees on flowers with more intensive approaches such as netting and specimen identification. These studies showed that native bee abundance is correlated with native bee diversity, and that standardized visual surveys can provide reliable estimates of bee abundance and relative diversity, particularly when surveys are conducted during peak bloom and repeated once within a season (Ward et al. 2014).

The SBMP foundational research informed several core elements of our protocol, including:

- Timed visual surveys of bees visiting flowers
- Sampling during peak flowering periods\*
- Multiple site visits separated by two to three weeks
- Standardized survey duration and plot dimensions

\*The SBMP recommends (May-July), however this protocol allows for surveys to be conducted through August 10 due to our projects' geographic distribution of sites, which includes Northern California coastal sites that have bloom periods that extend later in the season.

Another core element of our protocol consistent with the SBMP approach is that we account for European honey bees (*Apis mellifera*) separately from native bees; the reason for this is that honey bee abundance is often influenced by the presence of nearby managed hives and therefore may not reflect habitat quality for supporting native bees.

**Rationale for Floral Resource and Plant Use Metrics:** While the SBMP quantifies bee visitation, it does not assess floral resource availability or plant species use within planting plots. These factors are important for understanding how restoration design (e.g., planting palette) influences pollinator response. To address this, this protocol incorporates floral area estimation methods established by Williams et al. (2015) and Lundin et al. (2018). These methods allow us to evaluate:

:

- Floral resource quantification: Floral area estimates provide a standardized measure of resource availability, enabling comparisons across sites, sampling periods, and planting designs.
- Plant-species-specific bee visitation: Recording visitation by plant species allows evaluation of which plants are most frequently used by bees, supporting improved seed mix design and restoration planning.

**Rationale for Bee Morphogroups:** Identifying bees to species in the field can be time consuming and impractical without specialized training and specimen collections. To address this limitation, we incorporated an approach described in the California Pollinator Project’s [Citizen Scientist Pollinator Monitoring Guide](#) (CSPMG; Ullmann et al. 2011), developed by the Xerces Society and University of California at Berkeley, in which bees are categorized according to morphogroups – categories of bees with shared morphological characteristics – as a proxy or index for bee species diversity. Although morphogroups do not replace species-level identification, they provide a useful intermediate level of resolution for comparing sites and evaluating restoration outcomes.

**Sampling Design for Monitoring at Pollinator Habitat Planting Sites:** Sampling design in this protocol was adapted to meet the needs of response monitoring across diverse habitat planting types associated with Point Blue Conservation Science’s Roots Program and the California Association of Resource Conservation Districts (CARCD) Wildlife and Pollinator Habitat block grants. Given the wide range of projects associated with these programs, key considerations included in our sampling design were:

- Flexible plot numbers to capture spatial variability in floral resources and bee activity
- Inclusion of reference sites (when feasible) to provide context for evaluating restoration effects
- The ability to complete sampling within time and weather constraints typical of field conditions

**Development and Refinement:** The additional components of this protocol were developed and refined over approximately six years of monitoring restoration sites in Yolo County, California. Field methods were iteratively adjusted to better address:

- The influence of plant species composition on bee visitation
- Relationships between floral abundance and bee activity
- Variation in native bee community composition across sites.

This iterative process helped ensure that the protocol yielded ecologically meaningful data while remaining practical for implementation by trained field crews.

**Appendix B: Blank Datasheet and example filled-in datasheet – see next page**

# Streamlined Bee Monitoring Protocol Data Sheet – Adapted for Roots and CARCD projects

Site 4-letter code--Transect No. \_\_\_\_\_ -- \_\_\_\_\_ Date: \_\_\_\_/\_\_\_\_/\_\_\_\_ Visit #: \_\_\_\_ of \_\_\_\_ Observer (F. Last): \_\_\_\_\_

Skies (circle): Clear / Partly Cloudy / Bright Overcast Temp (>60°, <103°): \_\_\_\_ °F Start Time (2400, no colon) – Duration (min) \_\_\_\_\_ -- \_\_\_\_\_

Type of Planting (circle): Woody Plants Only / Woody and Herbaceous Plants / Herbaceous Plants Only / Other (describe): \_\_\_\_\_ Transect Length: \_\_\_\_\_

