Demographic summary of attendees:

Table 1. Summary of invitees (n = 704) and attendees (n = 123) 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.

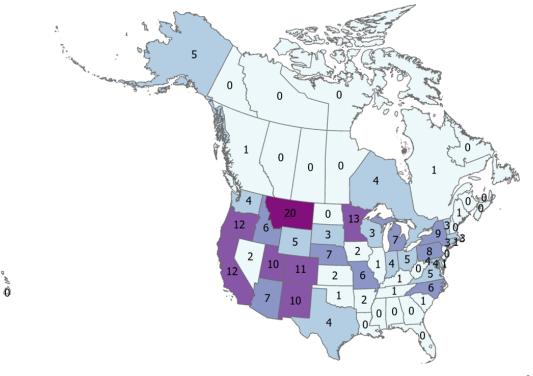|	Invited	Attended
Mountain West (MT, ID, WY, CO, NV, UT, AZ, NM)	160	39
Northeast (MD, DE, DC, NJ, PA, NY, RI, CT, MA, VT, NH, ME)	147	22
Pacific West (WA, OR, CA)	91	16
Lake States (MN, WI, MI)	65	14
Corn Belt (IA, MO, IK, IN, OH)	63	4
Northern Plains (ND, SD, NE, KS)	33	7
Appalachia (KY, TN, WV, VA, NC)	41	6
Southern Plains (TX, OK)	19	4
Southeast (AL, GA, SC, FL)	20	1
Canada	27	4
Delta (AR, LA, MS)	11	1
International	14	0
Alaska	8	5
Hawaii	4	0
N/A	1	0

Table 2. Summary of invitees (n = 704) and attendees (n = 123) of the RCN workshop on existing bee monitoring efforts by employment sector.

	Invited	Attended
Academic	261	39
Federal	236	50
State	65	12
Extension	45	5
Nonprofit	41	13
Tribal	18	2
Consultant	17	2
Industry	12	0
County	5	0
Local	3	0
N/A	1	0

Pre-workshop survey summary

Workshop organizers compiled a detailed survey for prospective attendees to complete along with their response for attending the event. The survey was optional; no questions were required to submit an RSVP. We received 222 responses to the workshop invitation, and all of those responses included one or more answers to the survey questions.

Q1: What state/province/territory are you based in? (222 responses)

Responses to this question revealed strong western US representation in the location of workshop attendees (Fig. 1). Of the top 10 states, with a tie for 10th, seven of the 11 were in the western US: MT, OR, CA, CO, UT, NM, and AZ. The remaining four were MN, NY, PA, MI. There was almost no representation from the southeast US.

Figure 1. North American map of survey respondent locations.

Q2: Are you currently (in the last year) engaged in native bee inventories, surveys, and/or monitoring? (217 responses)

Most respondents answered yes (132 responses, 60.8% of answers). Of the remaining answers, 14.7% were not currently monitoring native bees, but they had in the past; 8.3% have never monitored native bees; 8.3% were not currently monitoring native bees but were

interested in doing so in the future, and 7.8% were not currently monitoring native bees but would be in the future.

Q3: Please share the locations where you have monitored native bees. (176 responses)

As with the location of survey respondents, the answers to this question had very strong western US representation. There was also very little monitoring history provided for the southeast US (Fig. 2).
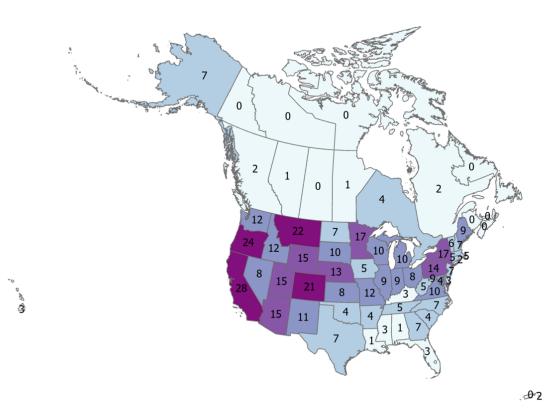

Figure 2. North American map of locations where survey respondents have monitored native bees.

Q4: If you are planning a native bee monitoring project in the future, where will it take place? (111 responses)

There were fewer responses to this question than the other monitoring location questions, though the western representation in those questions remained. Montana had 16 potential projects, all other states had less than 10 anticipated native bee monitoring projects (Fig. 3).
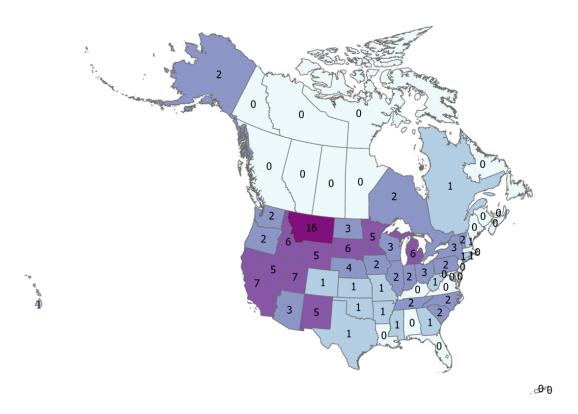
Figure 3. North American map of locations where survey respondents plan to monitor native bees.

Q5. What should be the primary goal of a newly established national scale native bee monitoring program? Please rank your top three choices.

