

Alaska Bee Atlas

Inventory and Monitoring Plan and Protocol



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I. Introduction

Importance of Pollinators

Pollinators play a key ecological role that directly and indirectly affects wildlife and their habitat. Many species of plants are completely or partially dependent on pollinators for fruit and seed production, including plants in northern latitudes (Fig.1). A wide range of mammals and birds are reliant on fruits that are the result of insect pollination in Alaska (e.g., cloudberry and blueberry). Pollinators indirectly affect wildlife diversity and populations by promoting seed production of keystone food resources. For example, many species of willows, which are the primary forage species for moose, are largely insect-pollinated and if early emerging bee and flower-visiting flies are not present, the willows will not be able to produce seeds and colonize new areas; thus limiting forage and habitat availability of moose.



Figure 1. Alaska mining bee, *Andrena* sp., collecting pollen on the native rose, *Rosa acicularis*.

Pollinating insects are wildlife of conservation concern in their own-right and the Bureau of Land Management (BLM) - Alaska identifies five species of bumble bees as [BLM Sensitive Species](#), as well as five additional bumble bees and three butterflies as Watchlist Animals.

There have been significant declines in both honey bee and wild bee populations in Europe and North America for the past 50 years (Potts et al. 2010, Cameron et al. 2011, Koh et al. 2016). The scope of pollinator decline in North America is not entirely clear due to limited inventory and monitoring practices. Pollinator decline has been attributed to several factors that include, but are not limited to, habitat loss and fragmentation, loss of preferred floral resources, pesticide use, invasive plant species, and climate change

(Potts et al. 2010, Scheper et al. 2014, Koh et al 2016).

Bombus occidentalis (Western bumble bee) has declined significantly in the southern portion of its range in the last few decades and is now listed under the International Union for Conservation of Nature and Natural Resources (IUCN) Vulnerable Red List Category (Goulson et al. 2008, Hatfield et al. 2015, Sheffield et al. 2016). Furthermore, the species has been petitioned as a candidate for listing under the Endangered Species Act. Based on molecular evidence, the northern distribution of the species in Alaska and the Yukon is considered a different subspecies, *B. occidentalis mackyi* (Williams et al 2012). The distribution and abundance of this northern subspecies is poorly known, but efforts from previous studies in Alaska suggest that the Western bumble bee may not be declining in the North (Koch and Strange 2012, Pampell et al. 2015).

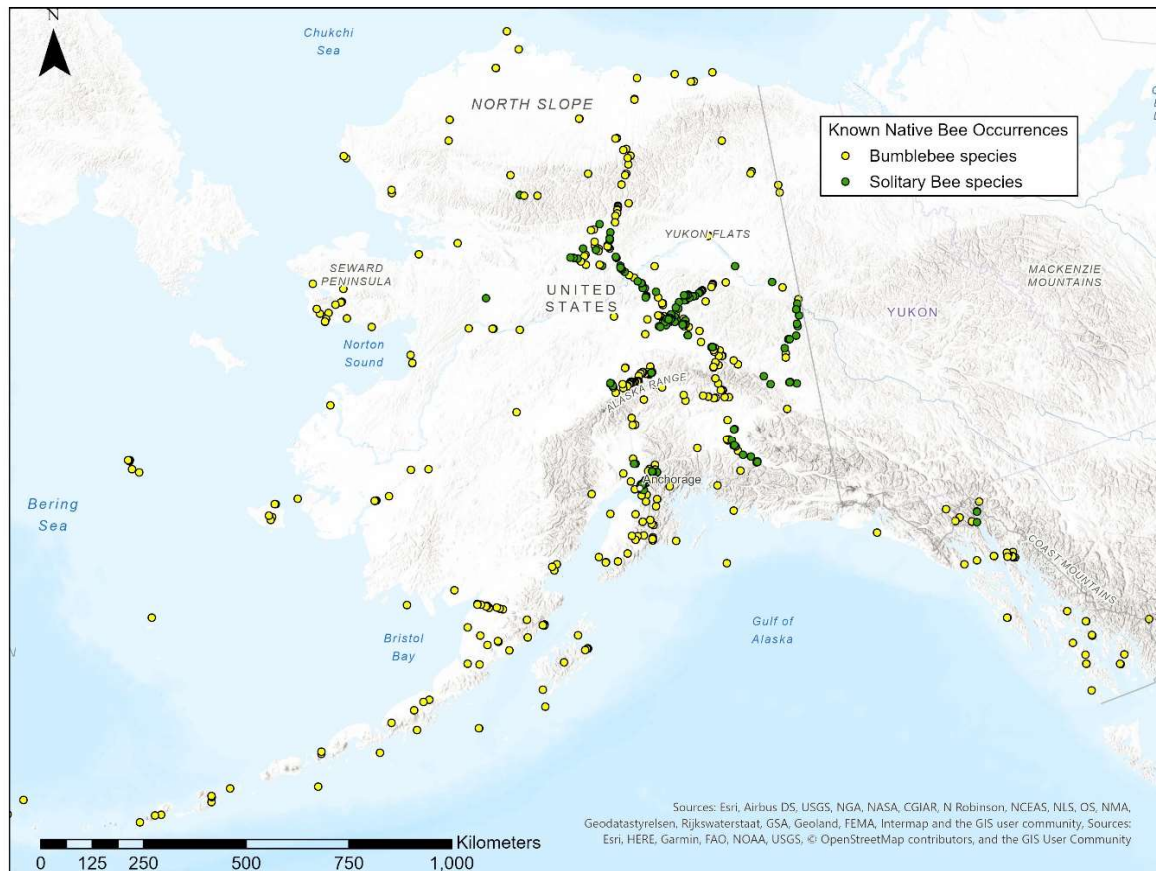


Figure 2. Distribution of bees collected across Alaska from 1877 to 2019. Data originate from museum collections and literature.

Current State of Pollinator Knowledge in Alaska

There are 22 species of bumble bees (*Bombus* sp.) found in Alaska which have been well documented across Alaska in a multitude of habitats, though less in the western and arctic regions (Figure 2). Some of the earliest bumble bee collections for the region date back to the late 1800's. Even with a long history of collections, new species are still being discovered in Alaska and neighboring Yukon Territory (e.g., Williams et al. 2016, Sheffield et al. 2020).

While pollinators provide essential ecological and agricultural services to Alaska, only one monitoring program has been initiated in the state and it was solely focused on bumble bees in an agricultural setting. Bumble bee diversity and abundance varied significantly throughout and between the two collecting seasons (Pampell et al. 2015). The monitoring study found that *B. occidentalis* had high rates of parasitic nematode infections.

An inventory of the National Park system documented pollinators in various habitats and elevations. The inventory program most frequently found *Bombus* and syrphid fly species in traps with solitary bees being less frequent (Rykken 2015, Rykken 2017). In Denali National Park, the alpine tundra habitats contained the highest diversity and abundance of pollinators compared to roadside and trails systems at lower elevations, though the alpine habitat had a higher intensity of

sampling (Rykken 2015). Conversely, in Gates of the Arctic National Park, disturbed and riparian areas had the highest abundance compared to alpine tundra habitats (Rykken 2017).

While the diversity of bumble bees is reasonably known, the diversity and distribution of non-social, or solitary bees, in Alaska is very poorly known. For example, available data are concentrated around Fairbanks and the road system of interior Alaska, limiting our understanding of their presence and importance statewide (Fig. 2). As their name implies, solitary bees do not conform to a socialize colonies or hives and do not have a separate caste system of workers and queens (female solitary bees both provision nests and lay eggs throughout their short adult lives). There is an estimation of 4,000 species of bees in North America (Cane and Tepedino 2001), with solitary bees accounting 98% of the species (Asher and Pickering 2020). Previous research documented over 50 solitary bee species in Alaska. They are most commonly found in open and sunny habitats in lowland settings such as roadsides and floodplains but many are primarily associated with the Steppe Bluff ecosystem in eastern interior Alaska and the Copper River Basin (Armbruster and Guinn 1989, Bishop and Armbruster 1999). Solitary bees have been found and observed in alpine tundra systems in Alaska at a much lower frequency than bumble bees, but extensive sampling has yet to occur.

The Alaska Center for Conservation Science (ACCS) initiated a bee monitoring program in Interior Alaska from 2017–2019 (with support provided by our state partners at the Alaska Department of Fish and Game) focused on the Steppe Bluff habitats; an ecosystem suspected to harbor a large diversity and abundance of solitary bees (ACCS *unpublished data*). This inventory effort has provided substantial data on the temporal habitat use of this rare ecosystem by pollinators. ACCS collected at least ten new species records for Alaska, the first male *Osmia maritima* in North America, and have molecular support for potentially undescribed taxa. The current estimated number of bee species in the state, combining data from the University of Alaska Museum, National Park Service, and ACCS is approximately 105.

