

A close-up photograph of a green and yellow wild bee on a purple flower. The bee is the central focus, with its body covered in fine hairs and its wings partially spread. The background is a soft-focus purple flower.

Vermont Wild Bee Survey

Discovering and Conserving Pollinator Biodiversity

MANUAL FOR PARTICIPANTS

Sponsors and Supporters

VTBees is a project of the Vermont Atlas of Life at the [Vermont Center for Ecostudies](#) in partnership with the [Vermont Fish & Wildlife Department](#) and [Stone Environmental](#) with collaboration from the [University of Vermont Field Naturalist Program](#) and the [University of Vermont Gund Institute for the Environment](#). Financial support has been provided by a State Wildlife Grant from the Vermont Fish & Wildlife Department and generous contributions from Vermont Center for Ecostudies supporters.

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Vermont Wild Bee Survey

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Project Overview

The Vermont Wild Bee Survey (VTBees) represents the first steps towards understanding the status and biogeography of these key elements of Vermont’s natural heritage. Field work will rely heavily on volunteers, for whom this manual has been prepared. Participants need little experience to join the survey—only an interest in bees.

Nearly 90% of flowering plant species, including 75% of agricultural crops, benefit from animal pollination. The United States alone grows more than 100 crops that either need or benefit from bee pollination, and the economic value of these native pollinators is estimated at \$3 billion per year. Here in Vermont, scientists at UVM associated with the VTBees project, demonstrated that more than 90 species of wild bees pollinate highbush blueberry flowers on Vermont farms, contributing thousands of dollars of value to the state’s agricultural economy. And nearby in New York, Cornell scientists recently found that native bee diversity is key to better apple production.

Bees are intimately tied to flowers by their use of pollen as a protein source, making them the most important pollinator group in many regions. Ongoing threats to managed, non-native Western Honey Bees (*Apis mellifera*) have raised public awareness of the importance of bees to human wellbeing, and there is concern that some of the approximately 4,000 bee species in the United States may also be declining.

Although we estimate there are over 300 species of wild bees found in Vermont, there has never been a full survey of the State’s bees. There are also several non-native species that have recently arrived in Vermont, but their distribution is not well known. Without even a checklist of species, it is very difficult to know whether populations of Vermont’s bees are healthy or declining. The Vermont Wild Bee Survey represents the first step in assessing bee populations across Vermont.

The success of the Vermont Wild Bee Survey (VTBees) depends on committed volunteers. With the help of volunteer citizen scientists, over the next 5 years (2019 – 2023), we’ll survey bees from the shorelines of Lake Champlain to Green Mountain Summits, boldly going where no melittologist has gone before! These new specimen records will be added to digitized historic records from museums throughout the region to build the first comprehensive survey of the bee fauna of Vermont.

The survey’s main objectives are to:

- Obtain a baseline of bee distribution at the beginning of this century for comparison to historic and future data.
- Curate and share all historic and current bee records from Vermont in an open data portal via the Vermont Atlas of Life (VAL) and the Global Biodiversity Information Facility (GBIF).
- Assess the conservation status and needs of Vermont bee species.
- Identify habitats of statewide and regional importance.
- Educate and involve more people in the discovery and protection of Vermont’s natural heritage.

The Vermont Wild Bee Survey is closely modeled after the recently completed Vermont Butterfly Survey and the Vermont Bumble Bee Atlas, which spawned a passionate network of volunteer citizen scientists, a valuable baseline, and a conservation concept and actions for some pollinators in the state.

Results from the survey will allow direct comparisons among states, with scientific and conservation implications extending throughout the Northeast and beyond. In short, this project offers the opportunity

for individuals, either professional or amateur, to make a significant contribution to the greater understanding Vermont's natural heritage and these important pollinators that we rely upon.

Survey Instructions

What follows in this manual are step-by-step instructions for participation in the Vermont Wild Bee Survey (VTBees). Before beginning any work, you should read this manual carefully, particularly advice on accurate record-keeping. And, help is never far away. The VTBees team is here to help you get started and to answer any questions you may have at any time.

A modest number of bees were collected and identified in Vermont over the last century, usually by netting. Recent studies suggest that to characterize the entire bee fauna in an area, sweep netting must be accompanied by other methods, such as pan trapping.

This project will require you to:

1. Adopt a survey block for the whole growing season, or at least part of the season, to survey bees using our standard protocols.
2. At a minimum, complete standard surveys at 3 different sites within your survey block one time each month.
3. Conduct other standard surveys in sites around your adopted block that have flowers and may harbor wild bees, with the goal of finding the most species possible during the season within your adopted survey block.
4. Fill out data forms and take care of bee specimens until they are delivered to the VTBees team.
5. Learn a lot about wild bees!

Selecting a Priority Block and Survey Sites

Once you officially adopt a survey block, you'll visit your own survey sites throughout the season within your survey block to document wild bee species and their relative abundance at each location. In 2019, we are focusing only on Chittenden County, which is home to both the highest and lowest elevations in the state and a wide range of natural communities. In 2020, we'll be expanding to the entire state.

