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Standardized protocol for collecting community-level bee data

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Abstract. A key component of assessing bee biodiversity patterns and supporting bee conservation is documenting bee communities. When integrated with additional ecological data, community-level data help reveal the relative impact of local- and landscape-scale factors on bee taxa. As such, these data can inform management decisions to support bee diversity and mitigate environmental drivers of decline. However, methods for sampling bee communities vary greatly across projects, making it difficult to compare existing datasets or design new, interoperable studies. Here, we provide a standardized protocol for collecting community-level bee biodiversity data and offer guidance on inventorying, surveying, and monitoring of bee communities. We also present case studies to illustrate how different components of the protocol could be implemented. Although we discuss the benefits of collecting physical specimens, we emphasize the importance of responsible collecting and highlight key strategies to minimize environmental impact while maximizing the value of the work in new projects. This protocol is part of a series developed in association with the U.S. National Native Bee Monitoring Network to standardize bee monitoring practices.

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INTRODUCTION

As the desire to support pollinators (in particular wild bees) has increased across the globe, efforts have begun to focus on documenting trends in bee populations and how they change over time and across their range (LeBuhn *et al*., 2016; Woodard *et al*., 2020; Potts *et al*., 2021; UK Pollinator Monitoring Scheme 2024). In many cases, efforts to document these trends focus on gathering data on particular species that are likely vulnerable to environmental stressors, such as landscape-level modifications (*e.g*., Boone *et al*., 2023) and climate change (Weaver & Mallinger, 2022). There is, however, also a need to assess bee communities, emphasizing the entire assemblage of bee species present in an area, rather than a single species in all its areas.

Studying communities rather than single species shifts the focus to a more comprehensive understanding of bee biodiversity, including richness, relative abundances, species turnover (*e.g.*, beta-diversity), and diversity trends across space and time (Winfree *et al*., 2018; Kammerer *et al*., 2021). Community-level data also provide insights into potential interactions among bee species, such as the relationship between kleptoparasitic and overall bee diversity in a community (Sheffield *et al*., 2013). Comparing community metrics, such as species richness, evenness, and compositional similarity across sites, while accounting for environmental drivers can help address questions about community resilience. For example, how landscape change affects the similarity of bee species in communities in different areas (Harrison *et al*., 2018). Community-level data also inform management decisions aimed at preserving species richness or community structure rather than focusing solely on individual species. For instance, they can be used to compare bee community diversity between forest plots with moderate disturbance from prescribed burns or thinning versus unburned or unthinned plots (Davies *et al*., 2023; Gelles *et al*., 2023), or to examine whether an invasive plant species increases or decreases bee species richness (Tepedino *et al*., 2008). Community-level data are particularly important because diverse bee communities benefit crop and wild plant pollination and promote pollination service resilience in the face of environmental change (Hoehn *et al*., 2008; Oliver *et al*., 2015; Lemanski *et al*., 2022). Moreover, integrating community-level data with bee trait data (Ostwald *et al*., 2024), such as nesting substrate, body size, or trophic specialization, can help identify general patterns in bee responses (Williams *et al*., 2010). For example, determining whether large- or small-bodied bees are more susceptible to landscape change (Larsen *et al*., 2005) or which bees are more sensitive to agricultural land transformation based on their nesting requirements (Forrest *et al*., 2015). When conducted effectively, community-level data collection can also provide valuable insights for studying single species.

Community-level bee data have been collected using a wide range of protocols and strategies (Westphal *et al*., 2008; Klaus *et al*., 2024) that vary in sampling effort and method as well as recorded and reported metadata. These differences can have significant consequences for the data generated (Levenson *et al*., 2024a) and can also make it difficult for those less experienced in bee community sampling to know how best to design their sampling plan. This lack of a unified protocol increases the barrier to entry by new researchers exploring bee communities. Thus, to promote a foundation for uniformity in bee community data collection, encourage greater participation in such efforts, and increase data interoperability, we provide a protocol for gathering standardized data that can be used for synthetic assessments of wild bee communities. Although this protocol provides useful guidance for sampling design, certain aspects of a project's sampling framework will necessarily be dictated by each project's unique question(s) and goal(s); thus, it is crucial to define these prior to data collection. In this protocol we provide guidance for three data collecting strategies, which require differing levels of effort: *inventory*, *survey*, and *monitoring* (Table 1). We summarize the data to be recorded (Table 2) and the necessary protocol components to meet the *core*, *recommended*, and *optional* practices of the protocol (Table 1, Table S1). We also provide detailed examples of how each strategy

could be implemented in Case Studies I–III, below. Although the guidelines outlined in this protocol are intended to be embedded within a broader sampling framework, they can also be used to collect data for independent projects, assuming data reporting standards are met (Du Clos *et al*., 2024a).

Table 1. This protocol is part of a series developed in association with the U.S. National Native Bee Monitoring Network to standardize bee monitoring practices. These protocols include three components of data (Core, Recommended, and Optional), which are outlined for three strategies of data collection (Inventory, Survey, and Monitoring). Details in Levenson *et al*. (2024a).

Components of Data Collection		
Core	*Recommended*	*Optional*
Practices that are essential for achieving one's objective(s) and need to be used to meet the purpose of the protocol	Practices that are extremely beneficial, but not essential, to the specific objective(s) of the protocol	Practices that can be followed and may be worth the additional effort required, depending on one's objective(s)
Strategies of Data Collection		
Inventory	*Survey*	*Monitoring*
An attempt to build a species list for an area, not standardized for space or time	An attempt to record data of an area, standardized over space and/or time	An attempt to record changes in community measures over time, employing a consistent and repeated protocol, standardized over space and time

Table 2. Core data fields to be recorded when implementing the community-level protocol to adhere to *The Wild Bee Data Standard* (Du Clos *et al*., 2024a).

***Core* Data field**	**Description**	**Darwin Core Term**
Protocol used	Cite this protocol and any additional protocol(s) used	dwc:samplingProtocol
Latitude	Precise location where sampling occurred, reported in decimal degrees (see dwc:geodeticDatum for recommended spatial reference system). Use the geographic center of the sampling location	dwc:decimalLatitude
Longitude	Precise location where sampling occurred, reported in decimal degrees. Use the geographic center of the sampling location	dwc:decimalLongitude
Area of sampling	Size of plot or length of transect used (in metric units). Specify whether a transect or a plot was used for netting or bowl traps	dwc:samplingEffort
Length of time traps were deployed	Start and end date and time (*e.g.*, 9:00–16:00h), and duration traps were deployed (*e.g.*, 6h)	dwc:eventTime, dwc:samplingEffort
Number of traps successfully collected	Number of traps successfully collected (*i.e.*, bowls that were not knocked over, damaged, missing, or devoid of liquid)	dwc:sampleSizeValue, dwc:sampleSizeUnit
Length of time spent netting	Start and end date and time (*e.g.*, 11:00– 12:00h), duration of netting (*e.g.*, 1h)	dwc:eventTime, dwc:samplingEffort
Number of net collectors	Number of people who collected bees by net during a sampling event (optimally record collectors' collections separately)	dwc:sampleSizeValue, dwc:sampleSizeUnit
Details of sampling event	Additional context regarding sampling event, including but not limited to weather and field conditions, additional bowl trap details, and field notes	dwc:eventRemarks