Most popular first choice, 116 votes: Establishing baseline information on bee species distributions
Most popular second choice, 67 votes: Tracking population trends over time
Most popular third choice, 59 votes: Informing policy and restoration efforts

The remainder of the choices provided were: developing and testing effective monitoring techniques, assessing rare species, building genetic libraries, and monitoring priority geographic areas.

Q6: How would you prioritize sampling locations for a national scale native bee monitoring program? Please rank the options from 1 (highest priority) to 7 (lowest priority).

Priority 1: Areas that lack basic data
Priority 2: Areas where there is concern of biodiversity loss
Priority 3: Areas which contain unique habitats or endemic or rare plants that depend on pollinators
Priority 4: Areas that are biodiversity hotspots
Priority 5: Areas with the greatest environmental change
Priority 6: Areas where historical data exist but current data does not
Priority 7: Areas with the greatest potential contribution to agriculture but are data deficient

Q7: Please rank the following habitat types in order of importance (1 = most important; 9 = least important) for national native bee monitoring:

Most important 1: Grasslands
Most important 2: Chaparral/sage steppe
Most important 3: Forests
Most important 4: Savannah
Most important 5: Deserts
Most important 6: Wetlands
Most important 7: Montane/alpine/tundra
Most important 8: Farmland
Least important (9): Urban/suburban

Q8: Please rank the following habitat types in order of current knowledge (1 = most studied; 9 = least studied) for national native bee monitoring:

Most studied 1: Farmland
Most studied 2: Urban/suburban
Most studied 3: Grasslands
Most studied 4: Forests
Most studied 5: Deserts
Most studied 6: Montane/alpine/tundra
Most studied 7: Savannah
Most studied 8: Chaparral/sage steppe
Least studied (9): Wetlands

Q9: Please specify up to three Level 3 EPA Ecoregions that you think are most lacking in native bee monitoring data. (143 responses, Fig. 4)

10.1, Cold Deserts: 46 votes
9.4, South Central Semiarid Prairies: 33 votes
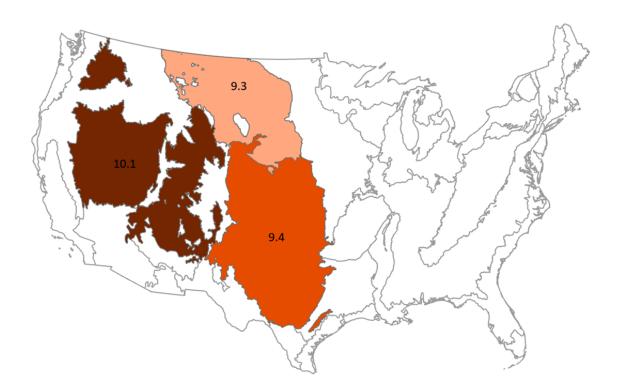9.3, West-Central Semiarid Prairies: 31 votes

Figure 4. Three Level 3 EPA Ecoregions that survey respondents voted most lacking in native bee monitoring data. Ecoregions are shaded by intensity based on the number of votes received.

Q10: Please specify up to three Level 3 EPA Ecoregions that you think are most at risk of environmental change and threaten certain populations. (136 responses, Fig. 5)

11.1, Mediterranean California: 37 votes
Tie, 30 votes each:
10.2, Warm Deserts
9.4, South Central Semiarid Prairies
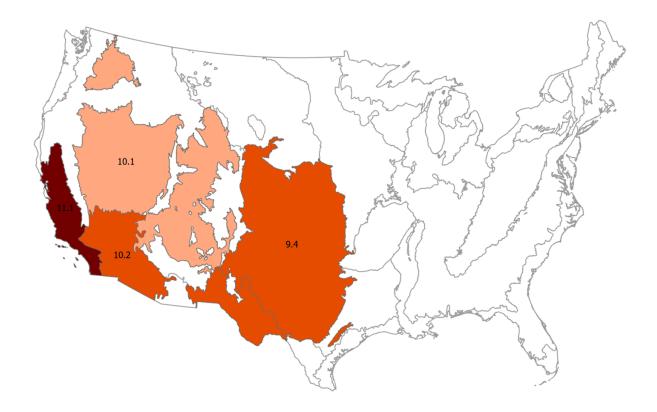10.1, Cold Deserts: 26 votes

Figure 5. Four Level 3 EPA Ecoregions that survey respondents think voted most at risk of environmental change and threaten certain populations. Ecoregions are shaded by intensity based on the number of votes received; therefore, the two tied ecoregions (10.2 and 9.4) are the same color.

Q11: Please specify which up to three Level 3 EPA Ecoregions that you think have the greatest concern of biodiversity loss. (131 responses, Fig. 6)

11.1, Mediterranean California: 43 votes
10.2, Warm Deserts: 31 votes
Tie, 28 votes each:
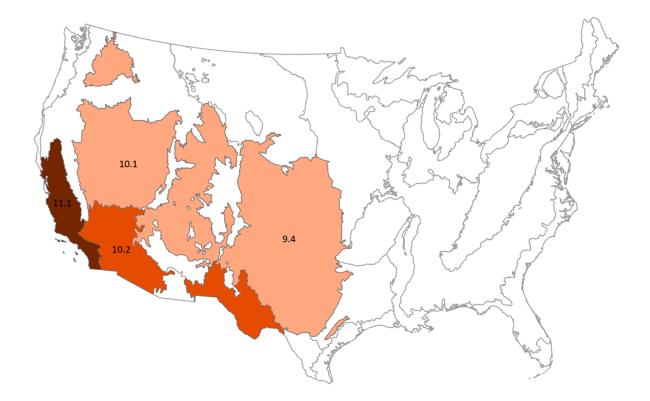10.1, Cold Deserts
9.4, South Central Semiarid Prairies

Figure 6. Four Level 3 EPA Ecoregions that survey respondents voted as the greatest concern of biodiversity loss. Ecoregions are shaded by intensity based on the number of votes received; therefore, the two tied ecoregions (10.1 and 9.4) are the same color.