Step 1: Choosing a Survey Block and Survey Site(s)

To make sure we survey the wild bee fauna evenly and systematically across Vermont, the project has adopted a grid mapping system. The system relies on the 184 U.S. Geological Survey 1:24,000 topographic maps ("7½-minute maps") that cover Vermont. We've divided each of these maps into six blocks of equal size (roughly 3 miles x 3 miles) and numbered them according to the example diagram below. That's a total of 1,104 survey blocks (184 maps x 6 blocks per map = 1,104 blocks).

Since we don't have the person-power to sample for wild bees in each and every block, VTBees has randomly selected 184 of these blocks (one per USGS map) for the focus of our work. We call these blocks "**priority blocks**" (you'll be hearing a lot about them). The 184 priority blocks make up a representative sample of the Vermont landscape; they're the minimum number of blocks that must be surveyed in order to obtain a statistically valid sample of bees for the entire state. This is the same survey block system used by the Vermont Breeding Bird, Butterfly and Bumble Bee atlases in the past.

Chittenden County has 12 ‘priority blocks’ that will be the focus of year one of this atlas. This is the minimum area for surveys this year. We’d like to add more if we have enough volunteers. We are hoping to have volunteers adopt a single block for the whole summer, but it is also possible to adopt them for shorter periods or with a team to share survey responsibilities.

Although survey data on wild bees anywhere in the state are important, VTBees prefers that you survey regularly in one of the 184 priority blocks. No one in Vermont is far from a priority block. Contact us and tell us where you’d like to survey. We’ll assign you your very own a priority block. You can then visit the VTBees web site to download a map of your block.

USGS Map
KNOX MOUNTAIN

1	4
2	5
3	6

Selecting Your Survey Sites within a Block

Once you’ve chosen or been assigned a block and have a map, you are ready to choose specific **Survey Sites** within that block. The Google map on the VTBees website () provides considerable information about potential sites in a block. Before visiting a block, look over the map and note the location of potential sites to check out.

1. Monthly Repeated Surveys - required

Within each block, at least three sites should be chosen for repeated surveys in three different general habitat types ~1 or more acres in size (see below). At a minimum, one survey per month at each site should be completed.

General habitat types for the three survey areas:

- **Open Areas without woody vegetation** – This includes meadows, old fields, or other grassy-like areas (no row crop areas or mowed lawn areas) with little or no shrubs or other woody vegetation.
- **Developed Lands** - Anywhere that is frequently manicured by humans, especially neighborhoods with lawns and gardens, city parks, village green, sports fields.
- **Early Successional** - Woody and herbaceous successional habitats, including powerlines, shrubby areas, abandoned beaver ponds, regenerating log landings, field that have not been brush hogged in several years.

2. Additional Survey Sites - needed

In addition, we would like to have an early spring survey from a forested site, before tree canopy leaf-out shades the forest floor, to survey bee species associated with spring ephemeral wildflowers. If possible, additional surveys can be conducted in the following habitats, ideally during periods with abundant flowers:

- **Shorelines** - Rivers, lakes, gravel bars
- **Wetlands** - Wetlands feature many flowers visited by bees, but they can be challenging places to collect. Place pan traps anywhere they’ll stay dry (you may not, so use caution!)

Step 2: Collecting Data on a Site Survey

The intense, repeated monthly site surveys at the three general habitat types are the heart of your survey work. And to make sure they are all comparable, we have detailed instructions for conducting them that have to be followed as closely as possible.

Before Your Site Visit

- ◆ **Get Permission** – Consult the landowner before visiting private property. If you explain the survey, you'll probably get permission to visit. Some private land—including reserves owned by The Nature Conservancy, for example—are fragile and require permits or permission to visit. When in doubt, contact our office for guidance and help.
- ◆ **Pick a Nice Day** – Bees are solar-powered creatures, most active between 10 a.m. and 4 p.m. They're less active and hard to find on cold, rainy, heavily overcast, or extremely windy days.

How to conduct a Site Survey

Two complementary methods are used to survey bees: bowl traps and timed sweep netting.

Bee Bowl Traps

Bee bowls (also called pan traps) will be the primary method for sampling at sites. A sampling event involves setting out 30 small plastic bowls that we provide (10 white, 10 yellow, and 10 blue) for a full day. Once established during the first sampling event, the same transect will be used for subsequent monthly visits, though the exact individual bowl placement does not have to be consistent. Of course, if conditions change and resurveying the area is not possible (i.e. flooding, cows, drastic habitat change, etc.), find another similar transect within the block -- don't forget to make notes and record the new coordinates!

Supply list (for one survey location)