PROTOCOL SAMPLING METHODS

Throughout this protocol, we provide guidance on two of many possible sampling methods: sampling bees passively using bowl traps with soapy water, referred to as bowl traps, and actively using handheld nets. We focus on these two sampling methods as they are widely used to sample bee communities effectively (Packer & Darla-West, 2021) and require minimal supplies, making them most easily adopted in a wide variety of contexts. We combine both passive and active methods to capture a more complete representation of the bee community (Cane *et al*., 2000; Roulston *et al*., 2007; Wilson *et al*., 2008). All collection methods have inherent biases (Rhoades *et al*., 2017; Campbell *et al*., 2023; Mathis *et al*., 2024). In netting, factors such as collector experience, dexterity, and timing of sampling can impact sample collection and resulting community measures (Westphal *et al*., 2008; Levenson & Tarpy, 2023; Larson *et al*., 2024). Moreover, some bees are crepuscular, active at only short periods of the day, not easily recognized as bees (*e.g*., wasp-like *Nomada* Scopoli*, Hylaeus* Fabricius), or otherwise less likely to be collected by hand netting. Although the use of passive traps removes collector bias (Westphal *et al*., 2008; Wilson *et al*., 2008), it also introduces its own biases due to trap type (Westphal *et al*., 2008; Tronstad *et al*., 2022; Campbell *et al*., 2023) and size (Wilson *et al*., 2016; Gonzalez *et al*., 2020), surrounding habitat and bloom availability (Wilson *et al*., 2008; Rhoades *et al*., 2017; Kuhlman *et al*., 2021; Mathis *et al*., 2024), differential attractiveness among bee taxa (Wilson *et al*., 2008; O'Connor *et al*., 2019; Briggs *et al*., 2022; Campbell *et al*., 2023; Larson *et al*., 2024), and the overcollection of certain taxa (Gibbs *et al*., 2017). As such, when designing a sampling plan, one will need to balance the biases of different sampling methods with input costs and overall project goals (Schlesinger *et al*., 2023; Levenson *et al*., 2024b). It may be worth exploring some of the many other passive sampling techniques used for assessing bee communities that are not included here (see Packer & Darla-West, 2021; Table 3, Supplemental Material). When implementing lethal collections, other insects will also be collected, referred to as 'bycatch'. Preserving and properly processing this bycatch is part of responsible collecting (Trietsch & Deans, 2018), but can be time-intensive; therefore, a plan to manage bycatch should be developed prior to sample collection.

We do not provide information in our protocol for non-lethal, community-level data collection, although see Cariveau *et al.* (2024) for one possible image-based method. When the goal of a project is to assess bee communities, identification to species is required to describe the community as precisely as feasible. At present, without intimate prior knowledge of the local fauna, most bees in most parts of the world can only be reliably identified to species with physical specimens, which requires lethal collection. We advise using our lethal sampling protocol to develop the most comprehensive baseline information for determining future sampling, monitoring, or conservation action. Once baseline information is established with lethal methods, non-lethal methods (*e.g.*, DNA barcodes, high-quality reference photos, eDNA) can then be vetted for accuracy and explored for future data collection.

In sum, our suggested community-level sampling methods are designed to sample as much of the bee community as possible while providing relative abundance measures, with an eye towards not oversampling.

COMMUNITY-LEVEL BEE DATA PROTOCOL

SAMPLING SCHEME: A sampling site is defined here as the extent of the area in which sampling occurs, and may contain multiple plots, transects, and habitat types (see Cariveau *et al*., 2024 for more details). We provide two basic approaches for how community-level data are collected

Table 3. Summary of additional passive sampling techniques that are not included in this protocol. See Supplemental Material for details and references.

Method	Specific Uses	Reasons for exclusion from protocol
Glycol traps	Long-term deployment in remote, hot, dry, or low-resource environments	Specimens are harder to process; risk of losing unattended traps; risk of large sampling impact on insect assemblages
Blue vane traps	Passive trapping of larger-bodied bees. See glycol traps	Risk of overharvesting sensitive species, particularly bumble bees and bumble bee queens; indiscriminate sampling in areas with protected species or species of concern
Malaise or flight intercept traps	Non-attracting passive trap for intercepting bees in flight. See glycol traps	Do capture bees, but also capture large volumes of bycatch; more expensive per unit capture
Emergence traps	Passive trapping of ground-nesting bees from nest sites	Very low capture rates; only amenable to ground-nesting bees
Trap nests	Passive trapping of cavity-nesting bees. Examination of nest construction behavior and nest contents	Variable capture rates; only amenable to cavity-nesting bees

within a sampling site: along a belt transect or within a plot. A belt transect (hereafter referred to simply as a transect) is defined here as a sampling route. Transects may be along a straight line or in a meandering line (see Cariveau *et al.*, 2024 for more details). Transects can be sampled passively using bowl traps or actively using nets; we provide details of both approaches. With bowl traps, traps are placed linearly along the transect line. With nets, samples are collected within a standardized distance on either side of the transect line. Regardless of the specifics, all transects within a sampling site should fall within one habitat type. Sampling plots within sites are defined here as a sampling area of standard size that falls within one habitat type. Transects and plots, thus, both emphasize standardizing a unit of area within which samples are collected but differ in the spatial arrangement of data collection. Generally, transects allow for greater precision of the exact area sampled as they better confine the collector within the sampling site, whereas plots allow the collector freedom to cover areas within the sampling site that might be missed in a classic transect. Plots often result in higher documented bee richness (Nielsen *et al*., 2011) and they have been shown to better sample highly mobile organisms in some settings (Ambrose, 2002).