Q12: Please specify up to three Level 3 EPA Ecoregions that you think have historical data but limited recent native bee monitoring activity. (108 responses, Fig. 7)

Unknown: 38 votes
10.1, Cold Deserts: 24 votes
9.4, South Central Semiarid Plains: 22 votes
Tie, 18 votes each:
8.3, Southeastern USA Plains
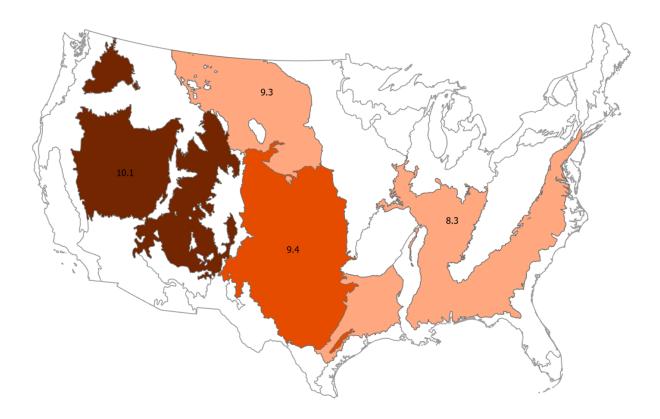9.3, West-Central Semiarid Prairies

Figure 7. Four Level 3 EPA Ecoregions that survey respondents voted as having historical data but limited recent native bee monitoring activity. Ecoregions are shaded by intensity based on the number of votes received; therefore, the two tied ecoregions (8.3 and 9.3) are the same color.

Q13: Please specify up to three Level 3 EPA Ecoregions that you think have the greatest contribution to agriculture but are data deficient. (108 responses, Fig. 7)

9.2, Temperate Prairies: 57 votes
9.4, South Central Semiarid Plains: 51 votes
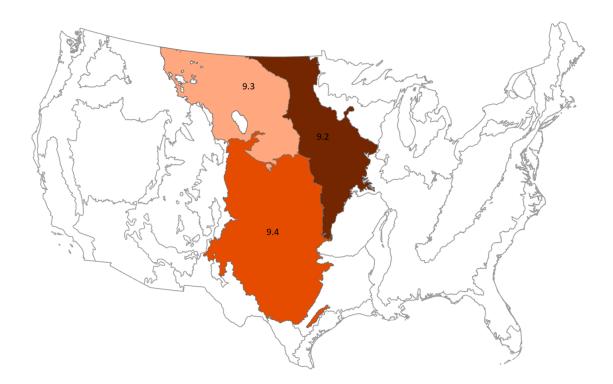9.3, West-Central Semiarid Plains: 45 votes

Figure 8. Three Level 3 EPA Ecoregions that survey respondents voted as having the greatest contribution to agriculture but are data deficient. Ecoregions are shaded by intensity based on the number of votes received.

Large group discussion summary

During the workshop, we asked attendees five questions using Mentimeter live polling:

Q1: Should we develop priority areas to implement national native bee monitoring?

There were 95 responses to this question, strongly supporting priority areas (Table 3)

Table 3. Responses to large group question 1: Should we develop priority areas to implement national native bee monitoring?

Yes	69
No	1
Maybe	25

Q2: Should we develop regional functional units to support national native bee monitoring?

There were 90 responses to this question, strongly supporting regional functional units (Table 4)

Table 4. Responses to large group question 2: Should we develop regional functional units to support national native bee monitoring?

Yes	68
No	1
Maybe	21

Q3: What are the ingredients of these units?

This was an open-ended question; the 80 responses varied across essentially all topics covered at the workshop through presentations or breakout group discussions. Common responses included sustained funding, taxonomic expertise, and dedicated staff. Specifics provided for dedicated staff were that they have expertise in native bee inventory or monitoring and that they have specimen processing capacity. Multiple responses addressed communication and coordination across these units. Engagement with existing infrastructure was suggested; specific examples provided were the US Fish and Wildlife Service, the National Resources Conservation Service, and the GRTS sampling scheme. Other responses related to communication were frequent reports to update participants, spatial balance to create a balanced workload across units, engaging local communities and community science groups, and encouraging participation from multiple stakeholders across a variety of sectors. Another

group of responses addressed habitats to sample through national native bee monitoring. Suggestions here included sampling similar habitats across units or utilize shared ecoregions containing similar taxa; conversely, it was also suggested to sample a variety of habitats for comparison. Following an established biologically-relevant regionalization scheme was suggested; if that is not possible, it was suggested to consider bee biogeography when establishing regions for national native bee monitoring. The last group of responses centered on logistics supporting a national native bee monitoring scheme and included establishing common, clear goals across all units along with following standardized protocols for data collection, processing, and management.