With new state records for solitary bees, syrphid flies, and new species to science being found in Alaska in recent years, the diversity and distribution of pollinators of the region are not yet fully known. Efforts to initiate a statewide biodiversity collection protocol are therefore warranted given the limitations of baseline knowledge, coupled with conservation concerns and ecological importance of the group.

National and International Coordination

This Alaska Bee Atlas is designed to be compatible with the forthcoming U.S. National Program for Monitoring Native Bees (Woodard et al. 2020). In 2016, the Governmental Accountability Office issued a Report of Bee Health (GAO 2016) (<https://www.gao.gov/products/GAO-16-220>), which recommended that the USDA coordinate with other agencies to develop a federal pollinator monitoring plan. The plan includes action areas on gathering and cataloging data, identifying optimal survey methods, and identifying priority areas for monitoring. While this Alaska plan will be completed before the National Plan is published and implemented, this plan has been designed to fit within the general action areas of the National Plan.

Additionally, the Arctic Council-Conservation of Arctic Flora and Fauna (CAFF) State of the Arctic Terrestrial Biodiversity Monitoring Report (CAFF 2021) has identified pollinators as a focal ecosystem component to prioritize for monitoring across all Arctic Nations. Since many bee species are shared throughout the boreal forests and arctic tundra, the Alaska Bee Atlas can contribute to arctic-wide knowledge on bees.

Who Benefits and How Will the Data be Used?

ACCS has produced rarity assessments of all 22 known bumble bee species, four mining bee species, and all 80 known butterfly species in the state. Having basic distribution, area of occupancy, and habitat associations for these species is necessary data for assessing state conservation status ranks, which facilitate and inform federal land managers of sensitive species or those of greatest conservation concern. Additionally, fundamental baseline data would provide scientific support for those taxa under review for listing under the Endangered Species Act. ACCS disseminates these data online as part of public education/outreach and have presented results to state and federal land managers and at scientific meetings. The data can be viewed online at (<https://accs.uaa.alaska.edu/wildlife/pollinator-diversity/>).

Sampling Plan

In Alaska, bee sampling is heavily skewed toward the major cities of Anchorage and Fairbanks, as well as Delta Junction and on the highway system of interior Alaska (Figure 2 & Figure 3). We propose a baseline collection program to determine biodiversity of bees in Alaska, before implementing a monitoring program where an area has yearly sampling events. This will allow us to identify regions, habitats, and species that are of conservation concern and more effectively target specific monitoring actions. The same methods outlined here can be adapted to monitoring plans to detect local population declines.

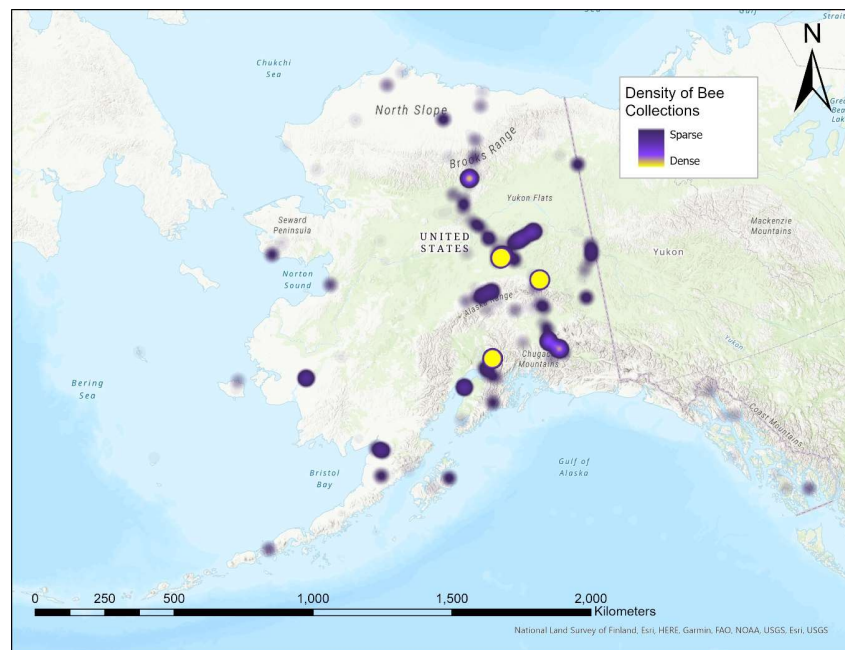


Figure 3. Density of bee collection occurrences in Alaska highlighting well sampled areas in bright yellow.

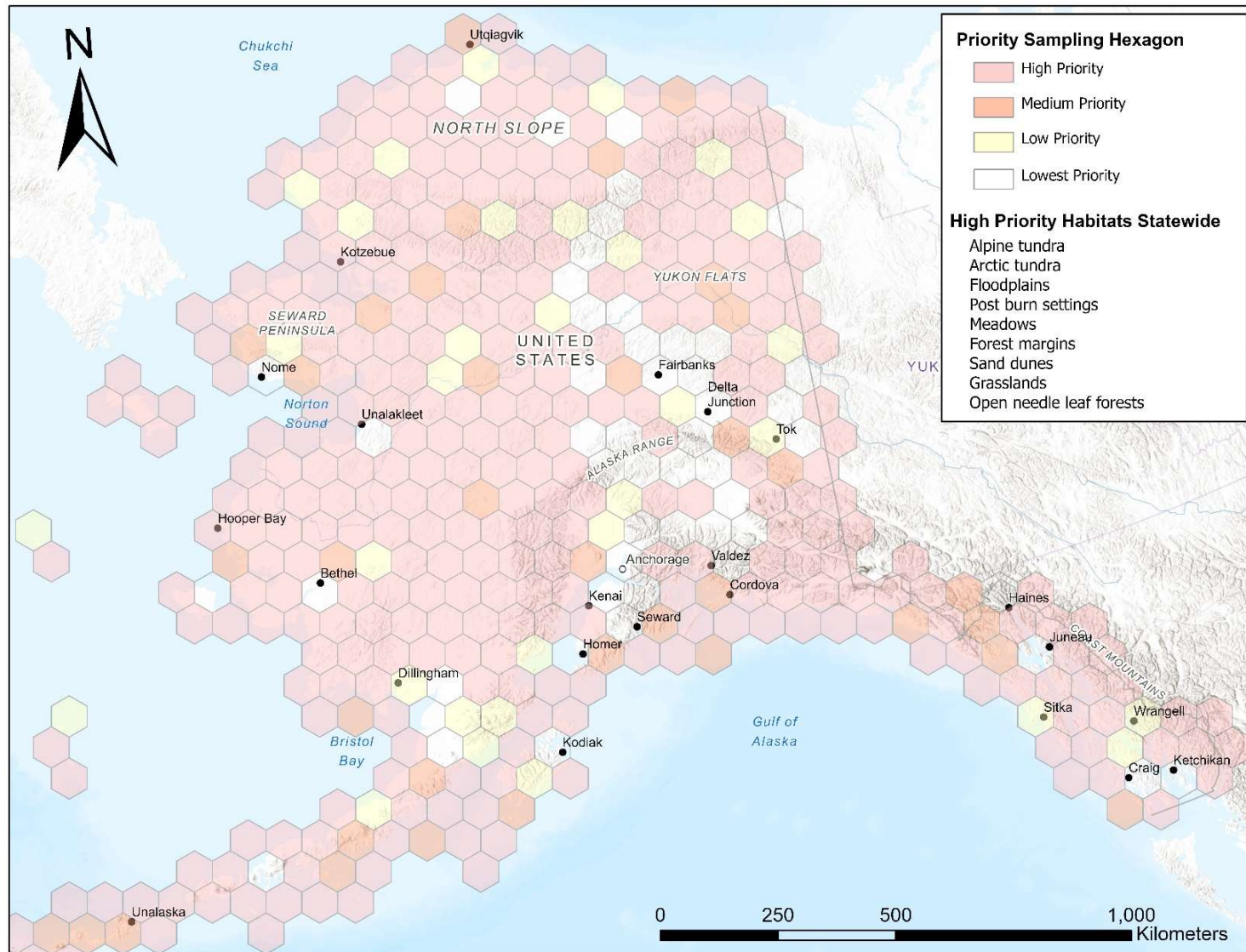


Figure 4. Sampling areas of priority in Alaska based on the number of bees collected in the past. The entire Aleutian region is not shown but is a High Priority. Areas marked 'Lowest Priority' can still be sampled in high priority habitats or a yearly monitoring station established.

The initial years of this survey plan will prioritize participants visiting regions away from the centralized road system, filling in the geographic and potential biodiversity gap of these areas. Regions of Interest are summarized in Table 1 and Figure 4. Participants staying within the road system are still encouraged to participate but recommended to sample the underrepresented habitats summarized in Table 1. Monitoring can occur at any location land managers find fitting, but alpine systems are of particular interest due to their intrinsic vulnerability.