Establishing and sampling within at least one plot or transect, in each sampling site, is a *core* practice for *survey* and *monitoring*, but only a *recommended* practice for *inventory* where sampling may be done in undefined areas. To make *inventory* data more interoperable, however, it can be beneficial to more closely follow the *survey* or *monitoring* protocol practices. For transects, we *recommend* surveying within 1 m on all sides of the transect line during sampling. Surveying within a standardized area on all sides of the transect line allows for data to be matched reasonably to those collected using plots because the sampling area is known. Further, at distances beyond 1 m, small taxa will not be visible, which introduces sampling bias. Transects may be any length and can be tailored to the sampling site, but we *recommend* a minimum of 25 m for small plots and 200 m for large plots, unless otherwise limited by habitat area. Regardless of length, a *core* practice is reporting the length and width of the transect used and the time spent sampling. *The Very Handy Bee Manual* (A Collective, 2024) provides additional useful guidance on transect protocols. For plots, the size used should be standardized

across the project so that all plots used for a study are the same dimensions. We *recommend* picking a size that falls in one of two bins: small (ranging from 0.01–0.24 hectare, *e.g.*, 10 x 10 m to 49 x 49 m) or large (0.25–1.0 hectare, *e.g.*, 50 x 50 m to 100 x 100 m), as it is difficult to fully sample areas greater than 1 hectare with a single plot. In some environments, habitats may be organized linearly (*e.g.*, riverine), requiring elongation for a given size (*e.g.*, 50 x 200 m to match square 1 ha plots). Further, using these bins increases the interoperability of data across studies. Regardless of size, a *core* practice is measuring, recording, and reporting the exact plot area used. As an *optional* practice, GPS can be used to record the sampling area as well as the precise locations of the transects or sampling plots used.

A *core* practice of the protocol is that the entire plot or transect must not cross an ecotone (a transition area between two biological communities) and must be situated entirely within one habitat (*e.g.*, upland prairie, wet prairie, oak woodland, chaparral, riparian grassland, early succession old field, wet alpine meadow, aspen forest), which should be recorded. This is because habitat type can greatly influence the portion of the bee community that is sampled (Hung *et al*., 2017; Du Clos *et al*., 2020), which can bias results. Thus, if the sampling site contains multiple habitats, and the intent of the study is to capture data across multiple habitat types, then separate plots or transects would need to be established per habitat type.

The level of plot replication for *inventory* and *survey* will depend on project goals, which may require consideration of statistical power (LeBuhn *et al*., 2012; LeBuhn *et al*., 2016; Breeze *et al.*, 2020), although, in general, more locations sampled will increase the completeness of the species list. For *monitoring*, the number of sampled plots or transects, and the number of repeated sampling events, are important components of a statistically defensible monitoring scheme, both of which are heavily impacted by the goals of monitoring. Power analyses and other assessments, focused on determining the sampling structure that would be required to detect changes of a defined magnitude through time, need to be performed to identify the appropriate spatial and temporal extent of sampling (number of plots or transects and number of sampling events at those locations; LeBuhn *et al*., 2012; LeBuhn *et al*., 2016; Breeze *et al.*, 2020); too few samples, and statistically rigorous comparisons will not be possible. We recognize, however, that in many cases the data required to perform full power analyses may not be available; in these cases, it may be necessary to reevaluate and update sampling designs later, when more rigorous power analyses are possible.

Many studies of wild bee communities geographically distribute plots and transects to avoid sampling within the estimated flight distance of bee species or based on the spatial scale at which bee community turnover occurs, to achieve statistical independence of plots or transects. For flight distance, a separation of at least 2 km is considered sufficient to avoid encountering the same individual bees in different sites (Greenleaf *et al*., 2007). For community turnover, change in bee community composition has been demonstrated to occur both within and beyond 2 km (Messinger, 2006; Rollin *et al*., 2015; Dorchin *et al*., 2018; Reverté *et al*., 2019); furthermore, local- and landscape-level habitat characteristics can also influence patterns of species turnover (Rubene *et al*., 2015; Martins *et al*., 2017; Beduschi *et al*., 2018; Christman *et al*., 2022). Thus, the geographic distribution of plots and transects will depend on specific project question(s) and goal(s). For example, sampling at more sites spaced farther apart from each other would provide information on the bee community across ecoregions or land uses, whereas sampling more frequently at fewer sites spaced closer together would provide more information on temporal turnover of species and species interactions. We advise seeking guidance from experts for establishing criteria of spatial independence for each project's unique specifications prior to sampling.

Sampling frequency: Bee community composition significantly changes across the bee flight season (Leong *et al*. 2016; Hung *et al*. 2017; Neave *et al*., 2020; Turley *et al*., 2022; Levenson & Tarpy, 2023), so visiting the same site multiple times during the season is important for documenting as much of the community present at a site as possible (Levenson *et al*., 2024b). For *inventory* and *survey*, the *core* practice is to conduct a single sampling event, but it is *recommended* that sites are visited multiple times across the season to account for phenological differences among bee species. For *inventory*, multiple sampling events in a season would be needed to generate a complete list of species in an area, whereas for *survey,* multiple sampling events may be important to gain a more comprehensive understanding of the bee community and how it changes across the season. For both *inventory* and *survey*, we *recommend* at a minimum of two sampling events that attempt to capture data at two distinct periods of time within the peak of the bee flight season (*i.e.*, while floral resources are available). More frequent sampling, however, such as every 2–3 weeks, will allow one to capture seasonal differences in the bee community. Note that site seasonality and species turnover through time may dictate the specific interval and number of sampling events that are needed to achieve a project's objective(s). Also note that in some parts of the world there are two discrete seasons; for example, in the southwestern US, one season is driven by winter precipitation and temperature, and the second the result of monsoons, with a midsummer hiatus in bloom. This should be considered when developing sampling plans in these areas.

For *monitoring*, the timescale over which sites are visited within each season and across years will depend on each project's goal(s) as these will be influenced by within-season dynamics, bee population dynamics, land use change, desired statistical rigor, and other variables (LeBuhn *et al*., 2012; Aldercotte *et al*., 2022), including available survey resources and costs (Breeze *et al*., 2020). Nevertheless, it is *recommended* that for *monitoring*, samples are collected during approximately the same time or part of the season each year.

Appropriate conditions for sampling: *Recommended* conditions for sampling bees are warm temperatures, clear skies, and no or minimal winds (Beneder, 1976; Kevan & Baker, 1983; Vicens & Bosch, 2000; Abrol, 2006; also see Mahon & Hodge, 2022), although this is not always achievable in certain environments or conditions (*e.g.*, coastal, alpine, prairie, desert, Arctic, early spring). Recording these elements at each collecting event is a *core* practice of the protocol as it provides users of the data the ability to evaluate what data to use. In general, we advise sampling when temperatures are above 50° F (10° C) or below 110° F (~43° C), with minimal cloud cover (no more than lightly overcast), and low winds (no more than a 3 on the Beaufort scale or 12 kph). We do not advise sampling if precipitation is occurring (or expected to occur while bowl traps are deployed) or when air quality (*e.g.*, smoke haze) causes conditions similar to extensive cloud cover.

Sample collection: We *recommend* two methods of lethally sampling bees: bowl traps and net collecting. For guidance on supplies and preparation of sampling materials, including the preparation of bowl traps, *The Very Handy Bee Manual* (A Collective, 2024), Packer & Darla-West (2021), and LeBuhn *et al*. (2016) provide relevant information. Prior to sample collection, a plan should be made for how samples will be processed after collection; see Table 4 and *The Very Handy Bee Manual* (A Collective, 2024) for guidance. For *inventory*, which is not necessarily standardized, the following methods do not need to be adhered to in such detail, but we *recommend* deploying all three bowl colors to maximize species richness captured.

