Introduction

The US National Native Bee Monitoring Research Coordination Network (RCN) held its first interactive workshop on May 13, 2021 on existing monitoring programs. Topics of discussion throughout the workshop addressed what pieces of these programs could be included in a US national native bee monitoring plan. The workshop consisted of two sessions: 1) a webinar session in which we heard six presentations on existing monitoring programs, and 2) a discussion session for which attendees split into breakout groups and discussed focal questions on outlining a US national native bee monitoring plan using information from the morning presentations. We heard presentations on bird, monarch butterfly, and bee monitoring projects. The RCN will continue to hold these interactive workshops through 2023 to gather feedback and insight on the development of a US national native bee monitoring plan. Upcoming workshops in the fall will address federal government bee monitoring efforts and the conservation goals of national bee monitoring.

Demographic summary of attendees

Table 1. Summary of invitees (n = 285) and attendees (n = 149) of the RCN workshop on existing bee monitoring efforts by employment sector.

	Invited	Attended
Academic	148	79
Federal	76	36
State	26	13
Nonprofit	15	9
Consultant	9	5
Extension	6	3
Industry	3	2
County	2	1

Table 2. Summary of invitees (n = 285) and attendees (n = 149) 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)	64	28
Mountain West (MT, ID, WY, CO, NV, UT, AZ, NM)	44	23
Pacific West (WA, OR, CA)	39	20
Lake States (MN, WI, MI)	31	16
Corn Belt (IA, MO, IK, IN, OH)	25	18
Northern Plains (ND, SD, NE, KS)	17	6
Appalachia (KY, TN, WV, VA, NC)	15	7
Southern Plains (TX, OK)	13	9
Southeast (AL, GA, SC, FL)	9	4
Canada	8	6
Delta (AR, LA, MS)	6	4
International	6	2
Alaska	5	5
N/A	2	1
Hawaii	1	0

Talk schedule for the webinar

- John Sauer and Sam Droege, USGS Eastern Environmental Science Center, on bird monitoring
- Karen Oberhauser, University of Wisconsin-Madison, on monarch butterfly monitoring
- Claire Carvell, UK Centre for Ecology and Hydrology, on the UK Pollinator Monitoring Scheme (PoMS)
- Sam Droege, USGS Eastern Environmental Science Center, on developing a US National Native Bee Monitoring Plan
- Matt Schlesinger and Erin White, New York Natural Heritage Program, on the Empire State Native Pollinator Survey
- Andony Melathopoulos and Lincoln Best, Oregon State University, on the Oregon Bee Atlas

Broad themes that emerged during the webinar

Community science

All six presentations described projects that are heavily reliant on community science to gather data on birds, monarch butterflies, or bees. Attendees were broadly supportive of these initiatives and discussed the potential benefits of community science as part of a national native bee monitoring plan, including: expanding the geographic areas surveyed, low labor costs, and empowering citizens to be engaged with and informed about the scientific process. Workshop attendees also brainstormed numerous ideas on integrating community science into a national native bee monitoring plan. Many attendees had experience leveraging iNaturalist to collect community science data on native bees, and there was much discussion on how to scale this up nationally.

The biases associated with community science were discussed at length during the webinar presentations. Methodological biases associated with community science include uneven geographic sampling, coarse identification of recorded species, and lack of environmental context. Accessibility biases associated with community science include geography, age, socioeconomic status, and race. Any national native bee monitoring plan must address these biases in order to successfully integrate community science into a large-scale monitoring scheme.

Pairing community science schemes with professional science or providing a flexible approach was also intensively discussed. Many of the programs presented at the workshop employ these tiered approaches, in which community members conduct broad observations and professional scientists conduct more targeted, rigorous study. Together, these efforts provide a clear, complementary assessment of pollinator populations.