Sampling under this plan should be coordinated through ACCS to ensure efficient sampling and available funding for specimen identification. Please contact ACCS to participate in the bee sampling survey and monitoring plan. Contact information is located below.

Please note: ACCS will only accept sampling efforts from participants who are in coordination with the appropriate land management agency for the proposed sampling area.

Table 1. Alaska regions and habitats with data gaps.

Regions of Interest	Habitats of Interest
Ahklun Mountains	Alpine tundra
Aleutian Islands	Arctic tundra
Bering Sea Islands	Floodplains
Cook Inlet Basin	Post burn settings
Davidson Mountains	Meadows
Franklin Mountains	Forest margins
Kuskokwim Mountains	Sand dunes
Lime Hills	Grasslands
North Slope	Open needle leaf forests
Nulato Hills	
Seward Peninsula	
Southeast Alaska (<i>broadly</i>)	
Southern Alaska Range	
Western Alaska (<i>broadly</i>)	
Yukon Flats	

II. Sampling Protocol

We describe four survey effort methods that participants can choose based on their time commitment and resources. We strongly encourage the Active Survey approach because it is the most comprehensive in documenting the diversity of bees at a location, however it requires more time and supplies. We understand the limitations this may impose and provide alternatives to suit a participant's available time or skills and abilities:

- **Passive Survey**- lowest time commitment and effort. Bee bowl traps are placed in a habitat for 24 hours and insects are collected at the end of the sampling time frame. Detailed instructions are in Appendix A. Passive Survey Procedure.

- **Intermediate Survey**- low time commitment but additional 15 minutes of effort. This follows the Passive Survey Procedure with the addition of a blue vane trap. Detailed instructions are in Appendix B. Intermediate Survey Procedure
- **Active Survey**- highest time commitment and effort. In addition to either the Passive or Intermediate Survey, participants will conduct two 20 min. sampling bouts with an insect net. This will require actively capturing and killing bees. A non-kill method is also available, but is only useful for bumble bees in which most species can be identified with macroscopic patterns of hair color. Detailed instructions are in Appendix C. Active Survey Procedure.
- **Netting Only Survey**- low time commitment and effort. This will be an active 20 min. sampling effort of netting bees. This is particularly useful if participants are not at a location for a long period of time. A non-kill method is also available, but is only useful for bumble bees. The non-kill netting method is the only approach we recommend in the spring for bumble bees to limit the killing of queens. Detailed instructions are in Appendix D. Netting Survey Procedure and Non-kill Methods.

Materials

Below is a list of supplies and materials needed to perform the bee survey. ACCS can provide many of the materials upon request. Photos of the various containers/jars included in Appendix E.

Bee bowls*	<i>Additional for Intermediate Survey</i>
Large bottle almost full of water (Plan on 1 L/15 bowls)	Blue vane trap*
Plain, unscented dish soap*	Zip ties*
Small strainer*	Stake or pole
Plastic spoon*	Hammer
Sealable plastic bags	Fumigant strip*
Specimen cups*	
Permanent marker	<i>Additional for Active or Netting Only Survey</i>
Pencil	Insect net
Scissors	Killing jar
Flagging tape	Killing agent
Preservative*: ethanol, propylene glycol, or denatured alcohol	Timer/stopwatch
Camera	<i>Non-kill methods for netting (A or B)</i>
GPS unit	A. Ice & ice chest or insulated box
Data sheet (end of this manual)	1. Vials*
Paper	B. Photo Chamber*

**Materials that can be provided by ACCS.*

Bee Bowl Traps

Bee bowl traps, also known as pan traps, are a standardized method for bee monitoring in the U.S. and are a favored method due to their low cost and high efficiency (Westphal et al. 2008, Dorege 2015). A standardized bee monitoring program for the United States is in the early stages and we follow the standardized guideline for bee monitoring as described by Droege (2015). The primary author has successfully used this method to monitor bees in southwest Idaho (Fulkerson and Kinter 2013) and adapted the methods for a pollinator study of the Steppe Bluff ecosystem of Alaska (Fulkerson et al. *in prep.*).

Bee bowl traps are 4-ounce translucent plastic cups painted white, fluorescent yellow, or fluorescent blue that reflect UV light (Figure 5). All three colors of bowls are used within the study because not all bee species are equally attracted to the same colors. We also use an asterisk design with black marker drawn on the base to mimic UV floral guides to enhance attraction (Wilson et al. 2016).

The bee bowls are filled with $\frac{1}{4}$ full with a soapy water solution. Soap is used to break the water tension, allowing bees to be trapped in the bowl. The soapy water solution does not need a consistent amount of soap; a simple unmeasured squirt is sufficient. Any brand will suffice, but **please use a non-scented dish soap**. Scented soaps can artificially attract unwanted insects, and mammals.

Seasonality Sampling

Collecting pollinators can occur anytime between late April and mid-August for most of Alaska. Even with most of the early spring vegetation looking brown, willows are often the first to flower and provide important food resources for bees. Pollinator activity diminishes in windy, rainy, foggy, or cold weather. Plan the bee collecting activity around favorable weather when bees are more active. Specifically, sample on sunny to partly sunny days when the temperature is between 60 and 90 °F (15 – 32 °C) and no rain is expected. Wind should be no greater than a gentle breeze (<12 mph). Visual cues of wind at this speed are where leaves and twigs are in constant motion, fallen leaves blow around, or flags extend out (NWS 2020).

The early spring marks the time for bumble bee queens to emerge and search for a new nesting location and floral resources. Sampling efforts at this time frame may have negative consequences since killing a queen in this early stage will disrupt colony development. This early sampling period varies across the state and special coordination with ACCS should occur. We recommend the Passive or Netting Only Survey options during this time frame in habitats that are particularly good for bumble bees (alpine and arctic tundra, boreal and temperate rain forests, and forest margins). Bee bowls do not catch a large number of bumble bees, however blue vane traps can catch large numbers of bumble bees (Sikes and Rykken pers. comm.)



Figure 5. Blue bee bowl with collected bees. Permanent marker included for size reference.

Trap Duration Time

We highly encourage bee bowls be left within the study area for 20 to 24 hours, though shorter time frames of 8 to 12 hours are acceptable. Lengths greater than 48 hours are not recommended as captured insects will degrade sitting in the trap, making identifications more difficult. The bowls can be reused many times and therefore several sampling events can occur if participants are in a given area for a long period of time.

We have observed bumble bees foraging in the late evening during the Alaska midnight summer sun, though at a lower frequency. Evening and night foraging behavior of bees has not been studied in Alaska, but we expect overnight bee bowls to enhance collection due to the longer daylight hours.

Sample Size

A sample size of 30 bee bowls has been recommended for estimating species richness and diversity of pollinators, however the sample size is subjective to regional habitat and fewer bowls have been found to be effective in some areas (Shapiro et al. 2014). In our previous work, we limited our sample size to 15 bowls per habitat due to the size of the microhabitat. There is insufficient data to recommend a specific sample size for habitats in Alaska; however, we suggest participants use 15 to 21 bowls for a sampling event.

There is no evidence in literature that the use of traps negatively impacts pollinator populations or non-target arthropods, even when monitoring methods are used bi-weekly for long term monitoring (Lebuhn et al. 2015, Gezon et al. 2015). However, we still suggest a well-planned collection effort that implements responsible collecting.

Bowl Placement

Bee bowls are placed on the ground in a transect line in alternating colors (Figure 6). The transect line location is up to the discretion of the collector with consistency in mind. The transect should be placed within a homogenous area or habitat. For example, a transect should occur entirely within a forest system, not crossing over into other habitat types such as tree line into shrubland or alpine tundra. Another example, if sampling a river



Figure 6. Example of a bee bowl transect with arrows showing bowls that are not as visible from the camera view.

floodplain, keep the entire transect within the river scrub floodplain, not partially in both the floodplain and forest setting.

Avoid sampling in dense tall vegetation unless extra effort is used to increase visibility of the bee bowls by trimming vegetation or attaching the bowls to a stake. The bowls can be secured to a stake in a cup holder made from PVC pipe to be elevated off the ground. Generally, *if you can see the bee bowl, so can the bees*. Avoid mountain ridges or other areas exposed to consistent windy weather, as this is typically less favorable for pollinator flight. Warm, sheltered microsites typically harbor more bees. In Alaska, forested habitats have yielded fewer numbers of bees compared to open meadows, but are still acceptable sampling habitats.

We have experienced the occasional loss of a bee bowl due to either wind or animals. Please record the number of bowls placed and retrieved on the data form.