Table 4. Additional, *optional* practices to consider when developing a sampling design, beyond what is outlined in this protocol. While each of these practices can provide valuable data, they also require additional time and resources. It is important to balance data collection with logistical constraints for each project.

Additional Practice	Considerations
Site documentation	Photographing the sampling site and bowl trap arrangement can aid future reference. Plan where and how photos will be stored for usability
Plant-pollinator interactions	While the protocol separates netted samples by plot or transect, further separation by host plant provides insight into bee ecology and plant-pollinator networks. However, this increases specimen handling time. See Cariveau *et al*. (2024) for guidance
Incrementation of collection time	For finer-scale sampling effort calculations, netting duration can be recorded in smaller increments (*e.g*., 10- or 15-min bins), pausing the timer during specimen handling. This increases processing time and requires more collection containers
Recording and reporting bowl trap details	Optional bowl trap details, such as deployment height, arrangement, size, color, and liquid medium, help assess potential biases but add to data management
Sample storage	Storage conditions in the field and during transport can affect specimens' suitability for molecular, parasite, and pathogen analyses (see López-Uribe *et al*., 2024, and Strange *et al*., 2024)

For *survey* and *monitoring*, we *recommend* that bowl traps be deployed along transects that form a single line (Fig. 1). For plots, bowls may be deployed in two lines, crossing the plot in an "X". Although it is more time consuming to deploy and retrieve traps in an "X" configuration, this is one reasonable way to deploy 30 traps in a one-hectare plot, using appropriate spacing; other configurations, such as a "Z" could also be used. We *recommend* placing bowls five meters apart, alternating among fluorescent blue, fluorescent yellow, and white bowls (Droege *et al*., 2010). The number of bowls deployed will vary based on plot size and project goal(s). A *core* practice of the protocol is that an equal number of each color is deployed with a minimum of nine bowls (3 bowls per color) used per plot or transect; this will aid in making data comparable to other studies. We note, however, that nine bowls is likely an insufficient number to estimate the bee community in many habitat types and plot sizes; thus, many data collectors will use a greater number than this. We *recommend* deploying a maximum of 30 bowls (10 of each color), when sampling plot or transect area allows, as Shapiro *et al*. (2014) estimate that this number adequately samples most communities while maximizing sampling efficiency.

Placing bowl traps on the ground is logistically easiest and most effective in open areas. If vegetation is thick or tall, however, it may be best to elevate bowls to the top of vegetation. To maximize bowl trap effectiveness, we advise placing the bowls so that they are just above the densest part of the vegetation, not towering over the sparser upper vegetation. In general, bowls should not be placed under brush or in significant shade, but rather in open areas where they can be easily detected by bees and seen by data collectors. Spacing bowls apart (versus clustering them together) maximizes bee capture (Droege *et al*., 2010). In some conditions (*e.g*., when vegetation is tall and bowls are elevated), clustering bowls together may make them easier to deploy and retrieve, but we *recommend* not clustering bowls whenever possible. For examples of implementing bowl traps, see LeBuhn *et al*. (2003), Wilson *et al*. (2008), and Meiners *et al*. (2019).

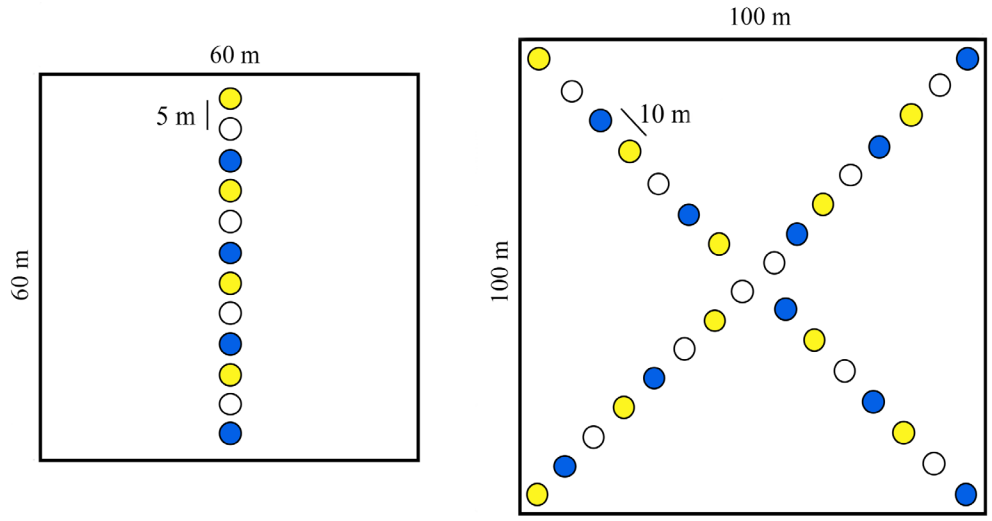

Figure 1. Possible layouts of bee bowls include a transect of 12 traps in a small plot (left) and a "X" configuration of 30 traps in a large plot (right). These are just two examples of how bee bowls can be arranged for sampling. Diagrams are not to scale.

The data to be recorded when using bowls traps to meet the *core* practices of *survey* and *monitoring* include latitude, longitude, plot size, the starting and finishing times that bowls are deployed (see below), and the number of bowls successfully retrieved (*i.e.*, bowls that were not knocked over, damaged, missing, or devoid of liquid). The latter includes bowls that did not collect any bees; the null data from bowls that were successfully retrieved but did not contain any bees are important for calculating sampling effort. Recording of these data fields is *recommended* for *inventory* as recording measures of effort greatly improves the usefulness of the data.

Active netting is inherently less standardized than deploying bowl traps because sample collection is heavily impacted by the skill and approach of the individual collector. Differences among collectors, however, can be measured and considered in data analysis if enough intra- and inter-individual replication has occurred (Cane *et al*., 2006). Netting at small sites can be conducted by a single collector, whereas netting at larger sites may require multiple collectors to ensure a more complete sampling of the community during an allotted period of time. When netting in a plot, we *recommend* searching for and collecting bees foraging on flowers (*i.e.*, targeted netting) along a meandering path throughout the plot boundaries. When netting along a transect, cover its entire length during the time period. Note that although most bees might be collected from flowers, bees can also be collected from the air and on the ground; these often include kleptoparasites and males. It is a *core* practice that all bees, of any species unless protected, be collected through targeted active netting (not 'sweep' netting) during a sampling event (regardless of whether they are observed on flowers or not) to avoid biased data. This includes honey bees. Although honey bees are feral or managed (not wild) in North America, they are frequently encountered in many regions and habitat types and can influence wild bee community composition (Mallinger *et al*., 2017; Page & Williams, 2023). Another *core* practice for *survey* and *monitoring*, and a *recommendation* for *inventory*, is to document sampling events when no bees are collected. These negative data are important for quantifying effort and can provide critical information for conservation decisions. When netting, documenting the number of collectors and the time spent sampling is a *core* practice of *survey* and *monitoring*.