Q4: How could we delineate units for national native bee monitoring?

There were 85 responses to this questions, strongly supporting other units over state based options (Table 5)

Table 5. Responses to large group question 4: How could we delineate units for national native bee monitoring?

Single states	6
3-4 state regions	26
5+ state regions	8
Other	45

When asked to elaborate on other options, consensus emerged around EPA ecoregions or other ecologically relevant boundaries over state or political boundaries.

Q5: How could bee monitoring regional units fit together? How could they align with other efforts?

This was an open-ended question; as with the previous open-ended large group discussion questions, the 34 responses varied across workshop topics. Coordinating with, emulating, or modeling after existing efforts was frequently mentioned, but there was no consensus on which efforts. Specific examples given were: the US Fish and Wildlife Service, NatureServe and the Natural Heritage Program Network, the Forest Inventory and Analysis program, the California Native Plant Society, and the Great Lakes Restoration Initiative pollinator monitoring task force. Other suggestions here were more vague: interagency efforts, community science programs, and entities collecting habitat data. There were many mentions of sharing and cooperation across a variety of components of a national native bee monitoring scheme: goals, protocols, data management, staff (particularly taxonomists), and communication regarding struggles and successes in implementing monitoring efforts. A central data portal was frequently mentioned, as it has been in multiple previous workshops. Strong and effective centralized leadership, facilitation, or coordination was suggested in multiple responses. Suggestions regarding

logistics of operating regional units for native bee monitoring included flexibility in implementing native bee monitoring protocols, using existing federal regions with stronger coordination than currently exists, avoiding state-level execution of a national monitoring scheme, and supporting cross-state operations. Some responses suggested that it is difficult to work across states that share ecoregion boundaries. Lastly, it was suggested to establish native bee species or habitats under threat to try and find common ground across regional units.

Synthesis of breakout group discussions

This workshop had four topics discussed simultaneously during two breakout sessions. Three topics were discussed by two groups; one topic was discussed by a single group. The topics were:

1) Locations with existing data on native bees
2) Developing a framework to determine locations to sample native bees
3) Existing infrastructure that could be used in national native bee monitoring
4) Habitat and other supporting data to collect when monitoring native bees

Topic 1: Locations with existing data on native bees (one group)

Where are there high quality existing data sets on native bees? Are these data accessible?

The USDA ARS PWA Pollinating Insect Research Unit (PIRU), colloquially referred to as the Logan Bee Lab, houses nearly 2 million native bee specimens from collections made primarily in the Western United States. Major research projects with specimens at the Logan Bee Lab include surveys conducted at Pinnacles National Park, Grand Staircase-Escalante National Monument, Clark County, Nevada, and others, including surveys of alpine sites in southwestern Idaho conducted by Andrew Moldenke. Pinnacles in particular has been resurveyed periodically since the late 1990s. These specimens are available by request or appointment. Most specimens are digitized, but less than half of those are publicly available.

Other areas mentioned included Connecticut, Washington, D.C., Michigan, Central California, and the agricultural regions of upstate New York, New Jersey, and southeastern Pennsylvania. Connecticut has native bee records dating back to 1905. Most of these records are digitized and publicly available on iDigBio and GBIF, and all physical specimens are available. Current sampling efforts in Connecticut include recreating historical crop scenarios and comparing recently collected data to previous surveys. Plummer's Island, Maryland, in the Washington, D.C. area, has been surveyed for bees since the early 1900s. The collection is not digitized and specimen availability was not disclosed. In Michigan, the Isaacs Lab at Michigan State University has digitized native bee records from the E.S. George Reserve, Kellogg Biological Station, and other survey efforts, and intends to make these records publicly available. Central California has historic records from work by Gretchen LeBuhn, Claire Kremen, Terry Griswold, and work done at the Hastings Natural History Reservation, a University of California property. Availability of these records is unknown. In the Northeast, a rich sampling history associated with the labs of Bryan Danforth at Cornell University and Rachael Winfree at Rutgers University was mentioned; though accessibility of physical specimens or digitized records is currently unknown. The New York Natural Heritage Program recently completed a multi-year statewide survey, though the accessibility of the data is currently unknown. The Oregon Bee Atlas is gathering bee specimens across Oregon; once the specimens are verified, all data is shared with the public via GBIF. Two ongoing long-term projects that have been sampling bees include

those at Sevilleta LTER in New Mexico and the Rocky Mountain Biological Lab in Colorado. All data from these projects is publicly available. Lastly, a recent resampling effort conducted on sunflower in the southwestern US repeated work from 1975 after 40 years (Hurd and Linsley 1975, Cumberland 2019); availability of these data are unknown.

Where are there NOT high quality existing data sets on native bees? What are possible reasons for this?

Rural areas in the West were frequently mentioned here, owing to limited infrastructure or means to access these large amounts of land. The state of Nevada was discussed at length. The reasons provided as to why Nevada has been historically undersampled centered around land access; in particular, the lack of roads in areas away from urban centers or major universities or in areas not already prioritized for conservation or agriculture. Nevada has fewer people working with native bees, although the group acknowledged that there have been more relevant hires there recently. The state is developing a bee atlas project, and group members implied that the lack of information on native bees in Nevada will be addressed in the near future.

Other western US regions mentioned included the Sierra Nevadas, Idaho, and parts of Oregon. Undersampled areas in Oregon were described as having high elevation, far from roads, and away from major population centers. Reasons given for not sampling these areas were 1) high cost and effort to access and 2) an assumption that these areas may not provide sufficient information to outweigh those costs, i.e., low productivity. Multiple areas in the central US were mentioned: Kentucky, Tennessee, Arkansas, northern Mississippi, northern Alabama, northwest Texas, and the Southern Plains region of the US, which includes Oklahoma.

What are potential limitations to re-sampling previously sampled sites?

Limitations associated with site quality and organizational change were frequently mentioned. Site quality issues mentioned were destruction of previously sampled sites, change in access to sites, natural habitat change over time, or finding the exact site location. Organizational change issues mentioned were funding availability, staff turnover, reliance on volunteer labor, and priority shifts.

Other potential limitations mentioned were understanding quantified effort, which was not usually quantified in historical surveys; understanding vague method descriptions including survey methods and specimen processing or management. Related to specimen management, other limitations discussed regarding resampling were locating the old specimens, as very few were likely digitized, or updating species names to current accepted nomenclature. Both of these limitations place additional strain on bee taxonomists.

What is a detailed workflow for finding best places to re-sample/survey?

The group had difficulty establishing one workflow, discussing instead that any established workflow will depend on the research questions and goals of a national native bee monitoring plan. Two possible questions were mentioned: 1) is resampling occurring to determine if a species remains in the same place? Or 2) is resampling occurring to determine a population trend? In the first question, the type of historical sampling may not be as important to replicate as it would be in the second question; establishing a population trend in a robust manner requires rigorous, repeatable sampling methods. A workflow could be built off of previously sampled places that have recorded methods, quantified effort, and make their specimens available. As part of the research conducting repeated sampling at Pinnacles National Park described in Meiners et al (2019), the authors established criteria to screen papers for rigorous sampling at biodiversity hotspots. These criteria included gathering more than 100 species and conducting extensive inventory-style sampling in a natural area. The group discussed focusing resampling on intact plant communities and protected areas, in part to avoid potential issues with site access or quality. Ultimately, a resampling workflow will depend on the priorities of the funding source or agency; keeping that under consideration when developing workflows may help sustain it over time.

What is the best way to carry out resampling?

Repeating methods and effort as true to the historical record as possible was determined to be the best way to carry out resampling. For new efforts that could be resampled in the future, the group suggested intensive faunal sampling at first, to determine species detection, then adapting sampling locations as needed to track bee populations and incorporate plant associations in the future. Focusing on places that are more likely to remain stable over time may prevent site quality and access issues during future sampling occasions.

Topic 2: Establishing a framework for prioritizing places to monitor native bees (Two groups)

Is there value for splitting the US into a subset of regions for monitoring coordination and prioritization?

The two groups discussed benefits and drawbacks to splitting the US into regions for national native bee monitoring. The most frequently mentioned benefit was the ability to connect with existing monitoring schemes or other related infrastructure, including money, equipment, and personnel. This would reduce redundancy across organizations with similar goals and allow more efficient use of limited funding. Most national, regional, or interstate conservation efforts have established regions to accomplish their shared goals. Established regions could lead to more sampling in areas not previously sampled or not frequently sampled; in particular, working across state lines could address issues where insects have no legal protections from the state. Ideally, these regions would be biologically relevant with similar environmental conditions, including phenology, plant composition, and climate; further, these regions could have similar

bee diversity to avoid disparity in effort needed to adequately sample them. Establishing such regions across the US would promote more complete spatial coverage of sampling and cover a wide range of habitat types, climate conditions, and bee communities. Within these regions, there could be some level of flexibility in how native bee monitoring is conducted. Integrating local knowledge or expertise could create buy-in and allow for regional priorities to be addressed in a monitoring scheme. As long as regions follow a basic protocol, sampling schemes could be customized to meet their needs.

The most frequently mentioned drawback to regionalization of a national native bee monitoring scheme was that infrastructure may not exist throughout the US or may be difficult to establish. Barriers to developing new infrastructure overlap with reasons why bee sampling has not occurred in parts of the US as described above; further, using existing infrastructure may not address the existing bias in native bee monitoring toward population centers. If regionalization is pursued, these regions should address equity issues in undersampled and underrepresented regions. Other drawbacks to relying on existing infrastructure included limiting the opportunity to produce new or fresh ideas for national native bee monitoring and overtaxing a likely already overburdened system. New administrative support staff would likely be needed to make relying on existing infrastructure work. Additionally, taxonomic expertise is not uniformly distributed across these regions. Lastly, cost and funding were discussed as drawbacks to establishing regions for national native bee monitoring. It will be more expensive to sample uniformly across the country, and the need to do so could create competition for limited funding sources.

Is there an existing regional split you think would be appropriate for the RCN? If not, how would you recommend splitting into regions?

Consensus emerged here around EPA ecoregions, a well-established, biologically relevant split of the US. Ecoregions were mentioned in the large group polling portion of the workshop as well. Other biologically relevant regional systems of the US include watersheds or hydrologic unit codes, Landscape Conservation Cooperatives (LCCs), and the Migratory Bird Joint Ventures. Group members with experience in LCCs mentioned to make clear which agencies/entities are responsible for what tasks in all participating states. Political region systems were also mentioned, including those from USDA, the Forest Service, USGS, and BLM. While these regions fall along state lines, they were developed with ecological conditions in mind. Most group members expressed support for using an existing regional split and hesitation toward developing new regions, and there was debate over biological vs political splits. Political region boundaries could change owing to population change, organizational priority, or funding capacity, whereas biological boundaries are less likely to shift over time. However, many group members worried about the logistics of administering native bee monitoring over biological boundaries rather than political boundaries. The administrative capacity required for biological regions is greater than political regions as biological boundaries will likely cross multiple state lines and some states may contain multiple biological regions. Additionally, community scientists may work better with political boundaries over biological boundaries. Two solutions were posed to this debate. First, political and biological boundaries could be combined. Political boundaries could account for the work within the biological regions

they contain. This would address administrative issues including staff, laws, and funding while monitoring for native bees across biological regions; however, workload could differ substantially across states or regions depending on the biological boundaries. The second solution presented was to pursue a grid based system for uniformity without relying on existing political or biological regional splits. This would allow for uniform sampling throughout the US independent of infrastructure, habitat type, or other considerations discussed here.

What are potential criteria for prioritizing places to monitor native bees, and how should locations be selected for each?

Five types of criteria were discussed:

1) Biodiversity hotspots, including areas with high bee diversity, high endemicity, and high habitat diversity. These could also be areas with rare or specialist species, threatened or endangered species, or places designated as important plant areas.
2) Threatened habitats, including places threatened by climate change, land use change, pesticide use, or sensitive habitats.
3) Undersampled areas or areas with little known information on native bees. Prioritizing these areas would fill both spatial and taxonomic gaps. Places that were last sampled 20-40 years ago would also meet these criteria.
4) Conserved or protected areas that could establish a modern-day baseline then be returned to for future sampling for 100 or more years, so long as they remain accessible and feasible to sample.
5) Areas with a record of long-term sampling to continue the sampling record and ideally begin to track population trends.

Group members seemed to agree that using any of these criteria requires a better understanding of current and historic native bee data distribution across the US. Additionally, more digitization of existing records would provide clarity to a prioritization process for places to monitor native bees. Intentional selection of sampling sites based on existing infrastructure was mentioned; additionally, selecting sites that are at greater risk or with higher diversity was suggested. Another thought was to sample both "good" and "bad" areas, including remnants of natural habitat in agriculturally-intense landscapes. More discussion focused on site selection methods that would avoid bias, including multiple modeling strategies and stratified random sampling. Potential modeling methods to use include species distribution models, such as those used in the workshop presentation by Paige Chesshire, climate models, land use change models, and spatial optimization with the prioritzr package in R. However, there was more agreement on stratified random sampling to determine sampling site locations. Sites would be chosen based on established goals, priorities, or targets for monitoring by picking cells from a grid overlaying the country; the GRTS protocol was suggested by multiple group members as the grid to use for this. This aligns with a competing perspective on selecting sites, which was to avoid prioritization altogether by using a grid system, GRTS in particular, to choose sites for uniform sampling across the country. This would establish a baseline from which sites could be prioritized for future sampling.

Based on today's discussion and pre-workshop survey results, are there "highest priority" places to monitor? What are these places? Why do you think so?

There were very few specific places mentioned as high priority places to sample for native bees, but general suggestions were given that follow the criteria discussed for selecting sampling sites. Places with high biodiversity, greater risk of change, that are undersampled, have a history of previous sampling, are protected areas, or have been highly disturbed were all criteria discussed here. Specific places that were mentioned were California deserts and other warm desert areas, Nevada, the central plains, the southeastern US, and the Channel Islands of California. Sampling sites will ultimately be chosen based on the priorities or goals of a national native bee monitoring scheme, though choosing sites may be difficult owing to very sparse existing baseline information on native bee populations. Building on this thought, it was again suggested that prioritization not occur at all; instead, use a grid system to uniformly sample across the US and create a robust baseline to prioritize future sampling from.

Reasons to sample in selected places centered around gathering information from undersampled, rare, or at-risk habitat. Addressing data gaps by sampling uniformly across the country will lead to a reasonable baseline upon which future decisions can be made on native bee conservation, research, and management. Understanding bee populations where threats are high can inform conservation efforts by targeting at-risk species and monitoring the spread of non-native species; it further allows for gathering information in places before threats lead to extinction or destruction. Three suggestions were offered to guide a prioritization process: 1) gather information that allows the assessment of change in bee populations; 2) account for the amount of effort it will take to reach and work in undersampled places, and 3) take advantage of existing resources and infrastructure.

Topic 3: Existing infrastructure (Two groups)

What are the national or other major infrastructures that a national monitoring strategy could tap into? What resources do these infrastructures offer? How can each contribute to a national native bee monitoring strategy?

Generally speaking, existing infrastructure discussed by these two groups offers the following resources: staffing, funding, facilities, land ownership and access, knowledge, experience, and professional networks. Limitations associated with each of these potential offerings were also discussed; these are finite resources currently operating with significant constraints. Approaching these entities for partnership should be done deliberately with clear expectations.

National long term monitoring research stations were the most frequently mentioned infrastructure. These include stations associated with the Long Term Ecological Research (LTER) Network, the National Ecological Observatory Network (NEON), and the Long Term Agricultural Research (LTAR) Network. These stations are distributed across the US over diverse habitat types; some of them are shared across the three networks. They vary in length of operation: the first LTER sites were established in 1980; NEON began operations across 81

sites in 2019, and LTAR sites were established in 2011 and 2012. These sites can offer historical collections, contextual or comparative data, physical infrastructure (labs and equipment), site access, staff or volunteers, and advice on establishing and maintaining long term research sites. Taxa that are surveyed at these sites vary; many do not currently survey pollinators.

The NatureServe Network consists of Natural Heritage Program (NHP) offices within all US states, Canadian provinces, the Navajo Nation, and Puerto Rico. Many NHP offices are affiliated with state, provincial, territorial, or tribal government agencies, unlocking a rich professional network with extensive local expertise and knowledge. Resources used by the NatureServe Network that could benefit national native bee monitoring include Biotics, their internal species occurrence database; NatureServe Explorer, a search tool for threatened and endangered species; and calculators to determine conservation status (S-rank) and threats. Partnering with state agencies would provide access to funding and regulatory infrastructure including State Wildlife Grants and State Wildlife Action Plans (SWAPs). SWAPs determine which species a state will support work on; getting native bees into more state SWAPs has been discussed at multiple RCN workshops. State agencies have access to reserve lands that may make suitable native bee monitoring sites and potentially personnel who can conduct monitoring efforts. Local municipal entities that manage or conserve land were suggested as partners for similar reasons.

There were multiple mentions of accessing tribal infrastructure with little information or suggestion on how to begin this process. Accessing traditional ecological knowledge (TEK) has been discussed at multiple RCN workshops. The EPA leads a tribal pesticide program; many of these programs do native pollinator work along with pesticide education.

Federal agencies have extensive infrastructure to tap into, including land, labs, personnel, funding, professional networks, historic data, and more. The US Fish and Wildlife Service (FWS) manages a national network of wildlife refuges where native bees can be monitored. Data could be managed by staff associated with refuges or the Endangered Species Program. The Bee Tool is a FWS product that could be useful in locating sites to monitor native bees. The National Park Service (NPS) has an Inventory and Monitoring program operating in 400 units across 32 divisions nationally. NPS is currently conducting a national native bee monitoring project within the I&M program for which they are developing a non-lethal protocol to collect and manage occurrence data on native bees. NPS offers access to protected land for monitoring sites. The Bureau of Land Management (BLM) has a pollinator action team and is currently developing a native bee monitoring protocol to implement across their land. The Department of Defense has a vast landbase that may be suitable for native bee monitoring. The US Geological Survey (USGS) offers the taxonomic services of the Bee Inventory and Modeling Lab (BIML) in Beltsville, Maryland; the BIML is also developing multiple monitoring protocols that may be useful in a national scheme. USGS administers the North American Bat Monitoring Program (NABAT), which relies on a national grid network (GRTS) of monitoring sites and protocol for site visitation and sampling. A national native bee monitoring scheme could use similar methods to gather information. USGS administers the US node of GBIF, gbif.us, and could be a source of

support for data management. USGS is also developing eDNA monitoring methods to collect information on native bee occurrences on various plants.

The US Department of Agriculture (USDA) and agencies within, including the Agricultural Research Service (ARS), the Natural Resources Conservation Service (NRCS), the Animal and Plant Health Inspection Service (APHIS), and the Forest Service, offers a wealth of resources suitable for native bee monitoring. The resources at the Logan Bee Lab were mentioned here, much as they were by group 1: the National Pollinating Insect Collection, with over 2 million specimens available for physical reference and within a robust database. Additionally, bee specimens can be identified by taxonomic staff at the Logan Bee Lab. Additionally, the lab is developing various protocols for bee monitoring that could be used in a national monitoring scheme. The NRCS Regional Conservation Partnership Program may be a source of sites to monitor native bees. APHIS runs the Exotic Bee ID site in partnership with Utah State University. National Forests offer land for bee monitoring; some forests are implementing monitoring practices to better understand native bee populations in forest land. Other USDA native bee monitoring resources center around data management, including the PLANTS database, the Partnership for Data Innovation, and the data science at the National Agricultural Library. The USDA is developing a web-based Pollinator Data Portal and is very open to collaboration and support of data management efforts involving native bees.

Universities have scientific infrastructure to support native bee monitoring, including specimen collections, research stations, lab groups that conduct native bee surveys and manage associated data, and taxonomic capacity. Universities also operate Cooperative Extension offices, which train Master Naturalists, Gardeners, and Mellitologists, creating a robust and informed volunteer body to participate in national native bee monitoring.

Nonprofit and non-governmental organizations also offer infrastructure to tap into for a national native bee monitoring scheme. Organizations including The Xerces Society, Pheasants Forever/Quail Forever, and the Pollinator Partnership all have biologists and staff working across the country in native bee conservation and advocacy. The Xerces Society administers a number of bumble bee monitoring community science projects, including Bumble Bee Watch and Bumble Bee Atlases in a growing number of states. The Monarch Joint Venture administers the Integrated Monarch Monitoring Program across the US; this existing monitoring scheme offers protocol, volunteer support and experience, a robust data set, and a widespread network. Other NGOs mentioned that would make good partners for national native bee monitoring included iNaturalist, DiscoverLife, and the Association of Fish and Wildlife Agencies (AFWA). AFWA recently hired an invertebrate conservation coordinator and will focus initially on pollinators; this group is connected with state agencies, whose infrastructure was discussed above. Broadly, nonprofits and NGOs could provide support for fundraising efforts to support national native bee monitoring.

Lastly, two unique examples were given that work across disciplines, agencies, states, and nations. The Migratory Bird Joint Venture (MBJV), mentioned earlier as an example of biologically-relevant regionalization of the US, is an initiative of the US Fish and Wildlife Service

that has grown to coverage across the US, Canada, and Mexico. Their offices are administered by various agencies and NGOs; they partner with other organizations to conserve habitat for migratory birds. Similarly, the Commission for Environmental Cooperation (CEC) is a tri-national collaboration that has projects on various conservation issues, including monarch conservation and native bee conservation. CEC has worked with a variety of organizations in all three countries and has demonstrated outcomes to support conservation and monitoring efforts.

Which previously discussed entities interact with one another?

Many of these entities have interacted or are currently interacting, typically in small groups of two or three for one-off projects. These interactions are often cross-disciplinary collaborations in which each entity brings their own components to create a productive and effective partnership. Awareness of these interactions and the outcomes they produce generally spread through word of mouth; they are not typically heavily publicized.

Specific examples mentioned include: USDA and the EPA creating a Pollinator Action Plan, the Department of the Interior Pollinator Working Group, Bumble Bee Watch, all of the Bumble Bee Atlas projects, the Natural Heritage Program, and universities working at NEON/LTAR/LTER sites. Additionally, local agencies and entities often interact with each other on pollinator conservation efforts.

Broad-scale coordination over a large geographic area or among more than three entities has not been common in native bee conservation and monitoring, and there were multiple requests to work to achieve this in some capacity.

How can we coordinate between these entities?

Strong consensus emerged from this question for designating a national native bee monitoring coordinator to develop and manage the broad scale interaction between multiple entities across the country. This administrator would likely need support staff; these staff would not necessarily need to be full-time, but ideally they would be affiliated with relevant agencies or organizations. Support for these employees would require sustained, dedicated funding.

Group members suggested that one entity should be designated as a host for a national native bee monitoring scheme; this host would employ the national coordinator. It was further suggested that this entity be a federal or national agency or organization that can influence the actions of national, regional, state, and local groups. This entity could also disperse funding to support national native bee monitoring. Given the complexity of such broad-scale interaction, group members suggested to a) work to use existing infrastructure as much as possible and b) set clear goals for collaboration and coordination to determine the most effective partners when implementing a national native bee monitoring strategy.

Topic 4: Habitat data to support national native bee monitoring (Two groups)

What are the habitat-related data that would complement bee monitoring, identify key drivers of change in bee communities, and provide other ancillary information to support native bee monitoring?

Habitat data that would complement native bee monitoring are information on feeding and habitat resources; various metrics measuring blooming plants and nesting substrate were suggested. These include floral associations (what plants bees were collected on), species composition, abundance, and density. Recording presence of native, non-native, rare, or specialist blooming plant species was suggested. Repeated site sampling would establish phenological patterns and potentially identify indicator blooming plant species. Nesting related variables were suggested to assess both cavity and ground nesting capacity across sampled habitats; these variables were also called overwintering resources. These include soil type, moisture, and quality, which can be characterized by measuring particle size, density, compaction, and organic content. Assessing micro-topography could support and clarify soil quality measures; further, all soil measures are relevant to blooming plant metrics. Cavity nesting resources could be assessed by counting woody plant species, their condition, and their abundance in comparison to herbaceous species. These nesting measures were provided as a "best guess" as little is known about how to properly assess nesting quality for native bees. Measuring these variables through national native bee monitoring could provide clarity on nesting requirements for native bees, and an assessment protocol could be modified over time to gather the most relevant information on nesting.

Data that complements native bee monitoring and tracks key drivers of change in bee communities includes weather, climate, and land use data. Assessing temperature, wind, and precipitation over short and long time scales and microsite, local, and regional spatial scales could provide insight on phenology of both bees and plants and track changes in weather, climate, bees, and plants over time. Assessing land use and surrounding landscape context could provide additional information on available blooming plant and nesting resources; it could also inform on the threat level at sites associated with land use change and pesticide load. Assessing the presence of invasive bee and plant species could also inform change in bee communities over time. Other ancillary information suggested that could support native bee monitoring includes pesticide load, pathogen load, historic land use, fire history, presence of honey bee colonies, site history with endangered native bee or plant species, and gathering eDNA.

What is a detailed workflow using native bee and habitat data to detect bee population trends, identify drivers of bee population trends, and inform management decisions?

Answers to this question were vague, suggesting a broad uncertainty about how to go about creating this kind of workflow. Most of the suggestions rehashed the previous discussion questions described above. One group suggested pulling together existing data, then using that

to determine what supplementary data would be most important to collect at sites. The other group ranked habitat data to collect in the following order: flower densities, bare ground, vegetative cover, pithy stems, honey bee densities, but issued a caveat regarding how little is currently known regarding nesting habitat. Both groups addressed the time required to collect this information and expressed concern that too much time spent on ancillary data would take away from the focus on native bee occurrence. They suggested potentially mitigating this time through use of drones or geospatial work.

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