Blue Vane Traps

Blue vane traps (BVT) consists of a plastic jar with and a blue funnel screw cap with interconnecting vanes (Figure 7). The BVT has been a successful passive collecting method for bees in lower latitudes but recently has been replaced by for cheaper and quicker traps such as the bee bowls. The use of BVT has had mixed results in Alaska from successfully collecting many bees to collecting no bees (Pampell 2010, Rykken 2015).

The BVT is attached to a stake or post one meter from the ground and sets on its side, parallel to the ground.

This reduces rain and water accumulation in the trap. Fumigant is placed inside the white bowl to kill insects that are trapped inside. Those that are still alive, the participant will need to transfer the insects to a killing jar.

The BVT is a supplemental trap that will be placed in the middle of the bee bowl transect. Traps have differing success based on bee species preferences and having multiple trap type enhances the biodiversity of the collecting event. If the BVT is particularly successful in collecting a large number of bees for the sampling period, the participant can use their best professional judgement to end the sampling time early.

Netting

Not all bees are attracted to passive traps or may not see a particular trap, therefore they are not caught. Active netting increases the sampling ability to capture the most reflective diversity of bees in the sampling site. It also provides an alternative opportunity to collect valuable data without killing bumble bees. An insect net is required for this activity. If participants are within the Anchorage area, they may be able to borrow a net from ACCS for their sampling plan if available. Insect nets can be inexpensive and suggested resources are listed in Appendix D.



Figure 7. A properly secured blue vane trap attached to a post horizontally with plastic zip ties and tied with string.

Participants will spend 20 active minutes walking in a defined habitat searching for bees and flies on flowers. If the netting activity is in addition to the passive traps, the meander should occur within 100 meters of the transect, within the same sampling ecosystem. A stopwatch is needed to time the active search. The stopwatch should be paused during the transfer of pollinators to a killing jar and data recording. The stopwatch will resume until another successful capture or the 20-minute time is completed. Participants should be actively walking within the sampling site and not a ‘wait and see’ approach with an individual flower.

The netting activity can be performed solo or with multiple people. The 20 minutes should be divided equally among the participants who follow the netting survey instructions independently. For example, if two participants are netting, then each will have 10 minutes to perform the netting activities. If three participants, then 6:36 for each participant.

There are many techniques to successfully capture pollinators and we highlight two here. A common netting technique uses quick swings to snatch pollinators from flowers, but this damages the plant and takes some practice. After a forceful swing, immediately rotate the net handle to close off the net opening and then inspect the net to see if a successful capture occurred. An alternative approach is to hold the end of the net in one hand and net handle in the other and slowly place the net over the flowers and then lower the net in one motion. Bees are typically focused on pollen and nectar collection and often do not notice the net. However, flies are quick to escape with this method. Insects naturally fly and crawl upwards to the net end, at which point the middle of the net is grabbed and closed off, holding the pollinator in the end of the net. Next, the netted insects are transferred to a killing jar or a photo chamber or vial if non-lethal methods are used (see below). At this point the stopwatch should pause so the participant can perform the sample and data collection. Netting requires some patience, finesse, and sometimes luck. Try several methods to find what best suits your skills and abilities.

The Netting Procedure is located in Appendix D. with some video references.

Preserving the Samples

Killing Jars and Killing Agent

A killing jar is needed for collecting pollinators in the Active Survey approach. An optional non-kill method is described in the next section but should only be applied to bumble bees. The killing jar is glass jar with screw lid and often contains plaster at the bottom to absorb and dissipate a killing agent. If such a kill jar is not available, a simple 1-quart canning jar with a layer of loose tissue paper and then cotton balls on the bottom is sufficient. **DO NOT USE PLASTIC CONTAINERS**, unless specifically designed for this purpose (e.g., BioQuip’s PET plastic-collecting jar series). Plastic containers will melt when in contact with most killing agents.

The most common killing agent is ethyl acetate, which can be obtained as nail polish remover. Alternatively, the killing jar can be placed in the freezer for an hour.

1. Charge the jar: add about 1 teaspoon of ethyl acetate to the kill jar and keep the lid closed. The jar will remain charged for several days.
2. If the jar is not labeled with a warning, do so with prominent lettering such as:

Poison- ethyl acetate

3. Add an additional crumpled paper towel or face tissue to absorb excessive moisture and to provide some separation of the insects/reduce damage to insects is recommended.

If the participant is flying to field locations: Ethyl acetate is a hazardous material but allowed in checked or carry-on luggage in small quantities. Please refer to TSA guidelines for updated information.

Preservative

ACCS can provide appropriate preservative to participants or participants can self-provide. The preferred preservative for insects collected in the field is ethanol. Ethanol maintains the integrity of the specimen, is easy to wash and remove, and minimizes DNA degradation. Pure grain alcohol, such as Everclear, can be used when diluted to 70% with water. Alternatively, propylene glycol (PG) can be used to preserve collected insects and minimizes DNA degradation but requires more lab work for processing the insects. PG is a non-toxic sugar alcohol that is used in non-toxic anti-freeze, food additives, and e-cigarette fluids. Lastly, denatured alcohol can be used, however insect samples experience DNA degradation resulting in slightly lower performance for DNA barcoding and should only be used if ethanol or PG can't be found. Klean Strip brand of clean burning fuel is available at local big box stores (Figure 8) and should be diluted with water to create a 70% mixture. Note that denatured alcohol and ethanol are not the same as rubbing alcohol. Please adhere to the brand names mentioned for consistency and safety.



Figure 8. Denatured alcohol for insect preservation.

Typically, 30 mL (1 ounce) of preservative is needed for each transect or sampling event. Pour just enough preservative to cover or saturate the collected insects in the specimen cup.

If the participant is flying to field locations, there are two options:

1. Store collected insects in a cold cooler for up to 5 days or freeze the collection. Immediately preserve the insects with preservative when returning to the office.
2. Use PG: either food grade or non-toxic anti-freeze (PEAK Sierra Brand only). PG is not hazmat and documentation is not needed. Either the full strength or a 50/50 blend are suitable.

Non-kill methods

Non-kill methods are not recommended for solitary bees since these species are identifiable only by microscopy or DNA barcoding. Non-kill methods can be used for bumble bees since identification can be achieved with photographs for most bumble bee species but error rates are higher than having physical specimens. A monitoring plan for bumble bees is possible with this method.

We adopt the approach of the Northwest Bumble Bee Atlas (www.pnwbumblebeatlas.org), for the non-kill methods and summarized here as two options, 1. the chilled method and 2. photo chamber method. The chilled method requires access to ice or very cold streams. Transporting ice

to remote locations in Alaska is not particularly feasible and best reserved for near populated areas or the road system.

1. **Ice Method:** After netting a bumble bee, the bumble bee is transferred to a vial and placed in a cooler with ice (crushed is best) for at least 10 minutes before photographing the bumble bee. If ice is not available, the vials can be placed in remnant snow banks, or in very cold running streams for 10 to 15 minutes or until the bees are cold and not moving fast.
2. **Photo Chamber Method:** After netting a bumble bee, the bumble bee is transferred to a photo chamber vial for photography.

*Clear macro photographs **are essential** for this method to be successful. Please review the detailed methods in Appendix D. and photography tips from the Pacific Northwest Bumble Bee Atlas (https://www.pnwbumblebeeatlas.org/photo_tips.html).*

Delivering Data and Samples

Deliver all samples, data sheets, and photos to ACCS for processing. Please contact ACCS for pick up or mailing procedures.

Contact:

Justin Fulkerson or Rachel Kelty
Alaska Center for Conservation Science
University of Alaska Anchorage
3211 Providence Drive
Anchorage, AK 99508
907-786-6387
jrfulkerson@alaska.edu OR rkelty@alaska.edu
<https://accs.uaa.alaska.edu/wildlife/pollinator-diversity/>

III. Identification and Data Processing

After ACCS receives samples, they are processed with a washing and blow dry method then pinned. Specimen data will be recorded and housed with databases at ACCS and displayed online. Final pinned specimens will either be retained at ACCS or sent to the University of Alaska Museum of the North Entomology collection for preservation.

Identification of bees is the most difficult and time intensive aspect of the inventory method. There are relatively few taxonomic experts in North America available for bee identification. Ecologists at ACCS have been identifying bees from previous studies and sending material to experts for identification. This has allowed ACCS



*Figure 9. Reference photo displaying mandible of *Osmia* cf. *simillima*. Photo by R. Kelty.*

to develop a reference collection of Alaska bees for identification purposes (Figure 9).

DNA barcoding is an additional approach for bee identification that is gaining in utility. ACCS has implemented this method with positive results. Small amounts of tissue from the bee, such as an antennae, are fixed in ethanol and sent to a lab for DNA sequencing. An online database processes the sequences and make comparisons to other taxa in online databases. For those specimens that might be difficult to identify or are of poor quality, the result is an accurate identification to the species level (Figure 10).