For *inventory*, netting can be done opportunistically and haphazardly rather than being constrained within plots. Even though an *inventory* is not necessarily standardized for space and time, it is still important to collect relevant metadata, including location data.

TIMING AND DURATION OF SAMPLING EVENT: Regardless of whether using passive traps or active netting, we advise collecting samples between 09:00–16:00 h (Vicens & Bosch, 2000) unless the specific habitat being sampled or project goal(s) require sampling outside of this time frame. Most bees are active during this period of the day; however, there are bee species that only forage at specific times of day–*e.g.*, matinal, crepuscular, xeric species–and may require different sampling timeframes. If project logistics allow, there are advantages to sampling a site in both morning and afternoon; this increases the likelihood of collecting species that are active at different times of the day.

For passive sampling, we *recommend* deploying traps for a minimum of 6 h (during peak bee flight activity) and a maximum of 24 h. For active netting, a *core* practice of the protocol is to sample a plot or transect for a minimum of 10 min; however, sampling time can be any length beyond this, especially when sampling in larger sized plots or transects. Regardless of how long each timed sampling event is determined to last, the entire plot or transect should be covered within that time period. To ensure that an entire plot is sampled, more than one transect may be needed; pace may vary depending on location and density of blooming plants. When a bee is successfully netted, the collector should immediately pause the timer, then transfer the bee into a collecting vessel. When the specimen has been securely transferred and appropriately labeled, resume timing and continue netting, starting and stopping the timer to process additional bees as they are collected. In some situations, multiple bees may be netted at once; if project goals allow, these can be collected into the same container.

For *survey* and *monitoring*, a *core* practice of the protocol (whether using passive or active sampling) is to record start and stop time so that sampling effort can be calculated. For passive traps, this would equate to the times that traps are deployed and retrieved, whereas for netting, this refers to the start and stop times for netting (including stopping of the timer during field specimen processing). For *inventory*, recording time is not a *core* practice of the protocol, but is still *recommended*.

DATA RECORDING: An important aspect of standardizing data collection is properly recording data. We provide descriptions of data fields to record and report when using this protocol in Table 2, which align with *The Wild Bee Data Standard* (Du Clos *et al*., 2024a; this issue). *The Wild Bee Data Standard* uses Darwin Core terms (Wieczorek *et al*., 2012) and describes their application to wild bee occurrence data. Darwin Core is a widely accepted biodiversity data standard used by leading biodiversity data providers, including the Global Biodiversity Information Facility (GBIF; https://www.gbif.org/), Integrated Digitized Biocollections (iDigBio; https://www.idigbio.org/portal/search), and iNaturalist (https://www.inaturalist.org/). Applying Darwin Core terms to wild bee occurrence data following *The Wild Bee Data Standard* increases interoperability of data across studies. Follow the case studies, below, and *The Wild Bee Data Standard* for guidance on full data reporting requirements. Additionally, examples of recorded data associated with the collecting events for each case study presented below can be found in worksheet and workbook templates provided with *The Wild Bee Data Standard* (Du Clos *et al.*, 2024b). Although we outline the *core* data requirements in Table 2, one should consider documenting data beyond what is outlined in this protocol if capacity allows (examples in Table 4).

EXAMPLES OF IMPLEMENTING COMMUNITY-LEVEL PROTOCOL

Case Study I. Bee Inventory for Conservation

A land conservancy group is interested in identifying what bee species occur on their properties, with the future goal of documenting the impacts that their land conservation efforts have on wild bee communities to inform future conservation decisions. To begin with the foundational step of discovering the bee species on their properties, the group would like to implement a single-year *inventory* of the wild bee species.

Before the *inventory* begins, an identification expert who will identify bee specimens is contacted and compensation is agreed upon for the work. Supplies are prepared based on the number of sites that will be visited in a day. Permitting and permissions are established, data worksheets are prepared, and sites for collection are decided upon and visited. A plan for bycatch is put in place: a local institution that specializes in outdoor education will use them for teaching.

The group will visit 25 sample sites at various dates across one year. Sites are selected to include as many habitats as possible to capture bees that may be habitat specialists, and areas with high floral abundance and diversity as these areas are expected to have high bee diversity. Each site will be in a distinct habitat so that bees collected in one place can be associated with that habitat. Tangentially, they will also pick sites that show contrasting management efforts, because these data may help determine what questions they want to try to answer with their future *survey* and *monitoring* efforts. Given that their immediate goal is to complete an *inventory*, rather than a more standardized *survey* or *monitoring* effort, selecting sites that will yield them the most bee occurrence data is the optimal approach. They will collect haphazardly and opportunistically, rather than setting up plots or transects.

The group wants their sampling effort to cover as much of the bloom period as possible in the area and have the capacity to sample monthly. They will sample once per month for the eight months during which most flowering plant species are blooming. They will use both bowl traps and netting for sample collection. For bowl traps they will set up 60-m transects at each site, which will include 12 bowl traps (4 each of white, yellow, and blue), placed in a line, spaced every five meters, in consecutive order to make it easier to find the traps (Fig. 1). The traps will be filled with soapy water and deployed for 7 h from 09:00 to 16:00 h.

The group will also have two collectors go to each site and net bees on the same day that bowl traps are out each month. On each of the eight visits, two collectors will wander for as long as scheduling allows, searching for areas with blooms or with bee nesting activity. Given that plants are important to this study, they will also record the plant on which each bee specimen is found.

The specimens collected from bowl traps are processed into storage containers (in this case WhirlPaks®) and stored in 95% EtOH (ethanol) (López-Uribe *et al.*, 2024). Netted specimens are euthanized in the field, also using ethanol. Because the collecting day is long, and there are 25 sites to visit each month, pinning is saved for one day out of each month. In the interim, netted bees are temporarily labeled with the date of collection, the site name, GPS coordinates, the hours during which collecting occurred, the collector's name, and the plant on which that container of bees was collected. Specimens from both collection methods are stored in a standard freezer (-10 to -20° C) until 'pinning days' occur. Specimens are pinned and labeled appropriately so that important information–such as date, coordinates, and name(s)–are recorded, but that anatomy can still be accessed for identification (see Burrows *et al.*, 2021;

A Collective, 2024; Du Clos *et al*., 2024a). After, all specimens will be sent to experts for identification and accession into a university insect museum collection.