Plants species in bloom USDA symbol <sup>1</sup>	Honey bee count		Native bee count		Morphogroups Codes <sup>2</sup>	Floral Units	Rad. (R) Bilat (B)	Diam <sup>3</sup> Length	Width <sup>3</sup>	Plants spp., no bloom (list), USDA symbol <sup>1</sup>
	Tally	Total	Tally	Total						
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										

<sup>1</sup> Enter USDA plant symbol/code for blooming and non-blooming plant species (see plants.usda.gov; e.g., *Eschscholzia californica* = ESCA2), or if unidentifiable, to genus (e.g., *Erodium* sp.=ERODI)  
<sup>2</sup> BM=bumble, LC=large carpenter, HL=hairy leg, GS=green sweat bee, SS=striped sweat bee, SD=small dark bee, SH=striped hairy belly, MH=metallic hairy belly, CU=cuckoo, OU=other/unknown  
<sup>3</sup> If radial symmetry, then Diam = Estimate of average diameter of floral units of this species inside the plot. If bilateral symmetry, then estimate of average Length and Width of floral units. All in centimeters, to the nearest tenth (e.g., 2.4, 0.3, or 3.7)

**Site notes (unique conditions, additional blooming plants, known honey bee boxes and distance, uncommon plants or plant codes, other floral visitors, etc.)**

# Streamlined Bee Monitoring Protocol Data Sheet – Adapted for Roots and CARCD projects

Site 4-letter code--Transect No. EXAM - P2 Date: 5/28/2026 Visit #: 1 of 2 Observer (F. Last): S. Noda

Skies (circle): Clear / Partly Cloudy / Bright Overcast Temp (>60°, <103°): 80 °F Start Time (2400, no colon) – Duration (min) 1215 - 7.5

Type of Planting (circle): Woody Plants Only / Woody and Herbaceous Plants / Herbaceous Plants Only / Other (describe): \_\_\_\_\_ Transect Length: 30

Plants species in bloom USDA symbol <sup>1</sup>	Honey bee count		Native bee count		Morphogroups Codes <sup>2</sup>	Floral Units	Rad. (R) Bilat (B)	Diam <sup>3</sup> Length	Width <sup>3</sup>	Plants spp., no bloom (list), USDA symbol <sup>1</sup>
	Tally	Total	Tally	Total						
1 GRCA		2	###	7	HL, SH, SD	170	R	2.2		HEAR5
2 VELA		1		4	SD, BM	320	B	0.2	0.2	FRCA12
3 CESO3	###	5		3	SH	70	R	1.2		MOVI2
4 ESCA2		0		3	SD	55	R	3.2		ERFA2
5 COARA		2		0	0	30	R	2.2		ACMI2
6										CEANO
7										
8										
9										
10										
11										
12										
13										
14										

<sup>1</sup> Enter USDA plant symbol/code for blooming and non-blooming plant species (see plants.usda.gov; e.g., *Eschscholzia californica* = ESCA2), or if unidentifiable, to genus (e.g., *Erodium* sp.=ERODI)

<sup>2</sup> BM=bumble, LC=large carpenter, HL=hairy leg, GS=green sweat bee, SS=striped sweat bee, SD=small dark bee, SH=striped hairy belly, MH=metallic hairy belly, CU=cuckoo, OU=other/unknown

<sup>3</sup> If radial symmetry, then Diam = Estimate of average diameter of floral units of this species inside the plot. If bilateral symmetry, then estimate of average Length and Width of floral units. All in centimeters, to the nearest tenth (e.g., 2.4, 0.3, or 3.7)

Site notes (unique conditions, additional blooming plants, known honey bee boxes and distance, uncommon plants or plant codes, other floral visitors, etc.)

Managed honey bee boxes ~500 meters away; wind BF 1



## Appendix D: Example Map of Transect Layout



Here is an aerial image of a hedgerow planting on a farm in the Central Valley. EXAM refers to the site code, P1, P2 and P3 refer to the three planting area transects. The orange line delineates the extent of a hypothetical 240-meter long hedgerow planting. Ticks along the line denote eight 30-meter transect options. The three red rectangles indicate the randomly selected segments for bee surveys, so each of these segments corresponds with a transect name.

## Appendix E. Bee Monitoring Site Summary Report

Insert report when this is completed or contact authors of the protocol.