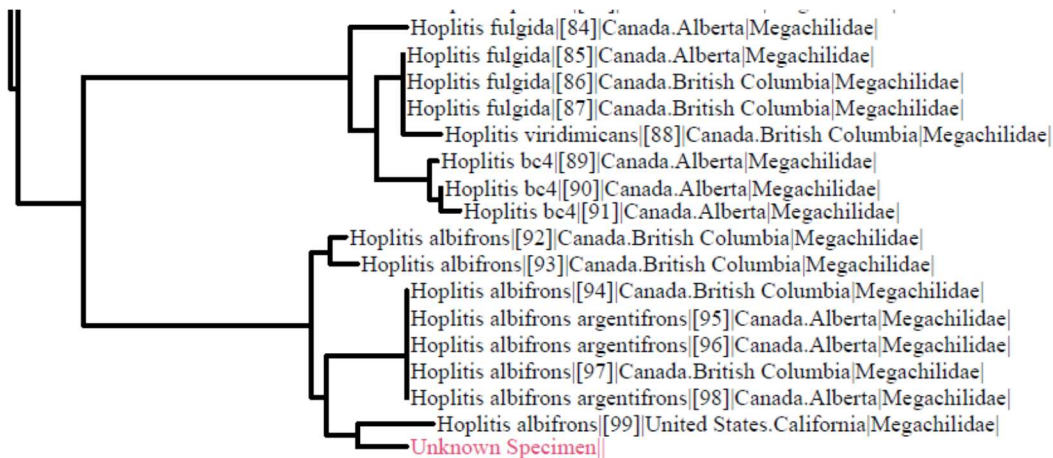


Figure 10. Results of DNA barcoding identify an unknown solitary bee as belonging to Hoplitis albifrons.

IV. Products

The initial effort will be focused on developing a network of participants, refining protocols, and ensuring the workflow is operating efficiently. Second, the project aims to summarize the biodiversity and biogeographic data to the public in an online portal. A significant goal is to document all bee species known to the region. ACCS and the Alaska Museum of the North Entomology Collection have been compiling a comprehensive list of bee species, but recent work has shown new species and data gaps. The list of Alaska bumble bees and some solitary bees with their biogeographic data can be found at: <https://accs.uaa.alaska.edu/wildlife/pollinator-diversity/>. Third these data will be used to update statewide conservation ranks that inform sensitive species lists with federal agencies.

After bee samples are curated by ACCS, bees will be deposited at the Alaska Museum of the North Entomology Collection and a small collection will be reserved at ACCS as identification reference material. Museum data will be displayed in the online ARCTOS database: <https://arctosdb.org/>. [DNA barcoding data are publicly available to scientists at online accessible databases.](#)

V. Management Implications

Management of native bee species and their habitat in Alaska has been hindered due to a lack of knowledge of species distribution, status, trend, habitat associations, and floral resource preferences. Proactive management will be facilitated with additional information on native bees.

While initially designed with BLM land management in mind, there will be immediate and long-term benefits to other managers in Alaska with this monitoring plan and additional data collection. Increasing coordinated monitoring will benefit all land and species managers by better informing statewide trends in the conservation status of pollinators and their habitats. A better understanding of native bee species will allow for more effective habitat management and could help avoid the need to list species through the Endangered Species Act.

Due to the remote nature of most habitat in Alaska, there is minimal information for many land managers on bee species present or likely to occur in a region. In order to assess potential impacts on native bees and bee habitat and make informed land management decisions, additional bee information is needed. Currently, the distribution of the five BLM Sensitive bumble bee species is poorly understood, making it difficult to manage habitat for these species or avoid or reduce impacts of proposed activities.

Suitable data that are useful to inform management decisions is costly, and the patchwork of land managers make it difficult for any single agency to collect all the data necessary. By working together with accepted sampling protocols to efficiently collect and analyze bee data, land and species managers can more effectively collaborate toward the common goals of proactively managing these species and minimizing negative effects of other authorized land uses.

VI. Outreach and Recruiting

We plan to continue and expand the bee monitoring effort and collaborate with agency partners and community (citizen) scientists in the following years. This will enhance data collection from a larger region to generate more accurate conservation status ranks. Community scientists trained by experts has been a successful model in developing a long-term bumble bee and butterfly monitoring project in Norway (Åström et al. 2019). Specifically, these data have detected changes in communities and abundance across time and space in a statistically defensible framework. See the Alaska Bee Atlas Community Science Plan (2021) developed by ACCS, BLM, FWS, and ADFG for more information.

VII. Additional Resources

Bee Information and Identification

DiscoverLife. (2020). BEES; APOID WASPS. <https://www.discoverlife.org/mp/20q>. [Accessed 10 Dec. 2020]

Bumblebees: their behaviour and ecology. D. Goulson, Oxford University Press, 2003.

Bumblebee Economics. B. Heinrich, Harvard University Press, 2004.

Bumble bees of North America: an identification guide. Paul H. Williams, et al., Princeton University Press, 2014.

Bumble Bees of the Western United States. Koch et al. 2012.

<https://www.fs.fed.us/wildflowers/pollinators/documents/BumbleBeeGuideWestern2012.pdf>
[Accessed 10 Dec. 2020]

Xerces Society for Invertebrate Conservation. <http://www.xerces.org/bumblebees/> [Accessed 10 Dec. 2020]

Floras and Wildflower Identification Guides

Alpine plants of the Northwest: Wyoming to Alaska. Jim Pojar, et al., Lone Pine Publishing, 2013.

DenaliFlora. LucidMobile. 2016. *Phone app. Available on iOS and Android devices*

Flora of Alaska and neighboring territories: a manual of the vascular plants. Eric Hultén, Stanford University Press, 1968.

VIII. Literature Cited

Armbruster, W., & Guinn, D. 1989. The Solitary Bee Fauna (Hymenoptera: Apoidea) of Interior and Arctic Alaska: Flower Associations, Habitat Use, and Phenology. *Journal of the Kansas Entomological Society*, 62(4), 468-483. Retrieved April 27, 2020, from www.jstor.org/stable/25085123

Ascher, J. S., & Pickering, J. 2020. Discover Life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila). https://www.discoverlife.org/nh/cl/counts/Apoidea_species.html. (Accessed 9 December 2020).

Åström, S., J. Åström, K. Bøhn, J. Gjerjaug, A. Staverløkk, S. Dahle, and F. Ødegaard. 2019. Nasjonal overvåking av dagsommerfugler og humler i Norge: Oppsummering of aktiviteten i 2019. NINA Rapport 1811. Norsk institutt for naturforskning.

Bishop, J.A., & Armbruster, W.S. 1999. Thermoregulatory abilities of Alaskan bees: effects of size, phylogeny and ecology. *Functional Ecology*, 13(5), 711-724.

Cameron, S.A., Lozier, J.D., Strange, J.P., Koch, J.B., Cordes, N., Solter, L.F., & Griswold, T.L. (2011). Patterns of widespread decline in North American bumble bees. *Proceedings of the National Academy of Sciences*, 108(2), 662-667.

Cane, J. H., R.L. Minckley, & L.J. Kervin. 2000. Sampling bees (Hymenoptera: Apiformes) for pollinator community studies: pitfalls of pan-trapping. *Journal of the Kansas Entomological Society*, 73(4), 225-231.

Droege, S. 2015. The very handy manual: how to catch and identify bees and manage a collection. (Brochure).

Fulkerson, J.R, and C.L. Kinter. 2013. Reproductive Ecology and Bee Associates of Packard's Milkvetch (*Astragalus cusickii* var. *packardiae*), A Rare Plant Endemic to Southwestern Idaho. Idaho Natural Heritage Program, Idaho Department of Fish and Game, Boise, Idaho, 33 pp. plus appendices.

Gezon, Z.J., Wyman, E.S., Ascher, J.S., Inouye, D.W., & Irwin, R.E. 2015. The effect of repeated, lethal sampling on wild bee abundance and diversity. *Methods in Ecology and Evolution*, 6(9), 1044-1054.