The group follows *The Wild Bee Data Standard* (Du Clos *et al*., 2024a) and uses either the worksheet or workbook data template to organize their data (Du Clos *et al*., 2024b). In their template, each specimen collected is assigned a unique **dwc:occurrenceID** and the following information is provided for each specimen record, or row, in the digitized data: the date on which sampling took place (**dwc:eventDate**), the method used to capture the specimen (**dwc:samplingProtocol**), the location at which the specimen was found (**dwc:decimalLatitude**, **dwc:decimalLongitude**, **dwc:fieldNumber**), the full name of the person who collected the specimen (**dwc:recordedBy**), and the start and stop time of the sampling event in which the specimen was collected (**dwc:eventTime**). For specimens netted on a flower, the plant species is recorded (**dwc:associatedTaxa**); for those netted on the ground or in the air, this too is recorded (**dwc:occurrenceRemarks**). To fully document sampling effort, each specimen record will provide additional details about the sampling event in which the specimen was collected, including the length of the transect for bowl traps or plot size for active netting (**dwc:samplingEffort**), the number of bowls successfully retrieved or the number of net collectors (**dwc:sampleSizeValue** and **dwc:sampleSizeUnit**), and the total duration of the sampling event (**dwc:samplingEffort**). Details of their bowl trap methods are provided, including the number of traps deployed, colors used, shape, height, and trap medium (**dwc:eventRemarks**). Finally, weather notes (**dwc:dynamicProperties**), habitat type (**dwc:habitat**), and accuracy of georeferenced site locations are provided (**dwc:coordinateUncertaintyInMeters**, **dwc:coordinatePrecision**). Example entries for this case study are provided in both the worksheet and workbook templates available for use through Zenodo (Du Clos *et al*., 2024b).

Case Study II. Surveying a Local Park

A researcher is interested in understanding how change in land use impacts the bee community in a local park. Several previous research projects have been conducted in the area and so they have some ideas of what species are present. It is not well understood, however, how different bee species within the community will respond to future, ongoing land use change. To understand the impacts on the bee community, the researcher would like to implement a *survey* of several sites along a nearby land use gradient.

The researcher will visit four replicates of three land use types for a total of 12 plots. At each plot, two one-hectare (100 m x 100 m), fixed sampling areas (one for each collector, see below) will be laid out, contained within a single habitat type, that best represents the land use change. Plots will be placed at least five kilometers apart. They will visit each plot at six different time points across three months of peak bee activity, sampling each plot at a regular two-week interval. Sampling will be repeated for these same plots across three consecutive years.

Before collecting begins, the researcher marks the corner of each sampling area with a GPS unit, as well as the center of the plot. They get permission from a local land-owner whose property must be crossed to get to one plot. Data fields to record are determined following guidance from *The Wild Bee Data Standard* (Du Clos *et al*., 2024a) and data sheets are prepared. A conversation is had with the in-house bee taxonomist or formally trained professional in bee identification to ensure time can be set aside to identify these specimens. No takers for bycatch can be found, and funding is not available to pin and label non-bee specimens. A plan is made to store the bycatch specimens in 95% EtOH (Marquina *et al.*, 2021; López-Uribe *et al.*, 2024)

with appropriate label information until an institution and funding are secured; while it may take time to find an institution and funding, having a developed plan for when this does occur is still important.

The researcher will use both bowl traps and netting for sample collection. Thirty bowl traps will be used in each plot (10 each of white, yellow, and blue). They will be placed in an "X" from corner to corner of the one-hectare plot, with 15 traps running along each leg of the "X" (Fig. 1). They will be spaced 10 m apart to span the corner-to-corner distance of the square. The vegetation is not very high, so the traps will be placed directly on the ground. The traps will be filled with soapy water and deployed for eight hours.

The researcher will have two collectors visit each plot to conduct netting on the same day that bowl traps are laid out. Each pair of collectors will sample one of the one-hectare sampling areas for 30 min, twice, for a total of 120 person-minutes of sampling per plot. Collectors will cover the entire sampling area during netting using meandering transects. As the researchers may consider using these specimens for genetic analyses in the future, both collectors wear a waist pack with a small ice pack in it. Each time a bee is netted, the timer is paused until the bee is collected into an individual tube; each tube is held in the waist pack, next to the ice pack to ensure that DNA quality is preserved and that the specimens are humanely handled during the field day. Although not essential to the study, the researcher opts to document the plants that the bees are found visiting as this supplemental information is potentially relevant to the land use types that are being documented. To do this, the researcher separates the tubed bees into Ziplock bags, one per plant species, and carries all Ziplock bags in the waist pack, next to the ice pack, for the duration of the sampling event. After collection is complete, the small plant-specific Ziplock bags are all placed in a large gallon zip-lock bag labeled with the site information, the date, the subplot, whether it was the first or second collection event, and the collector's name. Because the two sampling areas are relatively close together, netting for both will happen on the same day, and all plots can be covered in six field days.

The collectors transport the labeled bags from the field in a small cooler with ice, when back at the lab the specimens are placed at -20° C in a freezer until further processing. All specimens collected in the bowl traps are processed in the field, with bycatch separated from bees, moved into labeled containers filled with 95% EtOH, and transported back to the lab, also in the cooler, where they will be stored at -20° C in a freezer until further processing. Prior to pinning the specimens, the researcher removes a mesothoracic leg from each to preserve DNA for future use; these legs are held in cold storage following López-Uribe *et al*. (2024).

When ready to be pinned, each specimen will be given proper identification labels, including specimen numbers, so that the data can be added to the in-house lab collection and eventually added to public data aggregators, such as GBIF.

The researcher follows *The Wild Bee Data Standard* (Du Clos *et al*., 2024a) and uses either the worksheet or workbook data template to organize their data (Du Clos *et al.*, 2024b). In their template, each specimen collected is assigned a unique **dwc:occurrenceID** and the following information is provided for each specimen record, or row, in the digitized data: the corresponding specimen number from the identification label (**dwc:catalogNumber**), the taxonomic identification of the specimen (**dwc:genus**, **dwc:specificEpithet**, **dwc:scientificName**), the full name of the person who made the taxonomic identification (**dwc:identifiedBy**), the date on which that specimen was collected (**dwc:eventDate**), the method used to capture the specimen (**dwc:samplingProtocol**), the location at which the specimen was found (**dwc:decimalLatitude**, **dwc:decimalLongitude**, **dwc:fieldNumber**), the full name of the person who collected the specimen (**dwc:recordedBy**), the start and stop times of the sampling event in which the specimen was collected (**dwc:eventTime**), and the plant on which each netted specimen was collected (**dwc:associatedTaxa**). Specimen handling details, including field and lab storage on ice,

will also be provided (**dwc:preparations**, **dwc:materialEntityRemarks**). To fully document sampling effort, each specimen record will provide additional details about the sampling event in which the specimen was collected, including the size of the plot (**dwc:samplingEffort**), the number of bowl traps deployed (**dwc:eventRemarks**) and number successfully retrieved (**dwc:sampleSizeUnit**), and the total duration of the sampling event (**dwc:samplingEffort**). Further information is provided to describe sampling methods and conditions, including the land use type associated with each plot (**dwc:habitat**), weather notes (**dwc:dynamicProperties**) specifics about the bowl trap height and liquid medium (**dwc:eventRemarks**), and the GPS unit used to mark the plot center and corners (**dwc:georeferenceRemarks**). Example entries for this case study are provided in both the worksheet and workbook templates available for use through Zenodo (Du Clos *et al*., 2024b).