Targeting focal plants for pollinator observations

Two of the four pollinator monitoring programs presented at the workshop conduct observations on focal plants: the Monarch Larva Monitoring Program surveys for eggs and larvae on milkweed, and one tier of the UK Pollinator Monitoring Scheme counts bees and hoverflies on 14 focal flowering plants. Assessing host plant associations was a frequent topic of discussion among workshop attendees; connecting bees to their host plant and habitat provides environmental context and links bees to phenological changes that occur over the growing season. Further, observing bees on plant removes potential issues associated with passive bee sampling with traps, including non-pollinator bycatch, biased specimen capture, and accumulating too many specimens to identify (i.e., contributing to the taxonomic bottleneck).

Funding sources and potential partnerships

Workshop attendees were motivated to leverage existing local, state, or regional monitoring programs into a national native bee monitoring plan. Attendees frequently asked about funding sources for the programs presented. These programs are funded at multiple agencies at all levels of government, and some are supplemented with private donations. Leveraging existing infrastructure would reduce fiscal strain on a national native bee monitoring plan; examples include iNaturalist, the NSF LTER sites, and existing state and local level monitoring programs.

Breakout group topics

Breakout 1: What are some aspects of bee biology that might require us to use different monitoring techniques/strategies from those used for birds and monarchs? How could we address these differences in a national native bee monitoring plan?

Bees are smaller, more speciose, and harder to identify than birds or monarchs. Bees do not migrate, and less is known about their nesting biology, introducing complications to finding bees in the field. Bee populations fluctuate annually and throughout the growing season; therefore, annual and monthly information may be needed to accurately track population trends. Sampling bees is more complex than sampling birds or monarchs. Researchers require physical proximity to bees to identify them; birds and monarchs can easily be identified in flight, and birds can be identified by song. Additionally, reaching habitat with high bee abundance and diversity can be difficult; this includes isolated alpine and desert areas. Finally, bees are frequently sampled with lethal methods; this is not the case with birds or monarchs.

To address these differences, standardization of lethal and non-lethal sampling methods would be required for a national native bee monitoring plan. Identifying monitoring objectives early in the development process will aid in this standardization. The US has a broad array of habitats; which to survey more intensively can be determined with concrete monitoring objectives. Ideas

for a national native bee monitoring plan frequently included tiered schemes and leveraged community science.

Breakout 2: What techniques/strategies directly translate from the UK pollinator plan, and which do not? What are the unique opportunities we have here in the US, given our State and Federal systems, tribal groups, public/private lands, National Park System, etc?

Many components of the UK Pollinator Monitoring Scheme (PoMS) can be incorporated into a US national native bee monitoring plan, including their overall goal to track changes in pollinator populations over time while maintaining awareness of the pollination service that these populations provide. PoMS has targeted 14 plants that bloom across the growing season for community members to count visiting bees; further, the scheme pairs a broad community science effort with a rigorous systematic effort for a more comprehensive assessment of UK pollinator populations. PoMS was developed by an interdisciplinary team of professional scientists, and they worked with stakeholders iteratively to develop pieces of their scheme. THe development process was rigorous; they tested sampling methods and found using multiple methods in a standardized way is effective for monitoring pollinator populations. They ran pilot studies before committing to their standardized procedures, and they considered statistical power when designing their national study layout. The atlas-style grid scheme they selected has been applied in multiple US state and regional bee monitoring efforts and would be scalable to a national level.

Differences between the US and the UK exist that may make developing a US national native bee monitoring plan more difficult, namely that the US is much larger, both geographically and demographically. The US features far more habitat diversity than the UK, and that is reflected in the diversity of their native bee communities: the UK has fewer than 300 bee species; the US has more than 4,000. The target plant approach of the UK PoMS may not translate to the US owing to high habitat diversity; very few native plants occur throughout the entire country. The number of sites required to sample for sufficient statistical power to track pollinator population changes in the UK is fewer than 75; to achieve this in the US, up to 500 sampling sites may be required. The institutional infrastructure in the UK is more concentrated and has a longer history than the US, particularly in the natural history sector. A US native bee monitoring plan would require buy-in for a wide array of government agencies at multiple levels, which may be difficult to achieve. The high habitat diversity and infrastructural variability of the US suggests that sampling methods may need to vary; national standardization of these methods presents a major obstacle. The US also has different cultural approaches to conservation that differ geographically; these include baseline knowledge of native bees, opinions on or the role of federal lands, state politics, roles of Indigenious groups, and various languages spoken.

These differences present opportunities to take advantage of in a US national native bee monitoring plan. Monitoring bee communities in unique ecosystems is something to emphasize; new species may be discovered, existing species may be found to be in decline, and ultimately, this could lead to new conservation strategies. The US has a robust network of community

science initiatives to engage with in monitoring wild bees, and institutional partners are developing techniques and technologies to train community scientists. It is critical, however, to ensure long-term sustainability in the development of a US national native bee monitoring plan, by providing adequate personnel and securing sufficient funding.

Breakout 3: Is the state atlas model a viable model for all states? Why or why not? If a state-based approach were employed, how would state efforts be (a) organized and (b) integrated, at a national scale?

The state atlas model consists of a gridded map; within each grid cell, a standard sampling procedure is used to survey for and monitor native bee populations. Standardizing this approach for all states would encourage typically overlooked states to get involved in bee monitoring, particularly with targeted support. It would also allow for integration of existing state monitoring schemes into a national network.

However, there are a number of obstacles to a state-based approach to a national native bee monitoring plan. States, like the country as a whole, vary widely in habitat diversity, bee species diversity, phenology, and institutional capacity to support bee monitoring efforts. Attendees with interstate partnership experience noted that state institutional infrastructure often dictates implementation of collaborative conservation efforts. State funding agencies may have varying priorities; as so little is known about native bee populations, it is difficult to justify funding conservation efforts at the state level. Lastly, a monitoring scheme focused on federal protected land may not be viable at the state level, as the amount and accessibility of these lands varies widely by state.

A frequently suggested alternative approach to a state-based native bee monitoring plan was a regional approach based on ecoregions or habitat types with federal oversight. With ecological boundaries, regions may encompass multiple states, or there could be multiple regions within one state. This removes reliance on individual states to provide their own funding and personnel; ideally, a regional effort would leverage existing programs, partnerships, and funding opportunities. Fostering communication among states could lead to a more efficient monitoring scheme in which redundancies are discovered and eliminated; it could also encourage innovation in monitoring approaches. More guidance on the feasibility of a regional native bee monitoring approach with federal oversight is needed from federal agencies, some of which operate at similar regional levels.

Workshop attendees provided many suggestions on how to organize and integrate a state or regional based national native bee monitoring plan. A network similar to the RCN was suggested as a permanent advisory body to guide and coordinate the implementation of the plan. A tiered approach with broad and fine-scale survey efforts was frequently suggested, as was utilizing existing infrastructure, such as state agencies, non-profit organizations, and collaborative partnerships. Providing tiers of participation may encourage adoption by diverse stakeholders. Developing a standardized protocol is important, but such a protocol must also allow for flexibility owing to varying institutional capacity. Partnering with national organizations

such as the Xerces Society or the Association of Fish and Wildlife Agencies may provide credibility and infrastructure in coordinating a national effort with states or regions. Extension Service programs provide substantial opportunity for connecting community scientists to bee monitoring efforts through work with crop growers, Master Naturalists, Master Gardeners, and other community stakeholders with an interest in native bee monitoring and conservation. Target plants were a frequent recommendation, as were target bee species; charismatic and easy to identify bee species such as bumble bees were suggested as an initial focus of a national native bee monitoring plan. This would ease the taxonomic bottleneck, encourage participation by community scientists, and allow for refinement of sampling methods before expanding monitoring efforts to other bee species. Lastly, attendees suggested using existing GIS technology and spatial data to locate potential target habitats and sampling sites as a means of emphasizing the importance of host plant associations and environmental context when gathering information on native bee populations.