- Goulson, D., Nicholls, E., Botías, C., & Rotheray, E.L. 2015. Bee declines driven by combined stress from parasites, pesticides, and lack of flowers. *Science*, 347(6229), 1255-1257.
- Hatfield, R., Colla, S., Jepsen, S., Richardson, L., Thorp, R., & Jordan, S.F. 2015. IUCN assessments for North American *Bombus* spp. See <http://www.xerces.org/wp-content/uploads/2014/12/North-American-Bombus-Red-List-assessments-10-2014.pdf>.
- Koh, I., Lonsdorf, E.V., Williams, N.M., Brittain, C., Isaacs, R., Gibbs, J., & Ricketts, T. H. 2016. Modeling the status, trends, and impacts of wild bee abundance in the United States. *Proceedings of the National Academy of Sciences*, 113(1), 140-145.
- Koch, J.B., & Strange, J.P. 2012. The status of *Bombus occidentalis* and *B. moderatus* in Alaska with special focus on *Nosema bombi* incidence. *Northwest Science*, 86(3), 212-220.
- Lebuhn, G., Droege, S., Connor, E.F., Gemmill-Herren, B., Potts, S.G., Minckley, R.L., Griswold, T., Jean, R., Kula, E., Roubik, D.W. and Cane, J., 2013. Detecting insect pollinator declines on regional and global scales. *Conservation Biology*, 27(1), pp.113-120.
- National Weather Service. 2020. Estimating Wind. <https://www.weather.gov/pqr/wind>. (Accessed 10 Dec 2020).
- Pampell, R., Sikes, D., Pantoja, A., Holloway, P., Knight, C., & Ranft, R. 2015. Bumble bees (Hymenoptera: Apidae: *Bombus* spp.) of interior Alaska: species composition, distribution, seasonal biology, and parasites. *Biodiversity Data Journal*, (3).
- Potts, S.G., Biesmeijer, J.C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W.E. 2010. Global pollinator declines: trends, impacts and drivers. *Trends in Ecology & Evolution*, 25(6), 345-353.
- Rykken, J. 2015. Insect pollinators of Denali National Park and Preserve: A survey of bees (Hymenoptera: Anthophila) and flower flies (Diptera: Syrphidae). Natural Resource Report NPS/DENA/NRR—2015/952. National Park Service, Fort Collins, Colorado.
- Rykken, J.J. 2017. Insect pollinators of Gates of the Arctic NPP: A preliminary survey of bees (Hymenoptera: Anthophila) and flower flies (Diptera: Syrphidae). Natural Resource Report NPS/GAAR/NRR—2017/1541. National Park Service, Fort Collins, Colorado.
- Sheffield, C.S., Oram, R., & Heron, J.M. 2020. *Bombus* (*Pyrobombus*) *johanseni* Sladen, 1919, a valid North American bumble bee species, with a new synonymy and comparisons to other “red-banded” bumble bee species in North America (Hymenoptera, Apidae, Bombini). *ZooKeys*, 984, 59-81.
- Scheper, J., Reemer, M., van Kats, R., Ozinga, W.A., van der Linden, G.T., Schaminée, J. H., Siepel, H., & Kleijn, D. 2014. Museum specimens reveal loss of pollen host plants as key factor driving wild bee decline in The Netherlands. *Proceedings of the National Academy of Sciences*, 111(49), 17552-17557.
- Shapiro, L.H., Tepedino, V.J., & Minckley, R.L. 2014. Bowling for bees: optimal sample number for “bee bowl” sampling transects. *Journal of Insect Conservation*, 18(6), 1105-1113.

- Sheffield, C.S., Richardson, L., Cannings, S., Ngo, H., Heron, J., & Williams, P.H. 2016. Biogeography and designatable units of *Bombus occidentalis* Greene and *B. terricola* Kirby (Hymenoptera: Apidae) with implications for conservation status assessments. *Journal of Insect Conservation*, 20(2), 189-199.
- Westphal, C., Bommarco, R., Carré, G., Lamborn, E., Morison, N., Petanidou, T., Potts S.G., Roberts S.P., Szentgyörgyi H., Tscheulin T., & Vaissière, B.E. 2008. Measuring bee diversity in different European habitats and biogeographical regions. *Ecological Monographs*, 78(4), 653-671.
- Williams, P.H., Brown, M. J., Carolan, J. C., An, J., Goulson, D., Aytekin, A.M., Best, L.R., Alexandr, M.B., Cederberg, B., Dawson, R., Huang, J., Ito, M., Monfared, A., Raina, R.H., Schmid-Hempel, P., Sheffield, C.S., Šima, P., & Xie, Z. 2012. Unveiling cryptic species of the bumble bee subgenus *Bombus* s. str. worldwide with COI barcodes (Hymenoptera: Apidae), *Systematics and Biodiversity*, 10:1, 21-56, DOI: 10.1080/14772000.2012.664574
- Williams, P.H., Cannings, S.G., & Sheffield, C.S. 2016. Cryptic subarctic diversity: a new bumble bee species from the Yukon and Alaska (Hymenoptera: Apidae), *Journal of Natural History*, 50:45-46, 2881-2893, DOI: 10.1080/00222933.2016.1214294
- Wilson, J.S., Griswold, T., & Messinger, O.J. 2008. Sampling bee communities (Hymenoptera: Apiformes) in a desert landscape: are pan traps sufficient? *Journal of the Kansas Entomological Society*, 81(3), 288-300.
- Wilson, J.S., Jahner, J.P., Starley, L., Calvin, C.L., Ikerd, H., & Griswold, T. 2016. Sampling bee communities using pan traps: alternative methods increase sample size. *Journal of Insect Conservation*, 20(5), 919-922.
- Woodard, S.H., Federman, S., James, R.R., Danforth, B.N., Griswold, T.L., Inouye, D., McFrederick, Q.S., Morandin, L., Paul, D.L., Sellers, E., Strange, J.P., Vaughan, M., Williams, N.M., Branstetter, M.G., Burns, C.T., Cane, J., Cariveau, A.B., Cariveau, D.P., Childers, A., Childers, C., Cox-Foster, C.L., Evans, E.C., Graham, K.K., Hackett, K., T. Huntzinger, K.T., Irwin, R.E., Jha, S., Lawson, S., Liang, C., López-Urbe, M.M., Melathopoulos, A., Moylett, H.M.C., Otto, C.R.V., Ponisio, L.C., Richardson, L.L., Rose, R., Singh, R., & Wehling, W. 2020. Towards a US national program for monitoring native bees. *Biological Conservation*, 252, 108821.

Appendix A. Passive Survey Procedure

The Passive Survey will involve setting bee bowls out for a single or multiple sampling events.

Trap time length: 20 to 24 hours, but 8 to 12 hours could still be used. No more than 48 hours.

Trap number: a minimum of 15 bowls for small habitats and up to 21 bowls for larger habitat.

Trap placement: on the ground in a transect line in alternating colors within a homogenous habitat. For example, entirely within a forest setting, not crossing in other habitats like tree line into alpine tundra or into floodplains.

Setting out bee bowls:

Preparation

- Pick a warm sunny day if possible. Rainy and windy days can limit pollinator activity.
- Prepare a stack of bowls, consistently alternating between the colors (e.g. Yellow, White, Blue, Yellow, White, Blue, etc.). The order of color does not matter. Have a few extra bowls of each color with you just in case some in your stack are broken.
- Fill a bottle almost full with water and add a large squirt of dish soap. Shake until mixed and frothy. Top off with water.

Set up

- At transect start, mark where the locality of the first bowl with flagging tape to help with relocation. Create a GPS point of the transect start.
- Place the bee bowls on the ground in a straight line transect approximately three to five meters apart (~5 big steps apart is a good rule of thumb). As you set each bowl down, fill it ¼ full with the soapy water (do not overfill). Ensure the bowl is set securely on the ground so that it doesn't tip over or blow away. If the site is sloped or uneven, use a trowel, knife, or spoon, to dig out the soil or vegetation for secure placement of the bowl.
- Fill out the AK Bee Atlas Survey Form as completely as possible.
- Leave the bowls out for the selected amount of time of your visit.

Collecting samples from the bee bowls:

Preparation

- Create labels: cut out a small rectangle of paper for each transect. Label it with the transect name, date of collection (DD-Month-YYYY), BOWL, and collector name in **pencil**. Place the **label inside** the specimen cup.
- With a permanent marker, write the same information on the outside of the specimen cup.
- All of the bowls from one transect will be placed into one specimen cup.

Collect the bee bowls

- Pick up a bowl and dump the water and insects (all of them) into the strainer.
 - Place the empty bowl in a collecting bag.
 - Repeat with the remaining bowls.
- Once all bowls are emptied, gently scrape the insects from the strainer into the specimen cup with the plastic spoon. Insects are quite sturdy and gentle pressure will not harm the integrity of the insect, but be careful to not smear them against the strainer.

- Fill the specimen cup with *just enough* preservative to cover the insects, do not overfill. Tighten the specimen cup and place in a plastic resealable bag. Secure the bag so no leakage occurs.
 - Alternatively, the insects can be stored in a cooler for up to 5 days before being frozen or adding preservative.

Delivering data and samples:

- Deliver the samples, data sheets, and photos to ACCS for processing. Please contact ACCS for pick up or mailing procedures.

Contact:

Rachel Kelty or Justin Fulkerson
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3211 Providence Drive
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Appendix B. Intermediate Survey Procedure

This survey procedure will include bee bowl traps and a blue vane trap (BVT).