Case Study III. Monitoring Bees and Pesticide Use

A government agency needs information on the bee community within a specific state and how it might be impacted by a new pesticide, to inform new policy development. The agency decides to establish a *monitoring* program for the state, with funding secured for the next ten years.

As collecting long-term data could be used to address many future questions beyond the current focus, the agency wants to ensure they establish a robust sampling scheme that will collect high-quality, standardized data. To do this, the agency meets with a group of statisticians to decide where, when, and to what extent data will be collected to ensure they can detect what they consider meaningful changes through time. To address the current focus, their sampling framework also incorporates information about where the new pesticide will be deployed, allowing them to test hypotheses about how it will impact bee communities. They select 50 sites across the state that they will visit eight times each year, once per month. The sites are selected to represent a diversity of habitat types, focusing on those where policy may be most impactful. Sites are separated by statistically relevant distances and there are a range of sites with different pesticide schedules. In some sites, pesticide implementation is planned for the second and third years of the study, so an effort is being made to collect solid baseline data prior to pesticide use so that immediate and long-term effects can be assessed. Some sites will receive pesticide application annually, and others less frequently. A few sites have already received applications for many years prior to the beginning of this study.

Before bee sampling begins, permits are secured for bee collections happening in sites that are under special state and federal jurisdiction. Bycatch is to be housed in the land grant university of the state and funding is being secured to assess the impact of the pesticide on other insect groups collected during the bee surveys. A government employed bee taxonomist has agreed to identify bee specimens quickly to genus each year, and over the course of the ten-year project, will identify bees to species. The identified insects will be housed together at the government facility and given proper labels so that the data can be used for future, larger scale analyses that are combined with datasets from other states. All eight collectors who will be spending the season visiting sites will spend two weeks practicing bee collecting. This two-week training will involve learning to observe and sample bees on flowers or on the ground, recognizing different kinds of bees, and learning different netting techniques.

At each site, the plan is to use bowl traps and netting for sample collection. At each site, a 0.5-hectare plot is established for sampling. Since this plot is only 100 m from corner to corner, 18 bowl traps will be used (6 each of white, yellow, and blue), spaced 5 m apart, and deployed in an “X”. The traps will be deployed for 24 h, once per month, from March through October.

Teams of two collectors are employed for each quadrant of the state, with each team responsible for 12–13 of the collection sites.

Two collectors will conduct netting surveys when trap contents are collected, for efficiency. Each 0.5-hectare plot will be collected for 30 min by both collectors, for a total of 60 person-minutes of sampling per site per month. Even with two weeks of training, collectors are not fully trained melittologists, and so to ensure that the samples are as complete as possible, collectors are instructed to collect all "bee-like" insects actively visiting flowers, hovering in the air, or along the ground; by collecting all "bee-like" insects, the risk of missing unique or rare bees is reduced. Each collector will have a timer that starts at the beginning of netting but is stopped during specimen handling; this is especially important because new collectors take longer to process specimens, and also because all "bee-like" insects are being collected, which may slow down processing. Collectors net insects opportunistically within the plot.

Netted specimens are euthanized in soapy water due to limitations of ethanol accessibility while in the field (the use of soapy water is but one example of a collection method, see *The Very Handy Bee Manual* (A Collective, 2024) for other options; collectors should balance ease of collection with project goals when selecting collection methods). Specimens are stored in small sample vials with screw-on lids and detailed labels describing the date, collector, location, method, and time of collection. At the end of each day, the soapy water is drained from the vials and replaced with alcohol to prevent specimen rot. The collected specimens will not be pinned until the end of the season. With crews in four locations throughout the state, a central processing location is not feasible. All specimens, collected by both net and bowl trap, are stored locally in a freezer until they can be transferred to the government facility. In October, all specimens are relaxed and pinned and labeled for identification.

The agency follows *The Wild Bee Data Standard* (Du Clos *et al*., 2024a) and uses either the worksheet or workbook data template to organize their data (Du Clos *et al.*, 2024b). In their template, each specimen collected is assigned a unique **dwc:occurrenceID** and the following information is provided for each specimen record, or row, in the digitized data: the corresponding specimen number from the identification label (**dwc:catalogNumber**), the initial taxonomic identification of the specimen (**dwc:genus**), the full name of the person who made the taxonomic identification (**dwc:identifiedBy**), the date on which sampling took place (**dwc:eventDate**), the method used to capture each specimen (bowl trap or netting, **dwc:samplingProtocol**), the location at which each specimen was collected (**dwc:decimalLatitude**, **dwc:decimalLongitude**, **dwc:fieldNumber**), the full name of person who collected the specimen (**dwc:recordedBy**), the start and stop times of the sampling event in which the specimen was collected (for netting, **dwc:eventTime**; 24 hour bowl trap events are provided in **dwc:eventDate**). For specimens netted on a flower, the plant species is recorded (**dwc:associatedTaxa**); for those netted on the ground or in the air, this, too, is recorded (**dwc:occurrenceRemarks**). Specimen handling and storage details will also be provided (**dwc:materialEntityRemarks**). To fully document sampling effort, each specimen record will provide additional details about the sampling event in which the specimen was collected, including the size of the plot (**dwc:samplingEffort**), the number of bowl traps successfully retrieved (**dwc:sampleSizeValue**, **dwc:sampleSizeUnit**), the total duration of the sampling events (**dwc:samplingEffort**), and weather notes (**dwc:dynamicProperties**). Details about pesticide application schedules, bowl trap deployment, and collector experience are provided (**dwc:eventRemarks**) along with the habitat associated with each sampling location (**dwc:habitat**). Example entries for this case study are provided in both the worksheet and workbook templates available for use through Zenodo (Du Clos *et al.*, 2024b).

DISCUSSION

Our intention with this protocol is to provide the bee research, monitoring, and conservation community with standardized methods for collecting comprehensive bee community-level data, including data standards, that can be used for the *inventory*, *survey*, and *monitoring* of wild bee communities. Carrying out the protocol outlined here for community-level bee data has the potential to produce large, interoperable datasets that can be analyzed together to understand patterns in bee communities at scales far beyond individual projects or programs. To date, our ability to answer questions about bee communities and how they change over space and time has been severely hindered by a lack of historic data collected using statistically rigorous, standardized approaches. This has left our research community to find creative approaches to understanding bee community change (*e.g.*, Colla *et al*., 2012; Burkle *et al.*, 2013; Mathiasson & Rehan, 2019; Chesshire *et al*., 2023; Ruzi *et al*., 2023). Although these approaches have given us the only insights possible into historical change, they have taxonomic, spatial, or other limitations that ultimately undermine our ability to detect and understand true changes in bee communities as distinct from changes in recording effort over time (Bowler *et al.*, 2024). A standardized, reproducible, and widely-shared protocol will give us the ability, moving forward, to overcome many of the limitations that currently exist. Properly collected, identified, stored, and digitized specimens, with appropriately reported sampling effort and protocols, can be utilized repeatedly to answer future, unexpected research questions (Meineke *et al*., 2018; Vaudo *et al*., 2018; Nachman *et al*., 2023) with diverse foci. Moreover, with standardized data, collections from multiple years and sites will be interoperable, even if collection efforts change from year to year. There are precedents for research, monitoring, and conservation communities coming together to develop standardized practices for their mutual benefit. Projects such as the North American Bat Monitoring Program (NABat; Loeb *et al*., 2015; see https://www.nabatmonitoring.org/) show us what is possible for wild bee data, if improved collection and data standards are implemented.

Currently, our protocol only includes lethal methods for data collection as bee species identities must be known to understand community composition, enabling informed conservation decisions (Breeze *et al*., 2020), and because most bees can only be reliably identified to species using physical specimens under a microscope. We acknowledge that data can be collected for subsets of the entire bee community (*e.g.*, bumble bees) using non-lethal, catch-and-release methods; at present these methods cannot be deployed for projects attempting to capture data on entire bee communities. All indications are that, in the future, the bee research, monitoring, and conservation community will have more opportunities to use non-lethal methods to collect data on wild bees, such as using photos (Flaminio *et al*., 2021; Armistead, 2023; Schlesinger *et al*., 2023) and eDNA (Thomsen & Sigsgaard, 2019; Sickle *et al*., 2023) as evidence of occurrence. We welcome these approaches to minimize lethal collection, but note that at present, they are still undergoing the processes of thorough vetting, validation, and development for deployment at larger scales. Moreover, some of these methods may not ever provide abundance data, which are needed to estimate some of the key parameters of communities and may only be suited to sample a portion of the bee community (Turley *et al*., 2024). We also recognize the inestimable value of continuing to collect some physical specimens and properly stewarding them in natural history collections (Lane, 1996; Holmes *et al*., 2016; Hilton *et al*., 2021), as this provides a wealth of ecological and evolutionary information that cannot be retroactively obtained, if specimens are not collected.

In the meantime, as we move towards more non-lethal approaches, we need to ensure that collections are conducted mindfully to limit harm to the very organisms we hope to conserve (Fischer & Larson, 2019; Barrett *et al*., 2022). This includes using collection methods that

reduce the negative experiences of individual bees (Drinkwater *et al*., 2019; Gelperin, 2019) and minimize potential harm to bee populations. For the latter, it is important to fully articulate the goals of a project and optimize the sampling design to best meet those goals (LeBuhn *et al*., 2016; Schlesinger *et al*., 2023; Levenson *et al*., 2024b), while minimizing collection whenever possible (Drinkwater *et al*., 2019). Even when implementing this protocol, care will still need to be taken to minimize the multiple risks of lethal collection and difficulties of specimen stewardship, especially when moving toward the establishment of large-scale (*e.g.*, national) projects. Projects should estimate whether the scale of intended collection might have negative impacts on populations, although, in truth, this is challenging because we have so little information about how bee population sizes change through time (Williams *et al*., 2001; Aldercotte *et al*., 2022; but see Gezon *et al*., 2015) and what processes regulate wild bee population dynamics (Roulston & Goddell, 2011). We should also consider that as more bee species are protected under state and federal laws, certain sampling methods may become more restricted. Further, as population status can change rapidly, expeditious data access will be critical for conservation analyses and decision-making (Rousseau *et al*., 2024). Before a sampling plan is implemented, we advise reviewing the guidelines outlined in Drinkwater *et al*. (2019), Montgomery *et al*. (2021), and Trietsch & Deans (2018). As a summary of these guidelines, we suggest the following practices:

1. Select the sampling method and effort that will cause the least harm to bee populations, estimated to the researcher's best ability, while also collecting sufficient data to answer the project questions.
2. Review one's plan with experts in experimental design and statistics to confirm that the plan will address the project's needs.
3. Ensure the appropriate expertise is in place for identification of collected specimens, prior to initiating sample collection.
4. Properly store physical specimens, including labeling and depositing at an institution, to maximize the value of lethally-collected specimens.
5. Collect detailed data in association with physical specimens and deposit the data in an appropriate repository so that they may be used for future projects (see Du Clos *et al*., 2024a).
6. Make specimen-related data publicly available as soon as possible in light of institutional or other limitations.
7. Reduce bycatch of non-target species while sampling, properly preserve any collected bycatch, and arrange for these additional specimens to be provided to other researchers or maintain them securely for future use.

We would also add to this list that projects might consider involving volunteers in participatory science projects to engage and train the public, as this can generate support for bee conservation. Large-scale community-level monitoring programs can be designed to provide opportunities for public involvement in data collection (Best *et al*., 2022; Rondeau *et al*., 2023; Turley *et al*., 2024). These programs benefit all parties as they provide training to participants and result in large-scale datasets that would be otherwise unattainable due to labor and resource constraints.

As we navigate this time of unprecedented biodiversity loss (Ceballos *et al*., 2015) it is critical that we document bee communities in a standardized, interoperable manner. Whether a project's goal is to *inventory*, *survey*, or *monitor* bee communities, standardized data are incredibly valuable and support both our foundational understanding of bee communities and the conservation of wild bees and other insects. In the case of bee community monitoring, we hope to see a greater shift towards sampling designs that allow for hypothesis testing (Breeze

et al., 2020) and the establishment of explicit thresholds of community change (*e.g.*, percent reductions in species richness, evenness, functional group breadth) that would trigger specific conservation actions. This would also require projects or institutions (or their partners) to have the capacity to then take on those conservation actions through large-scale collaboration across the science-policy interface as well as effective dissemination of results and information to a wide range of stakeholders.

By using standardized protocols, as outlined here and in the other protocols included in this special issue, there will be the opportunity for the bee research community to come together on a scale not yet seen, so that we can better address current, pressing, and future needs for bee conservation.

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SUPPLEMENTAL MATERIAL

Table S1. Summary of the *core*, *recommended*, and *optional* practices for following the community-level bee data protocol, specifically regarding site set up and data recording.

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Journal of Melittology

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