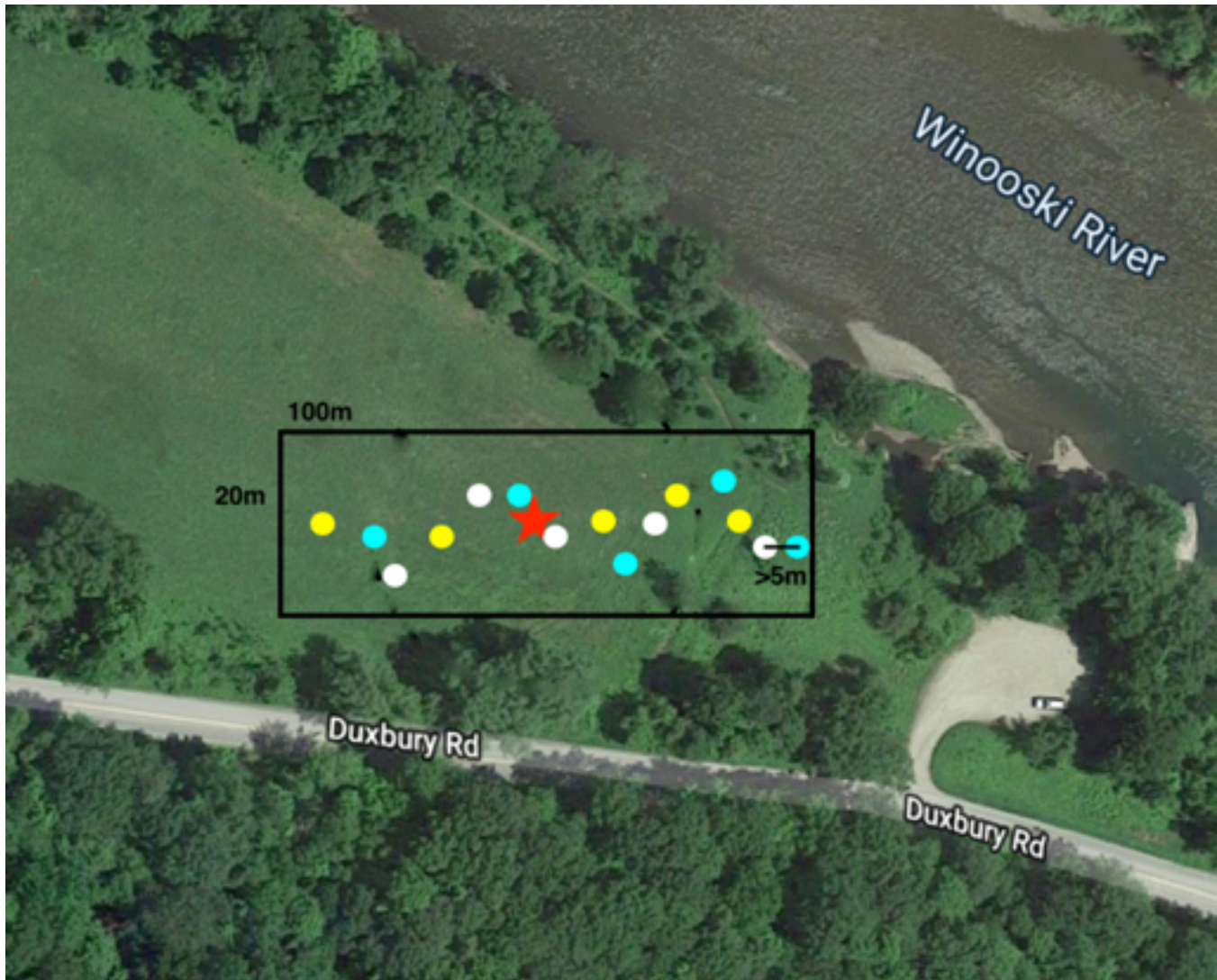
- 30 bowls (10 white, 10 yellow, and 10 blue) + a few of each color for backup
- ½ gallon or more soapy water
- Something to cut back vegetations as it grows to expose bowl to sky
- GPS unit or smartphone to record location
- Data sheet(s)
- Net strainer
- Camera/smartphone ideally with georeferencing
- Specimen labels (can be downloaded to print (DO NOT USE inkjet printer. Use copy machine or laser printer) at https://docs.google.com/document/d/1WAWXxLuMVEBo8-f4xEKOUmqoszVQ4389so_CNnL724s/edit?usp=sharing)
- PENCIL (not pen/sharpie/crayon as those are not resistant to liquids)
- small ziplock bags

Deploying Bee Bowls

Before setting off into the field, mix up a big jug of soapy water. We recommend adding a big squirt of Dawn Original Scent (blue colored) dishwashing liquid directly to a gallon jug of water, enough to give the water a very light blue tinge. Do not use any scented liquid soaps.

As you go through the transect, fill bowls $\frac{3}{4}$ full with soapy water solution and place on the ground in an open area, at least 5m from any other bowl and in alternating colors so no adjacent bowls are the same color. Do not place bowls in the shade or tall grass—if you can easily see the pan trap, then bees can too. You may need to cut an area of grass to create an opening for your bowl to be visible. Flowers need not

be apparent in an area. Be mindful of potential disturbances: cows, deer, tractors, dogs and dog walkers. Record GPS coordinates for the center of the transect. Place small signs if needed to indicate that these bowls are part of a research project (Download for printing more: <https://docs.google.com/document/d/1tH14ZXswCNw4D-Cw2IVXd-ssyXvX1aGmY2A9KpNqIPU/edit?usp=sharing>).



An example bee bowl transect in an open area without wood vegetation. A real transect would have 30 pans (represented by the color dots). The sweep net survey should occur within the same contiguous habitat area. Make sure to record the GPS coordinates of the transect centroid (red star) on the data sheet.

Retrieving Bee Bowls

If possible, remove all moths, butterflies, skippers, slugs, and very large bodied non-hymenoptera (e.g., grasshoppers and crickets) from each pan trap first. These groups tend to contaminate the bee specimens with wing scales and bodily exudates in the bags. Be careful to check for any bees that might be attached before removing these larger insects from the sample. All the other insects are fine to leave in as they will be sorted in the lab later.

Make a note of the number of bowls of each color that are disturbed/missing/dry--you will record this information on the data sheet so we can account for this in our analysis.

The contents of the 30 bowls from the transect will be combined into one sample. As you go, pick up each bowl and dump the contents into your net/strainer. Keep track of how many bowls of each color had no bees (or insects you think are bees). After you have the specimens from all 30 bowls in your strainer, use a plastic spoon or your fingers to gather the specimens from the net and then transfer them to the Ziploc or Whirl-Pak bags. If you are concerned or prone to drop specimens when transferring them to the bag, try doing this over a clean light colored or white surface (a sheet of 8.5 x 11" paper or a handkerchief laid on the ground works well) in order to avoid losing tiny bees in the vegetation and dirt if you accidentally drop them.

Example Bee Bowl Survey Data Sheet

VTBees Bee Bowl Survey Data Sheet

Site Name River Bend Farm	Unique Survey ID (sitename-mmddyy-observer initials) RVB-061519-KPM	Block Name - Number KNOX MTN-3	
Primary Observer Name and email Kent McFarland KMcFARLAND@VTELOSTUDIES.ORG		Latitude (4# ###) 42.123	Longitude (-7# ###) -72.123
No Bowls Out 30	Date Out 6/14/19	Time Start 12:00	Time End 12:45
No Bowls Collected 30	Date Collected 6/15/19	Time Start 12:15	Time End 13:15
No Bowls Disturbed or missing 2	white 0	blue 1	yellow 1
Netting Transect Area No. of Netters 1	Netting Date 6/15/19	Netting Time Start 13:30	Netting Time End 14:30

Check box for any of the following that apply:

- No bees captured in bowls
 No bees captured netting
 Bees observed but not captured
 No flowers blooming in transect area

Notes (flower species present, other observers names, etc.):

Red clover abundant.

Each bag must have a label inside, and labels must be written in PENCIL. We will provide waterproof paper labels for you to fill out, but a page of a Rite-in-the-Rain notebook will work well too.

IMPORTANT: Be sure to include the Unique Survey ID, date, and your name on each label.

Example Field Label for Specimens

Survey ID (sitename-mmddyy-observer initials):
 BIGFARM-061219-KPM
 Collection ID: 2
 Collector: KPMCFARLAND
 Date: 06/12/2019
 Circle one: Bowl | Netting | Incidental (lat-long for Survey ID)

Eliminate as much of the air from the bag as possible by squeezing the sides of the bag together with your fingers (without squeezing the specimens) and pushing air pockets up and out of the bag opening. Roll the top of the Whirl-Pak bag down so that the specimens are covered with liquid but loosely gathered in the bottom of the bag and twist the wire ends together with multiple twists (DO NOT just fold them around the sides of the bag like you would with a bag of coffee beans). Fold the twist ends towards the inside of the loop they make when twisted together, so that the ends of the wires won't poke holes in other sample bags. Place multiple sample bags into a larger Ziploc bag with a piece of paper or folded-up paper towel (to keep leaks in check) for temporary storage in the field, and then storage in the freezer when you arrive home. **IMPORTANT: Freeze the samples as soon as you get home and keep them frozen until they are delivered to us.**

As soon as you finish labeling and bagging your specimens. Fill out the appropriate data sheet, making sure to note how many bowls of each color were disturbed/dry/missing.

Contact Spencer (shardy@vtecostudies or 802-299-1034) to arrange for specimen drop-off.

Sweep Net Survey

Searching for bees and using an insect net to collect them is used in addition to bee bowls because the different methods capture slightly different bee communities. You need to search for bees and net those you find for 60 minutes (make sure to write down the start time and end time). If you have not detected any bees after 30 minutes, you can stop. Otherwise, complete the full 60-minute survey. Try to minimize the time you are handling bee captures and maximize the search time. If bee bowls were deployed, ideally complete this either before the bowls have been set out or after the bowls have been collected, within the same contiguous habitat area.

Important tips:

- Wander the survey site and try to focus your search time at flower species roughly in relation to the density of flower species present.
- Remember, many bees are quite small and others can look incredibly wasp-like. If you suspect something is a bee, catch it. We would rather have some wasps and flies in the samples than miss bees.
- Don't skip netting a bee because you see a flashier one nearby. Try to capture each bee in the order they are found.
- If there is more than one person netting, each person should have their own data sheet.

For netting surveys, we are interested in what flower species each bee is foraging on. We will collect this information by keeping specimens from each species of flower separate for a given netting survey. You should start each netting event with 10 - 20 numbered vials with soapy water. Each number will correspond to a species of flower and that number will be consistent through the netting session, on the corresponding data sheet, and for any photos you take of the flower they were on. You do not need to know the identity of the flower, and any bee from a flower that you can distinguish as unique should get its own vial, though some flower genera may not be identifiable to species. For example, if the first bee you catch is on a flower you can't identify then that becomes flower 1 and the bee goes in vial 1. Bee 2 was on New England Aster (*Symphyotrichum novae-angliae*) and that becomes flower 2. Then if bee 3 is on the same plant species as flower 1 again, then it will go in vial 1, but if bee 4 is on a different plant species, then it will go in a new vial (#3). Either during or after your survey, you will go to each flower species you caught a bee on and take a photo. To make sure your photo matches the vial with the bees that were visiting it, place the vial with number or use scrap paper with number in your photo next to the flower. Unless you are positive of the flower ID (for example, something like Common Dandelion), then

we ask you upload the photo to the Vermont Atlas of Life on iNaturalist.org. Once the photo is uploaded and the observation submitted, you will write down the unique observation number found at the end of the web address that was created for your observation. For example <https://www.inaturalist.org/observations/20958402> would be 20958402 and this number goes on netting data sheet under the corresponding flower number, which will also be in the bag of specimens collected from that flower. You will occasionally encounter bees that are not foraging, or bees that are caught from the air or the ground-- these can be all placed in one tube with a flower number of 0.

Example Netting Survey Field Data Sheet

VTBees Netting Survey Data Sheet

Site Name <i>RIVER BEND FARM</i>	Unique Survey ID (sitename-mmddyy-observer initials) <i>RBF-061519-KPM</i>	Block Name - Number <i>KNOX MTN-3</i>	
Primary Observer Name and email <i>Kent McFARLAND</i>		Latitude (4#.#)° <i>42.123</i>	Longitude (-7#.#)° <i>-72.123</i>
Date <i>6/15/19</i>	Time Start <i>13:30</i>	Time End <i>14:30</i>	
Temperature <i>74 F</i>	Sky Conditions (estimate % cloudy on average) <i>85%</i>	Wind (none, light, moderate) <i>light</i>	

Collection Field No. (write unique survey ID + number on container)	Flower species or iNaturalist observation number	Collection Field No. (write unique survey ID + number on container)	Flower species or iNaturalist observation number
1	<i>12345678</i>	11	
2	<i>12345692</i>	12	
3	<i>Common Dandelion</i>	13	
4		14	
5		15	
6		16	
7		17	
8		18	
9		19	
10		20	

Check box for any of the following that apply:
 No bees found Bees observed but not captured
 No flowers blooming in transect area Bee bowls deployed within 24 hours Honeybees observed

Notes (flower species present, other observer names, etc.):
Flowers sparse. Few bees found.

Once you return from the field, or between netting events if you plan on multiple events in the same day, you will transfer your numbered vials into small ziploc with the flower number and sample ID written in pencil on a piece of paper and placed inside the bag. All of the bags from a single netting event can be combined into a larger ziploc with the appropriate specimen label card.

Counting Common Bees

Honey Bees- if you know how to identify these readily, just simply count all those you see and add them to the field sheet.

Bumble Bees- If there are many foraging, after collecting one or two representative individual workers, you can count individuals, IF you confident with bumble bee identification in the field, and write it on your datasheet. The usual situation for this is when there can be large numbers of Common Eastern Bumble Bee workers foraging in mid to late summer.

Equipment

- Sweep net
- 10-20 numbered containers with soapy water
- Big ziploc for containers and whirl packs
- Net strainer
- Camera or smartphone
- Index cards with numbers that correspond to container numbers (used for photographing flowers that the bee was using)
- Paper labels and pencil. Label sheet for printing can be downloaded at https://docs.google.com/document/d/1WAWXxLuMVEBo8-f4xEKOUmqoszVQ4389so_CNnL724s/edit?usp=sharing

Extracting coordinates from phone or GPS

Ideally, we would like volunteers to record geographic coordinates in decimal degrees with precision rounded to three decimal places (e.g., 44.559, -72.578). You can get this information from a mapping service such as Google Earth or a mobile mapping app. For iPhone users: open maps, click the blue 'location services' arrow in the upper right corner, click the blue dot that indicates where you are, swipe up to reveal your coordinates. Learn more here: <https://www.techbout.com/find-gps-coordinates-using-iphone-android-mac-pc-28312/>

Step 3: Additional Surveys in Priority Blocks

The most important task is to complete the monthly site surveys in the three general habitats as described above. However, for those with more time and energy, we highly encourage additional surveys be conducted, especially in unique habitats (shorelines, wetlands, etc) and around certain plants that are either broadly attractive or are used by specialist bee species (see below). The protocol and data sheets are the same, though these locations do not necessarily need to be repeated every month. For these surveys, you can also just complete timed searches and netting and forego the bee bowls if you are short on time.

Try to target places that have these flowers of potential interest if possible:

Early spring:

- *Erythronium americanum* (American trout lily)
- *Salix* spp. (willows)
- *Claytonia* spp. (spring beauty)
- *Dentaria laciniata* (cut-leaf toothwort)
- *Hydrophyllum virginianum* (Virginia waterleaf)

Late spring:

- *Cornus alternifolia* (dogwood)

- *Cercis canadensis* (Eastern redbud)
- *Geranium maculatum* (wild geranium)
- *Kalmia* (sheep laurel)
- *Krigia* spp. (dwarf dandelions)
- *Lyonia ligustrina* (maleberry)
- *Potentilla* spp. (cinquefoil)
- *Uvularia sessilifolia* (wild oats)
- *Vaccinium* spp. (blueberries, including highbush and lowbush)
- *Vaccinium stamineum* (deerberry)
- *Viola* spp. (violets)
- *Zizia aurea* (golden Alexander)

Summer:

- *Arabis pycnocarpa* (hairy rock cress)
- *Ceanothus americanus* (New Jersey tea)
- *Cirsium* spp. (thistle)
- *Gaylussacia baccata* (black huckleberry)
- *Heuchera americana* (alumroot)
- *Ilex* spp. (holly)
- *Lysimachia* spp. (loosestrife)
- *Rhododendron* spp. (rhododendron)
- *Rhus* spp. (sumac)
- *Helianthus* spp. (sunflower)
- *Monarda* spp. (bee balm)
- *Oenothera* spp. (evening primrose)
- *Physalis* spp. (ground cherry or tomatillo)
- *Pontederia cordata* (pickerelweed)
- *Verbena hastata* (vervain)
- *Vaccinium macrocarpon* (American cranberry)

Late summer/fall:

- *Cirsium* spp. (thistle)
- *Euthamia* spp. (goldenrod)
- *Helianthus* spp. (sunflower)
- *Physalis* spp. (ground cherry)
- *Solidago* spp. (goldenrod)
- *Symphyotrichum* spp. (asters)

Incidental Sightings

Bees collected in unstandardized ways are of less value to this project, but we are still interested in these records. The best option is to photograph bees, ideally with a macro lens from several angles, and upload them to the Vermont Atlas of Life on iNaturalist, though identification to species by photos is not always possible. If you find a bee that you have never seen before or have reason to suspect is particularly interesting, please do net and collect it for submission to us. Be sure to record the coordinates, date, and the flower it was on (if it was foraging) and place label with specimen or on specimen container.

Historic Bee Specimens Wanted!

If you, or someone you know, has a private insect collection, we are especially interested in any data from the past.

Step 4: Submitting Your Data and Specimens

No survey work is truly complete until results are submitted to the VCE office. Prompt submission of accurate data is critical to the project's success. After each site visit, take time to make sure your forms are complete. **Resist the temptation to finish data forms after you've left the site.**

Organizing Your Data

When you return home from a site visit, keep your Site Visit Form in a safe place.

- ◆ **All materials must be labeled** with the date and Site Name.
- ◆ Any specimens **must be labeled** with their corresponding Site Name and date.
- ◆ Upload your plant images to the Vermont Atlas of Life on iNaturalist and record each observation number on your data sheet.

Literature Cited

- Droege, S, JD Engler, E Sellers and LE O'Brien. 2017. U.S. National Protocol Framework for the Inventory and Monitoring of Bees, Version 2.0. Inventory and Monitoring, National Wildlife Refuge System, U.S. Fish and Wildlife Service, Fort Collins, Colorado
- *The Very Handy Manual: How to Catch and Identify Bees and Manage a Collection*. Compiled mainly by Sam Droege at the USGS Native Bee Inventory and Monitoring Lab.
<http://bio2.elmira.edu/fieldbio/handybeemanual.html>

Appendix I

Resources

- ◆ *The Very Handy Manual: How to Catch and Identify Bees and Manage a Collection.* Compiled mainly by Sam Droege at the USGS Native Bee Inventory and Monitoring Lab with input from specialist researchers and taxonomists over several years from 2004-present. This guide provides detailed instructions on bee monitoring techniques including specimen collection, processing and management, bee identification, and more! The manual also provides guidance on the capture, monitoring, identification, and curation of native bees. <http://bio2.elmira.edu/fieldbio/handybeemanual.html>
- ◆ *A Guide to Identifying Bees Using the Discover Life Bee Keys.* Sam Droege. http://www.discoverlife.org/ed/tg/How_to_use_the_discoverlife_guides.html
- ◆ More resources at <http://val.vtcostudies.org/projects/vtbees/resources/>

Entomology Equipment

BioQuip Products
2321 Gladwick Street
Rancho Dominguez, CA 90220

Telephone: (310) 667-8800
Fax: (310) 667-8808
E-mail bioquip@aol.com
Web Site: www.bioquip.com
Insect Nets:

<https://www.bioquip.com/Search/DispProduct.asp?pid=7312NA>

Other Organizations

Vermont Entomological Society
www.vermontinsects.org/

The Xerces Society for Invertebrate Conservation
1971 – 2011: Forty Years of Conservation!
628 NE Broadway, Suite 200
Portland, OR 97232, USA
www.xerces.org

Appendix II

Vermont Bumblebee Survey Priority Block Numbers (#) for Selected USGS 1:24,000 Quadrangles (USGS Quad Name)

USGS Quad Name	#
Albany	4
Andover	5
Arlington	1
Averill Lake	6
Bakersfield	6
Barnet	2
Barre East	5
Barre West	3
Bellows Falls	3
Bennington	1
Benson	3
Bethel	6
Bloomfield	3
Bolton Mountain	4
Bomoseen	6
Brandon	3
Brattleboro	1
Bread Loaf	6
Bridport	5
Bristol	6
Brookfield	1
Burke Mountain	6
Burlington	4
Cabot	6
Caspian Lake	6
Cavendish	5
Charlotte	6
Chelsea	2
Chester	5
Chittenden	1
Colchester	3
Colchester Point	6
Cold Hollow Mts.	5
Concord	3
Cornwall	5
Craftsbury	6
Crystal Lake	3
Danby	1
Delectable Mtn.	1
Dorset	5
East Alburg	5
East Corinth	2
East Middlebury	1
Eden	2
Enosburg Falls	4
Essex Center	6
Essex Junction	3
Fairfield	5
Fairlee	4

USGS Quad Name	#
Gallup Mills	5
Georgia Plains	5
Gilman	1
Gilson Mountain	6
Governors Mtn.	1
Groton	2
Groveton	3
Hancock	3
Hanover	1
Hartland	4
Hazens Notch	1
Highgate Center	3
Hinesburg	6
Huntington	4
Irasburg	2
Island Pond	4
Jacksonville	3
Jamaica	5
Jay Peak	5
Jeffersonville	2
Joes Pond	2
Johnson	5
Juniper Island	6
Killington Peak	4
Knox Mountain	3
Lincoln	1
Londonderry	5
Lowell	3
Ludlow	2
Lyme	2
Lyndonville	4
Maidstone Lake	2
Manchester	2
Marshfield	2
Middlebury	2
Middlesex	3
Middletown Spngs	3
Miles Pond	1
Milton	2
Monadnock Mtn.	6
Monkton	4
Montpelier	5
Morgan Center	5
Morrisville	5
Mount Carmel	6
Mount Ellen	2
Mount Holly	4
Mount Mansfield	6
Mount Philo	3

USGS Quad Name	#
Mount Snow	3
Mount Worcester	1
Newbury	3
Newfane	4
Newport	6
Newport Center	3
North Hero	1
North Troy	2
Northfield	3
Norton Pond	6
Orleans	1
Orwell	4
Pawlet	5
Peacham	4
Peru	4
Pico Peak	5
Plainfield	5
Plymouth	1
Port Henry	5
Poultney	4
Pownal	6
Proctor	4
Putney	3
Quechee	2
Randolph	2
Randolph Center	6
Readsboro	4
Richford	4
Richmond	6
Rochester	3
Rouses Point	4
Roxbury	1
Rutland	2
Saxtons River	2
Seneca Mountain	4
Sharon	1
Sheldon Springs	4
Snake Mountain	6
	4
USGS Map Key N ↑	
1	4
2	5
3	6
South Hero	

South Mountain	5
South Royalton	3
South Strafford	5
Spectacle Pond	6
Springfield	2
St. Albans	4
St. Albans Bay	5
St. Johnsbury	1
Stamford	3
Stannard	2

USGS Quad Name	#
Sterling Mountain	3
Stone Mountain	4
Stowe	2
Stratford	2
Stratton Mtn.	3
Sudbury	3
Sunderland	5
Sutton	1
Tinkerville	2
Townshend	4
Underhill	5
Vergennes West	3
Vershire	4
Waitsfield	2
Wallingford	1
Walpole	3
Warren	4
Washington	1
Waterbury	4
Wells	5
West Burke	6
West Charleston	2
West Dover	3
West Rupert	5
West Rutland	1
West Topsham	2
Westminster West	3
Westmore	4
Weston	6
Windham	5
Windsor	1
Wolcott	4
Woodbury	3
Woodford	5
Woodstock North	2
Woodstock South	1
Woodsville	1

Appendix III

Field Technique and Specimen Handling

Although each volunteer will bring or develop his or her own skills and style in the field, below are some tips for project participants. For more details on field techniques consult the following excellent resource:

- ◆ *The Very Handy Manual: How to Catch and Identify Bees and Manage a Collection.* Compiled mainly by [Sam Droege](#) at the USGS Native Bee Inventory and Monitoring Lab with input from specialist researchers and taxonomists over several years from 2004-present, this guide provides detailed instructions on bee monitoring techniques including specimen collection, processing and management; bee identification; and more! The manual also provides guidance on the capture, monitoring, identification, and curation of native bees.

1. Netting Technique – Bees are visually-oriented insects. The most successful field workers move steadily and slowly. Always keep your shadow from passing over a perched bee (unless you want it to fly away). Trying to net a flying bumblebee is often difficult. So make your attempt on a bumblebee that has settled on a flower, its nectar source. Once a specimen is in the net, immediately flip the purse of the net over the metal ring to keep it from escaping.

Always hold your net in a “swing-ready” position. One hand should be below the head and the other towards the back or middle of the pole. Hold the tip of the net lightly against the pole with the hand near the head so that it does not drag in vegetation. When you start your swing drop the tip of the net.

Always keep a mental check for the presence of thorny plants in the area where you might swing—for obvious consequences to your net. Additionally, in some areas some plants have seeds that can implant themselves directly into the netting; if that is the case then you might try moving from the usual coarse weave net bag to the fine weave type that BioQuip sells.

When swinging a net, speed is important as well as follow-through. Bees are very visual and very fast. If you are timid in your swing or cut your swing short, bees will evade the net. Center your net on the bee if at all possible, even if it means having to plow through some vegetation. When a bee is flying low to the ground it is better to slap the net over the bee than it is to try to catch it with the corner of your net.

All else being equal, it is better to swing at a bee that is just flying into or away from a flower than a bee that is actually on a flower. Particularly if you are trying not to damage the plant, a less than vigorous swing of the net will simply push a bee on a flower under the net and it will fly away afterwards. After some practice you can bring your net up to a bee on a flower, wait for the bee to leave the flower, push the flower out of the way with your net and still easily capture the bee.

When looking at a clump of flowers that could contain bees stand 4-8 feet away. Most people stand too close to the flowers, which can scare away some of the bees you are interested in, limit both the number of flowers (and therefore bees) in your field of view, and limit your depth of field. In this way you can view a large area of flowers, spot a bee, and either lean forward or take one step to put that bee into your net. If you have to take 2 steps or more, you are too far away.

There are two ways to catch multiple individuals in a net. One way is to turn your net head sideways after capturing a bee, allowing the net bag to close over the head and hoping that the bee will not find a way out. The other is to physically hold the bag closed above the tip containing the bees (note, in between swinging at bees, you will be holding the closed net against the pole as you carry it from place to place). In both cases you will have to periodically snap the contents of the net to the bottom. Do this vigorously or some wasps (in particular) may not go to the bottom, and you could end up grabbing them through the net with obvious consequences to your hand.

A video that demonstrates how to use a net to collect bees can be seen at:

<http://www.youtube.com/watch?v=n6ZFlz3uA7E>

2. Removing Bees from the Net - In the beginning, there is usually a great fear of being stung by your subjects. However, even bumblebees do not sting in a net, unless they are physically grabbed or trapped against the net. Thus, over time you should concentrate on diminishing your fears, and spend more time sticking your hand and kill jar directly into the net. If you are putting your net on the ground to remove bees, you are taking too much time.

The most efficient means of collecting large numbers of bees is to use vials or containers of soapy water. In that way you can fill your net with bees and only have to remove them periodically rather than after catching an individual bee or small number of bees. However, cleaning and processing bees killed this way requires some care to do properly (see section on washing and drying bees).

Once you have captured a bee or bees in the net, there are several ways to remove them. In all cases, it is best to vigorously snap the net to drive the insects to the bottom. You can then safely grab the bag just above where they are resting. Even the larger and more aggressive bees can't get at the hand that is closing off the net, due to the bunching of the netting.

Most collectors take a more direct approach and bring the open kill jar and its lid into the net, trapping the bee against the netting. Slapping the hand on top of the kill jar through the netting is at times useful to drive the bee to the bottom of the jar. This can help prevent bees from escaping when you put the cap on.

A video that demonstrates how to remove bees from a net can be seen at:

<http://www.youtube.com/watch?v=n6ZFlz3uA7E>

3. Collecting Bee Specimens

In general, this manual describes survey methods that are lethal to the captured bees. This seems antithetical to our interest in the diversity and abundance of Vermont's native bees, but there is evidence that inventory and long-term monitoring programs like ours do not impact subsequent year bee populations and without collection, we would be unable to identify most species. Gezon et al. (2015) used a standardized method to sample thousands of bees of 132 morphospecies over multiple years, and found that this did not affect bee communities in terms of abundance, diversity, evenness, or functional group composition. Their results indicate that the bee communities were robust to such sampling efforts, despite removing an average of 2,862 bees per season. Mortality from collecting bees is generally compensatory, where collection deaths replace deaths that would have occurred naturally, and does not impact the population size/viability of bees in subsequent years.

To obtain the most complete assessment of bee populations at a site, collecting bees is recommended. Most species of bees cannot be identified in the field with binoculars or by photographs because identification characteristics are microscopic. Identifying bees on the wing is very difficult as bees are constantly moving and seldom provide sufficient opportunity to view and identify them. Variable skill levels of observers also make confidence in identification and comparisons between observers or surveys impossible.

The study of bees is still in the rudimentary stages compared to that of vertebrates and other insect groups such as butterflies. Without collecting specimens, we won't get vital information on native bees to be able to practice successful bee conservation and management. Failure to document a species' occurrence, by foregoing collecting, could jeopardize targeted conservation in areas that are able to support rare species.

Soap Jars or Vials – We recommend an alternative to chemical-based kill jars for ease of use and safety. We use containers filled with soapy water (a mix of water with dishwashing detergent). The best jars/vials have a tight-fitting lid and are large enough to hold a fair number of bees. They should fit in your pants pocket and be easy to hold in one hand along with the lid. Fill the vial about half full with soapy water.

The jar will form a constant head of suds while riding around in your pants pocket or field vest. Using it in the net has the great advantage of immediately trapping any insect in the suds, thus permitting you to clean out the net of as many specimens as you wish. With a chemical based (cyanide, ethyl acetate) kill jar, you can accumulate 2-4 specimens with some effort, but at some point, more would be leaving than going in. The soapy jar is particularly nice when dealing with large, nasty specimens. The Patuxent lab favors using the large centrifuge tubes, as they slip into the pocket easily.

You have to be a bit more aware of how you carry the jar when open (water seeking its own level and all that), but such jars can also easily be used to directly collect off of flowers without a net.



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