Trap time length: 20 to 24 hours, but 8 to 12 hours could still be used. No more than 48 hours.

Trap number: a minimum of 15 bowls for small habitats and up to 21 bowls for larger habitat.

Trap placement: on the ground in a transect line in alternating bowl colors within a homogenous habitat. For example, entirely within a forest setting, not crossing in other habitats like tree line into alpine tundra or into floodplains. *One BVT will be placed in the center of the transect line.*

Setting out bee bowls

Preparation

- Pick a warm sunny day if possible. Rainy and windy days can limit pollinator activity.
- Prepare a stack of 15 bowls, consistently alternating between the colors (e.g. yellow, white, blue, yellow, white, blue, etc.). The order of color does not matter. Have a few extra bowls of each color with you just in case some in your stack are broken.
- Fill a bottle almost full with water and add a large squirt of dish soap. Shake until mixed and frothy. Top off with water.

Set up the BVT transect

- At transect start, mark where the locality of the first bowl with flagging tape to help with relocation. Create a GPS point of the transect start.
- Place the bee bowls on the ground in a straight line transect approximately three to five meters apart (~5 big steps apart is a good rule of thumb). As you set each bowl down, fill it $\frac{1}{4}$ full with the soapy water (do not overfill). Ensure the bowl is set securely on the ground so that it doesn't tip over or blow away. If the site is sloped or uneven, use a trowel, knife, or spoon, to dig out the soil or vegetation for secure placement of the bowl.
- Set the BVT in the middle of the transect, with 5 meter spacing between the vane trap and bee bowls. For example, for 15 bowls, set the BVT between bowl # 7 and 8.
 - Pound a stake or pole securely into the ground and fix the BVT approximately 1 meter from the ground.
 - Two zip ties will be secured around the white base of the BVT. Slip the smaller zip tie around the fixed pole and secure loose but snug. Thread string into a hole at the end of the vane and secure to the post as shown in Figure 11. Tightly secure the zip tie in place.
 - Place the fumigant strip in the jar, screw the funnel to the jar, and then attach the vanes.



Figure 11. A blue vane trap being properly secured.

- Fill out the AK Bee Atlas Survey Form as completely as possible. Leave the traps out for the selected amount of time of your visit.

Collecting samples from the bee bowls

Preparation

- **Create 2 labels for 2 specimen cups**: cut out a small rectangle of paper for the bowls and the BVT. The insects from the bee bowls and BVT will have their own respective cup.
- Label them with the transect name, date of collection (DD-Month-YYYY), ‘BOWL’ or ‘BVT’, and collector name in **pencil**. Place the **label inside** the specimen cup.
- With a permanent marker, write the same information on the **outside** of the specimen cup.

Collect the bee bowls and BVT

- Pick up a bowl and dump the water and insects (all of them) into the strainer.
 - Place the empty bowl in a collecting bag.
 - Repeat with the remaining bowls.
- Once all bowls are emptied, gently scrape the insects from the strainer into the specimen cup with the plastic spoon. Insects are quite sturdy and gentle pressure will not harm the integrity of the insect, but be careful to not smear them against the strainer.
- Collect any bees in the BVT by unscrewing the funnel and transferring the bees to the sampling cup. If bees are still alive, the BVT can remain closed until they are killed by the fumigant or unscrew the BVT under a net, then transfer the bees to a killing jar.
- Remove the BVT if another sampling event will not occur
- Fill the specimen cup with *just enough* preservative to cover the insects, do not overfill. Tighten the specimen cup and place in a plastic resealable bag. Secure the bag so no leakage occurs.
 - Alternatively, the insects can be stored in a cooler for up to 5 days before being frozen or adding preservative.

Delivering data and samples

- Deliver the samples, data sheets, and photos to ACCS for processing. Please contact ACCS for pick up or mailing procedures.

Contact:

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Appendix C. Active Survey Procedure

In addition to the passive traps, the participant will sweep net pollinators they find on flowers while meandering throughout the sampling area. Participants will net bees within the survey area and use a killing jar or non-kill method to sample the bees. Please note that the non-kill method is only useful for bumble bees. Photographs do not provide the detail needed for identification of solitary bees. We adopt the approach of the Pacific Northwest Bumble Bee Atlas (<https://www.pnwbumblebeeatlas.org/>) or the non-kill methods.

NOTE: Please print the appropriate Appendix A or Appendix B in addition to this procedure. Here we only describe the netting procedure.

Trap set up

Follow either the Passive or Intermediate methods of placing bee traps. Netting bees will take place within the trap ecosystem after the traps are deployed. We suggest two 20 min. **active** netting events: after the trap deployment and retrieval, but a single netting event is acceptable.

Collecting samples

Preparation

- Prepare and charge one or more collecting jars.

Sampling with the net

Time the netting survey for 20 minutes. Multiple people can help with the netting survey but the time should be adjusted for each person to total 20 person minutes. For example, if four people are netting, then each person will independently walk and net for 5 minutes.

1. Start a stopwatch
 - Walk slowly throughout the bee bowl transect area, up to 100 meters away from the middle of the bee trap transect.
 - Maintain the walk within the same habitat as the bee bowl transect.
2. Find a bee or fly on a flower? Capture it!
 - Gently place the net over the flower, while holding the end of the net up. This is often effective – insects typically will fly or crawl upwards when disturbed into the net. Using strong sweeping motions can damage plants and often results in missed captures. After the insect is captured, turn the net over, allowing the net to close the opening or grasp it closed with your hand. *Please view this video tutorial from a colleague of the PNW Bee Atlas: <https://youtu.be/mVOi-jRpw2E>*
 - **Stop the stopwatch** and proceed with one of the following methods
 - Killing method
 - Transfer the pollinator to the kill jar while it is inside the net. You will need to slip the cover over the jar before removing it from the net.
 - Note the flower species and bee collection on the AK Bee Atlas Survey Form.
 - Non-killing method ICE
 - Transfer the bumble bee to a vial. Include a flower that the bee was visiting, or write a number on top of the vial and take a photo with the flower.

- Cover the vial with ice in the cooler for at least 10 minutes or until the end of the sampling time, then follow the photographing tips below.
 - For a video demonstration please view: <https://youtu.be/TjaOpZWNF4M>
 - Non-Killing method PHOTO CHAMBER
 - Transfer the bumble bee to the photo chamber.
 - Push the foam block to the clear plastic to lightly squash the bee for photographing. Follow the photographing tips below.
 - For a video demonstration please view: <https://youtu.be/Wva3qKUwIsE>
3. Timing notes:
- Watching and waiting for an active pollinator to land on a flower is acceptable.
 - Chasing after a pollinator is acceptable.
 - Sitting and watching one flower for 20 minutes is not acceptable.
4. Two or more net sampling events spaced in time from each other is preferred. The participant can decide the timing to suit their schedule. A single sampling event is acceptable.

Preservation from killing jars

- At the end of the active time, transfer all the collected pollinators to a specimen cup if they are dead. It's best to not keep insects in the kill jar for longer than 24 hours.
- Create labels: cut out a small rectangle of paper and label it with the transect name, collection date (DD-Month-YYYY), collection time, 'NET', and collector name in **pencil**. Place the label **inside** the specimen cup.
- Fill the specimen cup with *just enough* preservative to cover the insects, do not overfill. Label the outside of the cup with the same information, tighten, and place in a plastic resealable bag. Secure the bag so no leakage occurs.

Photographing for non-kill methods

Comprehensive photography tips and examples are at the PNW Bee Atlas project (https://www.pnwbumblebeeatlas.org/photo_tips.html). Some general requirements for good photographs are:

1. Place the bee on a solid background to enhance contrast. A suggestion is to place the bee on a Rite in the Rain notebook inner cover next to the ruler.
2. Use an 8 Megapixel camera. Cell phone cameras are generally acceptable and handy for reviewing photos.
5. Specific photos of the bees are needed. Move the bee around with a pencil to orientate the bee:
 - **FACE** at a slight side angle that shows the check length & colors
 - **SIDE & BACK** (tail/butt) at an angle getting the segment colors. The last few segments are crucial. It is helpful to place the bee on its back. Extra photos of this section are encouraged.
 - **THORAX** color patterns, easiest to photograph at a top view.
6. Ice method: after at least 10 minutes, the bumble bee should be cold and inactive. Uncap the vial and gently place the bee on a solid background like a notebook. Include the vial cap if it was numbered.

7. Photo chamber method: you will not be able to manipulate the bee to get the full range of photos, but please do your best. Pulling the foam back from the viewing window will allow the bee to move around slightly giving you another chance to reposition the bee for additional/better photo angles. Avoid glare from the acrylic window.

Delivering data and samples

- Deliver the samples, data sheets, and photos to ACCS for processing. Please contact ACCS for pick up or mailing procedures.

