

Demographic summary of attendees:

Table 1. Summary of invitees (n = 635) and attendees (n = 126) of the RCN workshop on existing bee monitoring efforts by location in USDA Farm Production Regions. Regions do not include Alaska, Hawaii, Canada, or International invitees/attendees.

	Invited	Attended
Northeast (MD, DE, DC, NJ, PA, NY, RI, CT, MA, VT, NH, ME)	145	24
Mountain West (MT, ID, WY, CO, NV, UT, AZ, NM)	122	23
Pacific West (WA, OR, CA)	83	18
Lake States (MN, WI, MI)	59	20
Corn Belt (IA, MO, IK, IN, OH)	58	8
Northern Plains (ND, SD, NE, KS)	30	8
Appalachia (KY, TN, WV, VA, NC)	39	10
Southern Plains (TX, OK)	18	2
Southeast (AL, GA, SC, FL)	18	1
Canada	23	8
Delta (AR, LA, MS)	10	0
International	15	0
Alaska	8	4
Hawaii	4	0
N/A	2	0

Table 2. Summary of invitees (n = 635) and attendees (n = 126) of the RCN workshop on existing bee monitoring efforts by employment sector.

	Invited	Attended
Academic	245	54
Federal	197	25
State	57	12
Extension	45	13
Nonprofit	39	13
Consultant	18	4
Tribal	15	1
Industry	11	2
County	4	0
Local	3	2
N/A	1	0

Interactive poll summary:

Poll question set 1: The first two multiple choice questions had follow up open ended questions to gather more context and nuanced thoughts.

What is the national capacity of the following groups to participate in native bee monitoring?

Of the five options presented, Cooperative Extension and academic collaborations ranked highest, with average rankings of 3.4 and 3.5, respectively, and a right-tailed skew. Government agencies also had an average ranking of 3.4; further, this rank was the center of a wide, even distribution. Nonprofit organizations and members of the public ranked 3.3 and 3.1, respectively, and both averages had a lower, left-tailed skew.

Could you share more on your thoughts?

Ninety participants shared short answers in response to this question. Themes among the answers included funding, taxonomic expertise, data sharing, and interdisciplinary collaboration. Securing funding for national, regional, or local-scale efforts is paramount to the success of any

group administering native bee monitoring projects. Specimens, photos, or observations collected through these projects need to be properly identified for the data to have value in any analyses or applications. The generated data should be easily accessible to any interested party. There were varying opinions on the leadership of the five groups. Multiple responses suggested that government agencies would be best, though others suggested these agencies are already overburdened and may not have the resources to lead monitoring efforts. Multiple responses denounced academic administration, owing to length of projects, reliance on peer-reviewed publications, and difficulty of data access. Establishing collaboration across these sectors was frequently recommended, perhaps to overcome any potential shortfalls of any one of these groups. The final frequent theme in these answers was the capacity of the public to participate in native bee monitoring. Though the public has high interest in native bees, there were concerns about data quality and adequate training for volunteers to conduct rigorous monitoring. Volunteer contributions to native bee monitoring can be rigorous and rewarding, though project leaders should be conscious of volunteer time. Encouraging participation from a diverse public was also suggested.

For those working in Extension, what is the primary way Extension could contribute to national native bee monitoring?

There were 37 participants who responded to this question, and they could select multiple answers. The most frequent answer was “to connect people to existing native bee monitoring efforts”, with 32 responses, followed closely by “to teach people about bees”, with 27 responses. Nineteen respondents were willing to implement ready-made monitoring projects, and just nine were willing to develop their own native bee survey. Lastly, there were two votes for “Other,” meaning the options presented were not the primary way Extension could contribute to national native bee monitoring.

For those who voted “other,” what are we missing?

As there were only two votes for “other,” we received just three suggestions here. The first was to centralize data and make it freely accessible. The second mentioned the variation in the capacity of Extension across states to administer or participate in native bee monitoring. Lastly, the third suggestion was to leverage public involvement to encourage policy makers to fund native bee monitoring projects.

Poll question set 2: This set of questions focused on incentives and barriers to participating in community science.

For those working in Extension, what incentives would encourage you to participate more in native bee monitoring?

There were 39 participants who responded to this question, and they could select multiple answers. The most frequent selection was “funds to support full-time employment,” with 27 responses, followed closely by a provided “protocol to include in your work plan,” with 24

responses. A request to collaborate on scholarship or authorship received 22 responses. Less frequently selected responses included “involvement from the beginning of a project” (13 responses) and “visible association with a university” (13 responses). Other incentives or no incentives received 4 and 5 responses, respectively.

What is the greatest barrier to you organizing a bee-focused community science project?

There were 71 participants who responded to this question, and they could select one answer. Time was the most common barrier, with 28 responses, followed by money (17 responses), infrastructure (14 responses), and guidance (5 responses). Seven participants responded that there was another barrier that was not listed.

Poll question set 3: This set of questions focused on Extension employees’ perspectives of bee monitoring in agricultural lands.

For those of you who work in crop systems, roughly how many of your stakeholders are interested in bee conservation?

There were 27 participants who responded to this question, and they could select one answer. Seventeen respondents indicated that some of their stakeholders would be interested in bee conservation. Five indicated most of their stakeholders would be interested in bee conservation, three indicated all of the stakeholders would be interested in bee conservation, and two indicated none of their stakeholders would be interested in bee conservation.

For those of you who work in crop systems, what do you perceive as the barriers to native bee monitoring on agricultural lands?

There were 33 participants who responded to this question, and they could select one answer. Short-term funding was the most frequent selection, with 18 responses, followed by lack of bee expertise (8 responses), unmotivated growers (4 responses), and lack of protocols (3 responses). No participants indicated there were no barriers to native bee monitoring on agricultural lands.

Poll question set 4: This question focused on data quality in community science.

Please share potential issues around data quality and native bee community science:

This question was presented as a word cloud. There were 90 participants who responded to this question, and they submitted 157 different answers. These were able to be sorted into 11 categories (Table 3).

Table 3. Categories of data quality issues workshop attendees associated with community science.

Category	Number of answers	Percent of total
Common species bias	4	2.5%
Data	6	3.8%
Effort	13	8.2%
Geographic bias	13	8.2%
ID	39	24.7%
Photos	15	9.5%
Plants	3	1.9%
Protocol	23	14.6%
Urban bias	9	5.7%
Volunteer quality	24	15.2%
Other	8	5.1%

Poll question set 5: This set of questions addressed taxonomic capacity associated with community science efforts.

For those working in Extension, does your program have the capacity and interest to support each bee monitoring tier below?

There were 40 participants who ranked three potential tiers from 0 (No) to 1 (Yes). All of the tiers skewed low: visual observation had an average of 0.4, photo vouchers had an average of 0.3, and specimen-based monitoring also had an average of 0.3. This indicates somewhat low support from Extension to participate in native bee monitoring.

If you have run or are running a bee monitoring project, have you experienced limitations in access to taxonomic expertise?

There were 50 participants who could answer Yes or No. There were 38 Yes responses and 12 No responses.

How have groups dealt with limited taxonomic expertise in community-based bee monitoring programs?

Thirty-six participants shared short answers in response to this question; these answers varied widely. Solutions included multiple online resources, such as iNaturalist and its expert community for taxonomic identification or self-instruction through DiscoverLife or the Bee ID seminars offered by the USGS/USFWS Bee Lab. Taxonomic training can also be provided to project participants, creating parataxonomists. Limiting the species or groups of species monitored relieves the taxonomic burden and was a frequent solution, as was identifying specimens to morphospecies level. Using photos submitted to iNaturalist or other platforms, such as Bumble Bee Watch, and relying on community identification online has also been done. Multiple answers indicated support for professional taxonomists, including writing their salary into grant proposals, establishing partnerships with them early on in a monitoring project, and advocating for their financial security. More long term options presented included storing specimens until suitable identifications could be made and building taxonomic capacity over time.

Synthesis of breakout group discussions:

Question 1: What incentives are there for getting Extension professionals and volunteers involved with native bee monitoring or what would incentivize you to work more with Extension?

Four incentives were frequently discussed: funding, public interest, partnerships, and regulation. Funding for Extension professionals working in native bee monitoring would support full-time employment for time spent on monitoring projects. Financial support is also necessary for taxonomic identification, specimen curation, and specimen storage. Greater public interest in bees has motivated Extension professionals to incorporate information on wild and managed bees into their educational programs. In adult education programs, growing concern from the public about honey bees and crop pollination have emerged as “gateways” to native bee education. Similarly, awareness of the Northern Giant Hornet has led members of the public to engage with Extension professionals; this is another potential gateway into native bee education. One frequent recommendation regarding adult education on native bees was to present materials in a relatable and relevant way to increase engagement and promote retention. Another suggestion was to provide standardized, implementable information and monitoring projects. Both of these can counter misinformation about native bees, honey bees, and the Northern Giant Hornet or other wasps. These ideas also apply to youth education programs. Cooperative Extension operates 4-H clubs nationwide, along with other educational programs on agriculture and gardening.

Master Gardener and Master Naturalist programs operated by Cooperative Extension are another means of disseminating science-based information on native bees. In some cases, these programs can implement rigorous native bee monitoring protocols. Attendees and presenters at this workshop spoke of two specific programs: first, the Master Mellitologist program administered through the Oregon State University Extension Service trains members of

the public to collect, curate, and identify native bee specimens. These monitoring efforts comprise the Oregon Bee Atlas, an effort launched in 2018 to document and catalog the native bee community across the state. The Pennsylvania Bee Monitoring Program, as of 2021, is training Master Gardeners to collect standardized data on native bee diversity and abundance, particularly in undersampled areas of the state. More generally, however, Master Gardener and Master Naturalist programs require annual education and service time to maintain certification. Workshop attendees frequently suggested that these hours could consist of learning, teaching, or conducting native bee monitoring protocols. Further, though, attendees strongly suggested that any time spent by Master Gardeners, Master Naturalists, or Master Mellitologists on native bee monitoring efforts should be acknowledged throughout the collection and curation process and in any output publications using collected data or developed protocols. Indeed, these acknowledgements give the participants more agency and involvement in the scientific process and may lead to greater volunteer retention over time. Specific means of acknowledgement suggested included sending reports to participants about the data as it is curated, cataloged, and analyzed and naming participants in publications, perhaps, in some cases, as co-authors.

The reliance on volunteers required for Cooperative Extension projects encounters difficulty based on the locations of both University-based or county offices and community members willing and able to volunteer their time and resources. Workshop attendees spoke of an urban/rural divide associated with Extension. County offices typically have a rural focus where there are smaller communities and often fewer volunteers. Populated urban areas, where it may be more likely to find volunteers, are not typically the focus of Extension work. Bridging this gap, perhaps through the work of University-based offices in more populated areas, could mitigate this issue. Additionally, there were reservations raised regarding data quality associated with volunteer monitoring. These can be addressed following other suggestions on developing easy to implement protocols and training volunteers extensively on monitoring methods.

While the vast volunteer network found through Cooperative Extension programs provides a means to conduct widespread native bee monitoring, Extension offices could not administer native bee monitoring on a national scale on their own. Strategic partnerships were frequently discussed at the workshop, particularly those related to specimen management. Whether collected through lethal catch or non-lethally through photos, specimens must be identified, and partnerships with taxonomists or parataxonomists could provide those services. Further, the data collected must be managed and stored, digitally or in collections, and ultimately analyzed to track trends in native bee populations. Partnering with entities who conduct this work or can aid in conducting this work, including universities, government agencies (federal, state, or local), and nonprofits or other non-government agencies, could contribute to the success of large-scale native bee monitoring projects. Additionally, working with partners to develop, test, and implement native bee monitoring protocols was discussed. Workshop attendees further suggested multiple best practices to establish these partnerships. First, engage early. Cooperative Extension personnel have wide-ranging work responsibilities and face frequent performance evaluations. Establishing a relationship with them early in a project planning process respects their time and expertise. Second, clear communication regarding the roles of Cooperative Extension personnel and volunteers and goals of the overall project was

suggested, again, out of respect for the time and effort requested from these partnerships. Lastly, Extension personnel are eager to collaborate and find new collaborators. Please do not hesitate to reach out to try and establish a partnership.

Regarding regulation, as with the conservation community, Extension personnel may not be able to engage in native bee monitoring activities if they operate in a state with no regulatory authority over insects. Working with state governments to get this regulation could address this.

Question 2: How can participation in native bee monitoring be included in Extension plans for your program evaluation?

Extension personnel may be more likely to engage with native bee monitoring efforts if they are presented or provided in ways that are easily accessible, implementable, and adaptable to various age groups. Examples suggested included templates for educational programs or simple protocols that can be quickly deployed. Further, incorporating templates or protocols for native bee monitoring into existing Extension programs, including Master Gardener, Master Naturalist, and 4-H may increase the likelihood of adoption. Attendees suggested creating consistent and repeatable native bee monitoring education and training programs in collaboration with Extension personnel to streamline and standardize program offerings and ultimately contribute to a national network of trained volunteer monitors who collect usable data. However, flexibility in such templates or protocols is required, as Extension programs have different focal areas. Some focus on unmanaged plants, restoration, and conservation, while others promote crop production and pollination. Extension programs serving urban areas could incorporate native bee monitoring to track garden performance over time, while those serving rural, crop-focused areas could incorporate native bee monitoring into other insect monitoring efforts. Extension infrastructure and capacity also varies by state. Possible evaluation metrics specific to native bee monitoring program performance were suggested by workshop attendees, including number of bee observations, hours of involvement, and participant knowledge gain. These metrics could also be used to assess the effectiveness of coordinators and collaborators administering the program.

Question 3: What aspects of native bee monitoring have worked well for you?

Workshop attendees from Extension programs that have administered native bee monitoring work shared that they have found greater success when partnering with other institutions, particularly when they gain institutional support for identifying collected specimens or photos. Partnering across sectors with government agencies or nonprofit organizations was also mentioned as benefitting Extension-based native bee monitoring programs. Engaging with the public was also mentioned as a successful component of Extension-based native bee monitoring, and multiple best practices were provided. For example, promoting active and continued engagement can be accomplished by connecting volunteers to each other, perhaps by having returning volunteers serve as mentors to new volunteers. For coordinators of these projects, it was suggested to be excited to foster cross-volunteer connections, as this encourages self-sufficiency. Ultimately, these practices promote volunteer engagement.

Volunteers can be further motivated to continue participating in native bee monitoring if they are providing—and know they are providing—a meaningful contribution to conservation. A specific example here are the Master Mellitologists that contribute to the Oregon Bee Atlas. Master Gardeners can also be successful at native bee monitoring; the Pennsylvania Bee Monitoring Program uses Master Gardeners to conduct rigorous, standardized native bee monitoring surveys across the state.

There are a number of easily accessible educational resources and protocols currently available to those interested in native bee monitoring owing to the popularity of native bees. Identification resources for public use, including DiscoverLife, the USGS/USFWS Bee ID seminars, iNaturalist, and the virtual short courses offered by The Ohio State University Extension office, have made native bee taxonomy more accessible. Specifically, bumble bees were discussed as an approachable, introductory group of species.

Methods for volunteer based native bee monitoring were frequently discussed at the workshop, though the suggestions varied widely. One consistent suggestion was to have tiers of participation to provide flexibility for volunteers with varying levels of experience, interest, and capacity. Using existing infrastructure or methods, including iNaturalist or the BioBlitz, was suggested to simplify implementation for volunteers. There were many suggestions on specific methods: some found pan traps and lethal catch successful, others preferred implementing existing protocols that use photos instead of specimens. Some suggested coarser monitoring protocols to reduce taxonomic requirements while still gathering useful information, including general abundance of native bees. Visual observation methods were suggested to educate and engage the volunteers conducting the monitoring. Observing the bees in the field could allow additional information to be collected, including interactions with flowers and foraging behavior.

Question 4: What barriers are there to Extension participation or collaboration in native bee monitoring programs?

Partnerships were discussed at length throughout this workshop as a means to create effective, engaging volunteer-driven native bee monitoring programs; however, establishing these partnerships was the most common barrier to achieving this goal. Cooperative Extension generally operates at the county level, and there were concerns from Extension personnel about finding local partners. Many offices are in rural areas. Distance between potentially cooperating institutions or organizations was cited as a barrier to partnerships, as was unreliable location and operation of Extension offices and potential cooperators. Access to transportation across these distances may be difficult to obtain for some. Further, cultural differences between urban and rural areas may prevent the successful establishment of partnerships for native bee monitoring. Programmatic differences are also common. Extension offices may focus on honey bees instead of native bees or on crop land instead of wild land. These priorities may be determined at the state or federal level and then implemented at the county level. Extension agents operate following this regulatory guidance and may not have the flexibility to modify their priorities. Another contributing factor may be that the general awareness of potential Extension collaborators is too low. Extension faculty operate differently than academic faculty, often with

multiple, disparate areas of focus, therefore identifying collaborators is more difficult. More broadly, some Extension personnel mentioned that knowledge of Master Gardener, Master Naturalist, and 4-H programs as Extension programs is lacking. This could be solved by sharing information about these programs and personnel that clarifies the role of Cooperative Extension in their administration. Promoting access to the Extension network was suggested. If partners are located, attendees suggested engaging them from the earliest stages of a native bee monitoring project. This gives them agency and ideally funding for their involvement; further, it respects their current responsibilities. Another hurdle to establishing these partnerships is inter- and intra-agency bureaucracy. Multiple attendees expressed difficulty breaking through bureaucratic barriers.

Establishing sustained programs was another frequently discussed barrier to participating in native bee monitoring efforts. Grant funding is typically short term, leading to frequent changes in priorities and personnel. However, successful monitoring programs, including eBird, take time to mature. Another shortfall of short-term native bee monitoring programs is a lack of volunteer retention and continued engagement. Sustained programs may be more likely to establish credibility and attract long term volunteers and staff.

Other barriers that were discussed at the workshop focused on sampling protocols, including site access, data processing, and scientific rigor. Locating sites, obtaining permits or permission to access them, and maintaining any permits or permission is a time-consuming process. Dealing with multiple types of owners adds further strain to accessing high-quality native bee sampling sites. Distance to these sites from Extension offices may be an issue, particularly given limited access to transportation, which was discussed as a barrier in some situations. If specimens are collected, Extension professionals were unsure what to do with the specimens, as many offices lack access to proper storage facilities and equipment to prepare specimens for long term storage. Digitizing specimens was discussed as a further barrier. And lastly, access to taxonomists to identify specimens is a barrier for Extension professionals. Native bee monitoring programs that use photos may be better suited to Extension professionals, as photos eliminate specimen management. However, getting native bee photos that are identifiable to species can be difficult. Broadly, a tradeoff between scientific rigor and Extension personnel time and interest was frequently mentioned. Identifying a monitoring strategy that balances these is imperative.

Once specimen or photo data have been collected, curated, and identified, how the results are shared was discussed as another barrier for Extension professionals. Cooperative Extension does publish scientific information, but it is considered gray literature as it is not peer reviewed. This saves time and money, as well as allows any publications to be publicly accessible. Publication is often not a priority for Extension professionals, and there were multiple mentions of loss of information owing to staff turnover and retirement. Establishing means to disseminate results from Extension-based native bee monitoring programs could reduce these losses.

Question 5: How do we connect educational work with generating rigorous data? What is the foundational level of effort?

Generating native bee data that is sufficiently rigorous for scientific analyses was a topic of concern throughout all of the discussions at this workshop, particularly if those data were to be used at a national scale. Attendees identified a major challenge to create standardized educational protocols that could be used nationwide in order to collect rigorous native bee monitoring data. One particular challenge that was frequently raised concerned the level of taxonomic resolution that can be achieved by community science projects at a national scale. This was countered by comments on the usefulness of bee data at any taxonomic resolution, even categories as broad as honeybee or non-honeybee. Additionally, attendees mentioned that professional scientists may have low expectations of the capabilities of community scientists; these are commonly unfounded, as existing projects demonstrate that public participants are highly capable of rigorous native bee monitoring work. There were also multiple suggestions for how to gather such data. Before any data is collected, Extension and community science projects conducting native bee monitoring can define clear goals for their monitoring efforts. These goals can answer the following questions: 1) How can the data be used? 2) Where will data be collected and why work in those locations? And 3) Which native bee species should be monitored and why? Further, attendees suggested establishing a data management plan before collecting data by determining where the collected data will be stored, who will manage the data, and how it will be shared with volunteers and the public. It was suggested to present the data in an engaging way to encourage volunteers and the public to interact with it. When data collection begins, using standardized data collection, processing, and storage protocols can lead to more rigorous native bee monitoring data. These protocols should be easy to follow and implement. Training participants to use such protocols can in turn generate rigorous data. Participants can be motivated to collect rigorous data through consistent communication from professional scientists and project coordinators, receiving proper credit in project outcomes, creating specialized reports detailing their efforts, or providing rewards or awards for their work.

Workshop attendees outlined two training approaches when working with community scientists: 1) intensively train a small group of volunteers or 2) broadly train a large group of volunteers. Both approaches can be used to generate rigorous native bee monitoring data, as exemplified by the Oregon Bee Atlas, which follows the first approach, and by the Xerces Society's Bumble Bee Atlas projects, which follow the second approach. Workshop attendees suggested new protocols can be tested by community scientists, including those that collect data appropriate for abundance or occupancy analysis or assess nesting habitat.

A foundational level of effort to generate rigorous native bee monitoring data can be established based on comments from workshop attendees: either take a photo or collect a specimen, then gather both a geolocation and a date to associate with the photo or specimen. In the field, photos can be collected with a geolocation and a date automatically with iNaturalist, though in some cases, iNaturalist data obscures the location. The community native bee monitoring project Shutterbee uses this protocol in their data collection. Training participants on taking high

quality photos is a crucial part of using this protocol. Two additional components to this protocol were suggested. 1) record survey effort by noting the number of surveys conducted and/or the time spent conducting surveys, along with noting any absence surveys; and 2) record the floral host the photo or specimen was collected from.