Contact:

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jrfulkerson@alaska.edu
<https://accs.uaa.alaska.edu/wildlife/pollinator-diversity/>

Appendix D. Netting Only Survey Procedure

Participants will net bees within the survey area and use a killing jar or non-kill method to sample the bees. Please note that the non-kill method is only useful for bumble bees. Photographs do not provide the detail needed for identification of solitary bees. We adopt the approach of the Pacific Northwest Bumble Bee Atlas (www.pnwbumblebeeatlas.org) for the non-kill methods.

Collecting samples

Preparation

- Prepare and charge one or more collecting jars as described above *if using*.
- 8. **Non-killing methods:** Prepare ice chest or insulated lunch box with ice and vials **OR** prepare the photo chamber.

Sampling with the net

Time the netting survey for 20 active minutes. Multiple people can help with the netting survey but the time should be adjusted for each person to total 20 person minutes. For example, if four people are netting, then each person will independently walk and net for 5 minutes.

9. Start a stopwatch
 - Walk slowly throughout the bee bowl transect area, up to 100 meters away from the middle of the bee bowl transect.
 - Maintain the walk within the same habitat as the bee bowl transect.
10. Find a bee or fly on a flower? Capture it!
 - Gently place the net over the flower, while holding the end of the net up. This is often effective – insects typically will fly or crawl upwards when disturbed into the net. Using strong sweeping motions can damage plants and often results in missed captures. After the insect is captured, turn the net over, allowing the net to close the opening. *Please view this video tutorial from a colleague of the PNW Bee Atlas:*
 - <https://youtu.be/mVOi-jRpw2E>
 - **Stop the stopwatch** and proceed with one of the following methods
 - Kill method
 - Transfer the pollinator to the kill jar while it is inside the net. You will need to slip the cover over on the jar before removing it from the net.
 - Note the flower species and type of bee on the datasheet. Take photos if necessary.
 - Non-killing method ICE
 - Transfer the bumble bee to a vial. Include a flower that the bee was visiting, or take note on the data sheet.
 - Cover the vial with ice in the cooler for at least 10 minutes or until the end of the sampling time. This will cool down the bee for photographing later.
 - For a video demonstration please view: <https://youtu.be/TjaOpZWNF4M>
 - Non-Killing method PHOTO CHAMBER
 - Transfer the bumble bee to the photo chamber
 - Push the rod or foam block to the clear plastic to lightly squash the bee for photographing. See photo tips below.

- For a video demonstration please view: <https://youtu.be/Wva3qKUwIsE>
 - **Restart the stopwatch**
 - Resume the meander and repeat until the allotted time is complete.
- 11. Timing notes:
 - Watching and waiting for an active pollinator to land on a flower is acceptable.
 - Chasing after a pollinator is acceptable.
 - Sitting and watching one flower for 20 minutes is not acceptable.
- 12. Two or more net sampling events spaced in time from each other is preferred. The participant can decide the timing to suit their schedule. A single sampling event is acceptable.

Preservation from killing jars if using

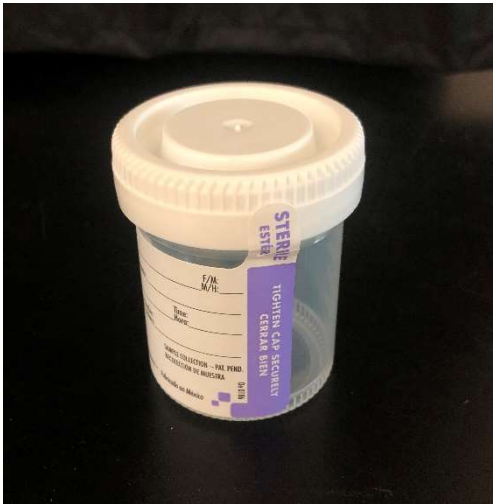
- At the end of the active time, transfer all of the collected pollinators to a specimen cup if they are dead. It's best to not keep insects in the kill jar for longer than 24 hours.
- Create labels: cut out a small rectangle of paper and label it with the transect name, collection date (DD-Month-YYYY), collection time, 'NET', and collector name in **pencil**. Place the label **inside** the specimen cup.
- Fill the specimen cup with *just enough* preservative to cover the insects, do not overfill. Label the outside of the cup with the same information, tighten, and place in a plastic resealable bag. Secure the bag so no leakage occurs.

Photographing for non-kill methods

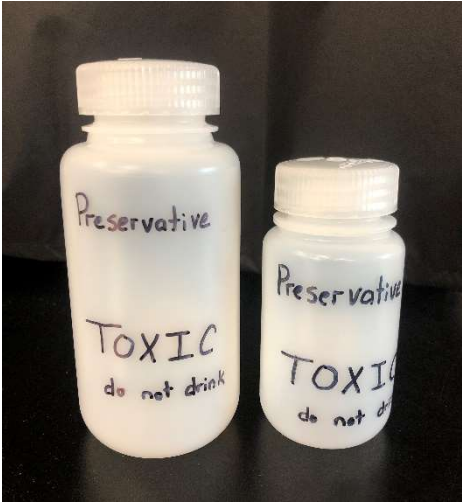
Comprehensive photography tips and examples are at the PNW Bee Atlas project (https://www.pnwbumblebeeatlas.org/photo_tips.html). Some general requirements for good photographs are:

3. Solid background the bee is resting on or the photo chamber. A suggestion is to place the bee on a Rite in the Rain notebook inner cover next to the ruler.
4. 8 Megapixel camera. Cell phone cameras are generally acceptable and handy for review of photos.
5. Specific photos of the bees that are needed. Move the bee around with a pencil to orientate the bee.:
 - a. FACE at a slight side angle that shows the cheek length & colors
 - b. SIDE & BACK (tail/butt) at an angle getting the segment colors. The last few segments are crucial. It is helpful to place the bee on its back. Extra photos of this section are encouraged.
 - c. THORAX color patterns, easiest to take photo at a top view.
13. Ice method: after at least 10 minutes, the bumble bee should be cold and inactive. Uncap the vial and gently place the bee on a solid background.
14. Photo chamber method: you will not be able to manipulate the bee to get the full range of photos, but please do your best. Pulling the foam back from the viewing window will allow the bee to move around slightly giving you another chance to reposition the bee for additional/better photo angles. Avoid glare from the acrylic window.

Appendix E. Supply Photos



Specimen cup



Preservative bottles



Dish soap bottle



Kill jar



Non-kill vial

AK Bee Atlas Survey Form

Survey Type: Passive / Intermediate / Active / Netting Only

Survey Date (day-month-yy):

Site Information *the 'site' is composed of the traps and a 100m buffer radius in the same habitat*

Site Name (last name-Year-locality name):

Observers:

Lat. (dd): N No. of bowls: Trap time length (hrs):

Lon. (dd): W No. missing bowls:

Netting date/time #1:

Netting date/time #2:

Weather *avg. over trap/netting time frame*

Air temp. (for traps, record the daytime high): (for netting, estimate the temp. during sampling):

Cloud cover %: Wind: none calm (1-3 mph)
light breeze (4-7 mph) gentle breeze (8-12 mph)

Habitat Information

General Habitat Type:

Photo numbers of the site:

Agriculture	Alpine	Grassland	Dunes	Coastal beach
Developed/Roadside	Arctic	Meadow	Marsh/Bog	
City/Village	Forest margin	Shrub/Scrub	Lake	
Garden/Park	Woodland/Forest	Bluff	River/Stream	

other description:

The vegetation of the sampling area is primarily composed of:

Conifer tree	Tall shrub (>1.5 m)	Low shrub (0.2-1.5 m)	Grass/Sedge	Forbs
Broadleaf tree	Barren ground	Dwarf shrub (<20 cm)	Moss/Lichen	

Vegetation Classification (optional) Viereck or NVCS:

Floral Resources

How many different flower species do you see in the survey area?

1 2 3 4 5 6 7 to 9 10 to 12 13 to 15 >15

Flowers observed within the site. List as many blooming plants as you can within the survey area (<50m from traps/netting area). List the most abundant plants in descending order. If a plant is unknown, take pictures of the flowers & leaves, record the photo numbers, then record 'Plant 1'. Continue on other side if needed.

Bee Collection: (for capture/release) document the vial number and/or photo number of the bee to associate the collected bee with the flower it was caught from. (for capture/keep) write the number of bees caught from the flower.

Common Name	or	Scientific Name	Photo #	Bee Collection

Cut Out Labels *PENCIL ONLY* Trap types: BOWL, BVT, NET

Cut out this label and place it *inside* the sample cup. Follow this template for additional labels.

Date (dd-month-yy):	Date (dd-month-yy):	Date (dd-month-yy):
Site Name:	Site Name:	Site Name:
Collector Name:	Collector Name:	Collector Name:
Trap type:	Trap type:	Trap type:

