



Northeast Region Survey Instructions for Non-Lethal Bumble Bee Inventory



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ON THE COVER

Bumble bee (*Bombus* sp.) foraging on purple cone flower (*Echinacea purpurea*)

Photograph by: Ryan Hagerty

Survey Instructions Summary

This survey instructions document provides guidance for conducting a non-lethal bumble bee inventory. The primary purpose of these survey instructions is to describe how non-lethal surveys can be conducted in a standardized fashion that allows for comparison of bumble bee relative abundance and species richness between sites and seasons. The survey described herein involves repeated collections of live bumble bees using hand nets from June 1 – August 31. Data on habitat conditions, management actions, and stressors in surveyed sites are also collected, allowing habitat management recommendations to improve site-level conditions for bumble bees to be made. These survey instructions draw upon elements from the National Protocol Framework for Bee Inventory and Monitoring (Droege et al 2017) and the Survey Protocols for Rusty-patched Bumble Bee (v. 2.1).

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Narrative

Element 1: Introduction

Background

The National Wildlife Refuge System (NWRS) is directed by policy to maintain and restore the biological integrity, diversity, and environmental health of lands under its jurisdiction (601 FW 3). By definition, this includes the variety of all living organisms, the habitats within which they occur, as well as the maintenance and/or restoration of these populations and their associated habitats in an ecologically functional condition.

Bees are recognized as an integral part of virtually all ecosystems on earth and are essential for the long-term persistence of most flowering plant species via their pollination of trees, shrubs, and forbs. As pollinators, bees represent an essential link between flowering plants and the food and shelter they provide to humans and wildlife. Though generally overlooked during NWRS station management activities (NWRS stations are land units managed by the USFWS such as national wildlife refuges, national fish hatcheries, wetland management districts, conservation areas, leased lands, etc.), bees provide a critical, yet often unrecognized function in almost every aspect of wildlife and habitat management and restoration – including providing pollination services for the reproduction and survival of plants and the non-pollinating nectivores, herbivores, and frugivores that depend on them for forage; and as a forage source themselves for insectivores such as the bee and wasp specialist scarlet tanager (*Piranga olivacea*) (Robinson 1996; Skutch 1989) and tyrant flycatchers (Tyrannidae) (Craig and Williams 1998). Thus, they are an integral link in food webs in addition to providing these valuable ecological services. Because of the specialized nature of bees and their preferred or sole pollen sources, there is a direct link between healthy and biodiverse bee populations and a healthy and biodiverse plant population (Kearns and Inouye 1997, Mandelik et al. 2012a and 2012b, Kevan, 1999, Russell et al. 2005). As human dominated landscapes become more and more utilitarian, fragmented, invaded by non-native species, and otherwise disturbed and simplified, their capability to hold and maintain uncommon, sensitive or narrow niche native plant and bee habitats declines, making restoration and maintenance of native habitats on NWRS stations and other types of protected areas increasingly valuable as repositories of regional biodiversity. Therefore, it is vital that NWRS stations maintain healthy and diverse plant and native bee communities within their managed and unmanaged landscapes.

Standardized protocols are important for inventory and monitoring (I&M) activities related to wildlife and plants. This Initial Survey Instructions document is written so that a user can collect data on the bumble bee fauna present at John Heinz, Petit Manan, Missisquoi, and Supawna Meadows NWRs using standardized and repeatable inventory methods. This survey will result in increased knowledge of bumble bee species distribution that can inform conservation and Endangered Species Act listing determination efforts. The basis for the document is the National Protocol Framework for Bee Inventory and Monitoring (Droege et al 2017; <https://ecos.fws.gov/ServCat/Reference/Profile/74109>) and the Survey Protocols for Rusty-patched Bumble Bee (v. 2.1; <https://www.fws.gov/midwest/endangered/insects/rpbb/>).

Lethal versus Non-Lethal Sampling

Important trade-offs exist between lethal and non-lethal sampling. Lethal sample collection has many benefits (Droege et al. 2017 pp. 1-4). Many more places and more specimens can efficiently be sampled with lethal traps, and trapping is more likely to detect rare/uncommon species. Trapping techniques are more easily replicated, and can provide statistically valid comparisons among sites and over time, providing information needed for monitoring and conservation actions. Non-lethal photographic and observation techniques are greatly affected by the skill of observers; therefore, it is difficult to reliably compare observations between observers. Thus, lethal sampling of bees offers the opportunity to obtain the most complete assessment of bee populations at a site (Droege et al. 2017 pp. 1-4, 7), especially if the goal is to detect all species of bees.

However, this survey is more narrowly focused on bumble bees, which are not well-sampled using pan traps, the most common type of lethal bee sampling (Droege et al 2017 pp. 3). Typical survey methods for bumble bees include hand-netting (lethal or non-lethal), malaise traps (lethal) and blue vane traps (lethal; Droege et al 2017 pp. 3, 7). An important consideration when selecting a survey technique for bumble bees (lethal vs non-lethal) is whether there is any potential presence of threatened or endangered bumble bees, other bumble bees of conservation concern,¹ or vulnerable life stages, such as queens emerging in the spring (Droege et al 2017 pp. 2-3). If bees listed as threatened or endangered (T&E) are known to occur in an area, there may be restrictions on “taking” these bees. The rusty patched bumble bee (*Bombus affinis*; hereafter “RPBB”) has been listed as an endangered species and is known to occur in Region 5. The USFWS maintains a webpage that gives guidance on doing surveys for *B. affinis* in areas where they may occur: <https://www.fws.gov/midwest/Endangered/insects/rpbb/guidance.html>.

The National Wildlife Refuges included in this survey were selected because they are either 1) within a potential zone of occupancy of RPBB, as defined by the USFWS (Petit Manan NWR), 2) near a potential zone of RPBB occupancy (John Heinz and Supawna Meadows NWRs), or 3) have large acreages managed for pollinators (Missisquoi NWR). Thus, because an objective of the surveys described in this document is to locate and positively identify bumble bees, including rare or federally listed species, we will use non-lethal hand netting as the sampling technique.

We acknowledge that there are known limitations of non-lethal sampling, such as the potential error introduced by differences in observer hand-netting and bumble bee field identification skills. We plan to address this by using two professional observers who have similar skills and abilities in bumble bee netting and identification, and who will be following standardized methods for collecting. Additionally, the taxonomy of bees is still evolving and many new bee species are being discovered and collected. Specimens provide the opportunity to upgrade identifications and allow for additional studies of morphology, taxonomy and DNA in the future (Droege et al. 2017 pp. 3). We plan to address this by taking high-quality photographic vouchers of each species collected. Prior to photographing, the bumble bees will be cooled in a cooler to

¹ Dramatic range-wide declines have been documented in three North American bumble bee species that historically occurred in the Northeast (*B. pennsylvanicus*, *B. affinis*, and *B. terricola*; Cameron et al. 2011). Similar declines have also been recorded in four species within state of New Hampshire (*B. affinis*, *B. fervidus*, *B. terricola*, and *B. vagans*; Jacobson et al. 2017).

ensure that they are still and that photographs from multiple angles can be taken. However, we acknowledge that photography will not allow us to positively identify every species (e.g., some *B. sandersoni* individuals can only be identified via examination under a microscope and thus may be counted as *B. vagans* using our methods). This instance of taxonomic uncertainty is acceptable for this survey because the alternative is to lethally sample every *B. sandersoni* / *vagans* individual and this is not feasible or desirable for this project.

A limitation that is common to both lethal and non-lethal surveys is a lack of understanding of the detection probability of the survey methods. We also presently lack a rigorously estimated confidence level that is possible to achieve with bee surveys. The USFWS RPBB Working Group is working to provide this information.

Objectives

The objectives of this survey are as follows:

Survey Objectives

- Inventory bumble bee species
 - In habitats with high availability of floral resources, such as early successional grasslands/meadows/old fields or shrubby wetlands.
 - On refuges
 - Between June 1² and August 31
 - In areas with available floral resources
- Investigate bumble bee relationships with habitat.

Sampling Objective

In each habitat patch,

- generate a bumble bee species list (inventory);
- measure bumble bee species richness using raw counts (unadjusted for detection probability) with high confidence* that we will detect the majority of bumble bee species present;
- measure bumble bee relative abundance by species using raw counts (unadjusted for detection probability);
- explore habitat relationships with bumble bee richness and relative abundance.

*At this time, we do not have the ability to mathematically calculate the confidence level associated with the estimates of bumble bee species richness and relative abundance obtained through this survey. Very little is known about detection probabilities for timed-search surveys for bumble bees (RPBB Protocol p. 27). However, we have high confidence that we will likely sample every bumble bee species present because we are using professional, experienced observers and the surveys will be repeated three times across the peak season of bumble bee abundance.

² In some cases, surveys may begin as early as May 1, if desired habitat conditions are present. See “*Survey timing and schedule*” below.

Element 2: Sampling Design

Inventory design

Sampling units, sample frame, and target universe

A sampling unit is the defined element at which data is collected and analyzed. The sampling units in this survey are hand-netting events, consisting of multiple bee specimens collected from survey plots in refuge habitat patches from June 1 – August 31, 2018. Habitat patches are areas of a similar habitat type, such as early successional fields, shrubby wetlands, or bogs, which have defined edges or boundaries. The boundaries of a patch can be defined by vegetation (e.g., an open field surrounded by forest) or by refuge administration (e.g., a management unit). We selected a survey duration of three months in order to capture the peak period of bumble bee activity, and to reduce potential negative impacts to bumble bee queens in the spring (RPBB Protocol p. 7).

The sample frame is the spatial area to which the sample is associated. The sample frame for this inventory is the individual refuge habitat patches that are surveyed.

The target universe refers to the bee-specific attributes that a protocol aims to sample. The target universe for this inventory is all bumble bee species using each refuge habitat patch that is surveyed.

Sample selection and size

We define a sample as a one-hour inventory of a maximum four-acre area or survey plot. The number of samples that can be taken at each refuge (assuming one sample requires approximately one hour to complete) is determined by the project budget.

Patch selection is driven by the desire to survey good quality bumble bee habitat from June to August. Sampling frequency is stratified into two groups: 1) Patches sampled three times from June – August, and 2) patches sampled opportunistically (once or twice) during that period.

Patches sampled *three times* are those that conform to characteristics of suitable habitat following the RPBB Protocol (pp. 21-23), which include: open, upland, early successional habitat; high abundance and diversity of flowering plants; not dominated by grasses, sedges, or agriculture; ideally minimal pesticide use. Patches sampled *opportunistically* are those that are assumed to provide good quality bumble bee habitat only during the flowering periods of certain plants, such as buttonbush and purple loosestrife. For example, wetlands or bogs that provide abundant floral resources for bumble bees during short periods during the growing season may only be sampled once. The number of times a patch is sampled is determined prior to the field season.

In both cases, the number of survey plots in each patch are defined using the following rules (Figure 1):

- Patches ≤ 3 acres receive 1 survey plot, which encompasses the entirety of the patch.
- Patches 3.1 – 6.0 acres receive 1 plot, but it encompasses only a portion of the patch. The plot should be placed in the area of greatest concentration of flowering plants (this area

may shift over the course of the summer sampling period; see “*Establishment of sampling units*” in Element 3).

- Patches > 6.1 acres receive at least 1 plot based on the variability of the vegetation in the patch (more variable = more plots). Again, plots should be placed in the areas of the greatest concentration of flowering plants (this area may shift over the course of the summer sampling period; see “*Establishment of sampling units*” in Element 3).

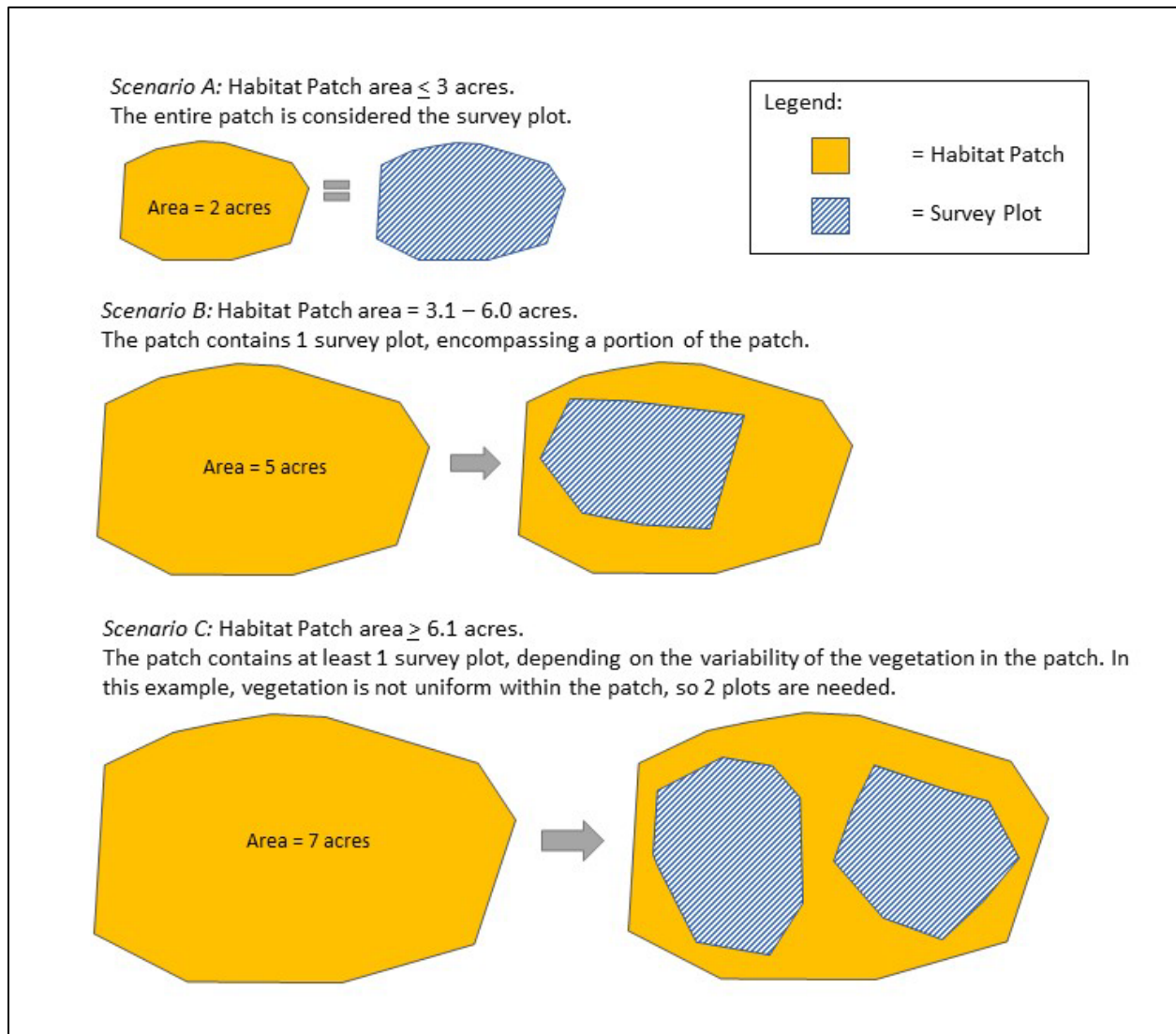


Figure 1. Illustration of the number of survey plots in habitat patches of various sizes. The number of survey plots per patch is determined by the patch size and the variability of the vegetation within it.

Survey effort

In order to have high confidence that we will detect every species using the survey plot, the minimum survey effort will be one person hour per three acres (RPBB Protocol pp. 14-15), which is based on expert bumble bee surveyor opinion. Person-hours are calculated based on the number of experienced bumble bee surveyors present (e.g., one person hour = one experienced person surveyed for one hour). Novice surveyors may be present and, in some cases, may

participate in the survey (see “*Guidance on novice observers*”), but their survey time should not count towards the minimum effort required.

When one experienced bumble bee surveyor is present:

- The target survey length is one hour
- The target survey plot size is three acres (a max of four acres is acceptable)

When more than one experienced surveyor is present:

- The target survey length remains one hour
- The survey plot size may be increased to six acres, if space is available.

Survey timing and schedule

The survey schedule for this inventory will be:

- From June 1 – August 31, 2018, there will be one survey visit to each Refuge in each month, based on flowering phenology.
 - Some surveys may begin before June 1 due to local flowering phenology (e.g., Missisquoi will be surveyed in late May). However, the general scheme for this inventory is to begin after June 1.
- Some patches will be surveyed each of the three months, while others will be surveyed only one or two months out of three (see *Sample Selection and Size*).
- Surveys will be conducted at least 2 hours after sunrise and at least 3 hours before sunset (RPBB Protocol p. 7).
- Robert Jean will survey John Heinz and Supawna Meadows NWRs. Leif Richardson will survey Missisquoi and Petit Manan NWRs.

June 1 – August 31 coincides with the period of peak activity of bumble bees. We chose to do one survey per month because bumble bee population size and relative abundance of species may vary throughout the season. Also, the species pool present at each Refuge may vary across that time, with nest parasites appearing later in the summer and other species (i.e., *B. bimaculatus*) vanishing by mid-August. Because this is the pilot year of this survey, we will examine the variability of species richness, relative abundance, and occurrence from month to month for each patch and within each Refuge. This information will be used to inform the number of surveys needed to completely inventory bumble bee species in a patch (create a species list for the patch), and to revise future iterations of these survey instructions.

Sources of error

It is likely that factors such as pollen availability, surrounding vegetation composition, and phenological status or phenophase influence the number and species of bumble bees collected during a given sampling event. Error can also come from unknown variation in bee life cycles, ecological preferences and tolerances, influences of natural and unnatural conditions (e.g., pesticide use on population dynamics), and the taxonomic uncertainty of some bee species. Results can be affected by weather, observer bias (not following protocol, ability to see and/or catch bumble bees), sampling effort, annual variations in life cycles, regional trends, misidentifications, and erroneous analyses.

Element 3: Field Methods

Pre-survey logistics and preparation

As part of the development of this ISI, a Planning and Review of I&M activities on Refuges (PRIMR) survey template was created. PRIMR surveys for each refuge should also be created prior to fieldwork, using this template. If possible, a survey priority should also be assigned.

Surveyors will notify each Refuge manager and biologist at least 1 week prior to their arrival for each survey. They will also notify refuge staff of any changes to the schedule due to weather or other factors. The refuge staff should inform the surveyor if any gate keys or codes are required to access the sites, and make arrangements to meet the surveyor to provide them.

Equipment

The following list can be found in the RPBB Survey Protocol (p. 8) and was modified for this ISI:

- Cloth aerial hand net with fairly transparent netting (Insect net that is 12 – 18 inches in diameter). Do not use sweep, beater, or wire nets.
- Timer/stopwatch
- Weather station for measuring temperature and wind speed.
- Cooler with cold packs or ice in a bag. Cooler should be $\frac{1}{4}$ to $\frac{1}{2}$ full of cold packs or ice.
 - Medium or large cooler with 4 cold packs can be used when driving to field sites.
 - Small (six pack) cooler with 1-2 pint-sized cold packs can be used when hiking to field sites.
- Handheld weather station (such as Kestrel Weather Meter)
- At least 200 vials or baggies to contain live bumble bees.
 - Suggested vials from Bioquip:
 - #8813P, 9.5 drams, diameter 26.6x95 mm, length 1x3.75”, neck 17.4 mm
 - #8814P, 11 drams, diameter 26.6x102 mm, length 1x4”, neck 17.4 mm
 - Vials should either have light-colored lids or a blank sticker attached to them so that observers can record data on them during the survey.
- Camera (e.g., Olympus TG-4 point and shoot) with fully-charged, backup battery
- Small photographers tent
- Copy of this Initial Survey Instructions document or at a minimum, maps and descriptions of habitat patches and target sampling sites (print out entirety of ***“Habitat patches to be surveyed in 2018”*** section below)
- GPS-enabled device (e.g., iPad) that can be used with the apps Collector and Survey123. The apps should be installed and logged in, and the appropriate maps and surveys downloaded, before going into the field (see SOP 3).
 - If a GPS-enabled device for mapping the survey plot is not available, contact the Regional Project Lead.
 - Datasheets for *Bombus* surveys (as a backup in case of device failure) and clipboard.
- Portable charger for GPS-enabled device
- Pencils
- Sharpie markers
- Hand lens or loupe

- Permits
- Flagging or stake flags to mark the perimeter of survey plots
- Contact information for Refuge biologists/manager, and Regional Project Lead
 - Regional Project Lead = Becky Longenecker. 413-253-8636 (office). 413-404-3037 (cell)
 - Regional Data Manager = Maritza Mallek. 413-253-8783 (office).
 - John Heinz Biologist = Brendalee Phillips. 215-365-3118 ext. 3213 (office). 610-842-4363 (cell).
 - Missisquoi
 - Manager = Ken Sturm. 802-868-4781 ext.3236 (office). 802-393-3833 (cell)
 - Biologist = Judy Sefchick-Edwards. 802-868-4781 ext. 3238 (office).
 - Petit Manan Biologists =
 - Sara Williams. 207-546-2124, ext. 13 (office). 207-557-7813 (cell)
 - Linda Welch. 207-546-2124 ext. 11 (office). 207-557-7810 (cell)
 - Michael Langlois. 207-594-0600 ext. 3 (office).
 - Supawana Meadows Biologist = Heidi Hanlon. 609-463-0994 Ex. 2372 (office)

Laws, policies, and permits

- Consult with the nearest ES Field Office, the USFWS Information for Planning and Conservation website (<https://ecos.fws.gov/ipac/>) or the USFWS rusty patched bumble bee website (<https://www.fws.gov/midwest/endangered/insects/rpbb/>) to determine if the proposed survey will require a Section 7 or 10 incidental take permit.
- Obtain any state permits required for sampling
- Consult with the Refuge and determine if a Special Use Permit is required. Follow refuge-specific guidance for preparing a Special Use Permit application.

Establishment of sampling units

Prior to the survey, maps of each target sampling site in each patch (see “***Sample selection and size***” in Element 2) will be created in GIS and provided to the observers. Shapefiles of the sampling sites and patch boundaries will also be provided to the observers and taken into the field on a GPS-enabled device.

Just prior to the start of each survey, observers will navigate to a target sampling site and perform a visual inspection of the area around it. They will visually identify the area of greatest density of plants in flower, which will be the survey plot (maximum area = 3 acres; Figure 6). There will be one survey plot for each target sampling site. It is critical to note that the target sampling site (point) need not be at the exact center of survey plot (polygon). The target sites, generated prior to the survey, are merely a guide to ensure that the survey plots are placed in the correct sections of each patch and are distributed at the desired density in the patch (if the patch is large enough to contain multiple plots). Once the observers have identified the survey plot, they will use a GPS-enabled device to delineate the perimeter, and mark the perimeter with stake flags. Make sure to record the geodetic datum (and the UTM zone, if using UTM) when recording coordinates.

Because the density and location of plants in flower may change throughout the growing season, survey plots will be selected and delineated on each survey visit (June, July, and August). Plots will be located in the same habitat patch for each survey visit, but their exact location may change if the flowering plant density and distribution changes (Figure 2). Rationale: bumble bees will follow the flowers. In order to accomplish the survey objective, which is to inventory bumble bee species in habitats with high availability of floral resources, such as early successional grasslands/meadows/old fields or shrubby wetlands; on refuges; between June 1 and August 31; in areas with available floral resources; and to investigate bumble bee relationships with habitat, we should survey where the flowers are most dense, which will not necessarily be the same from visit to visit (see SOP 1).

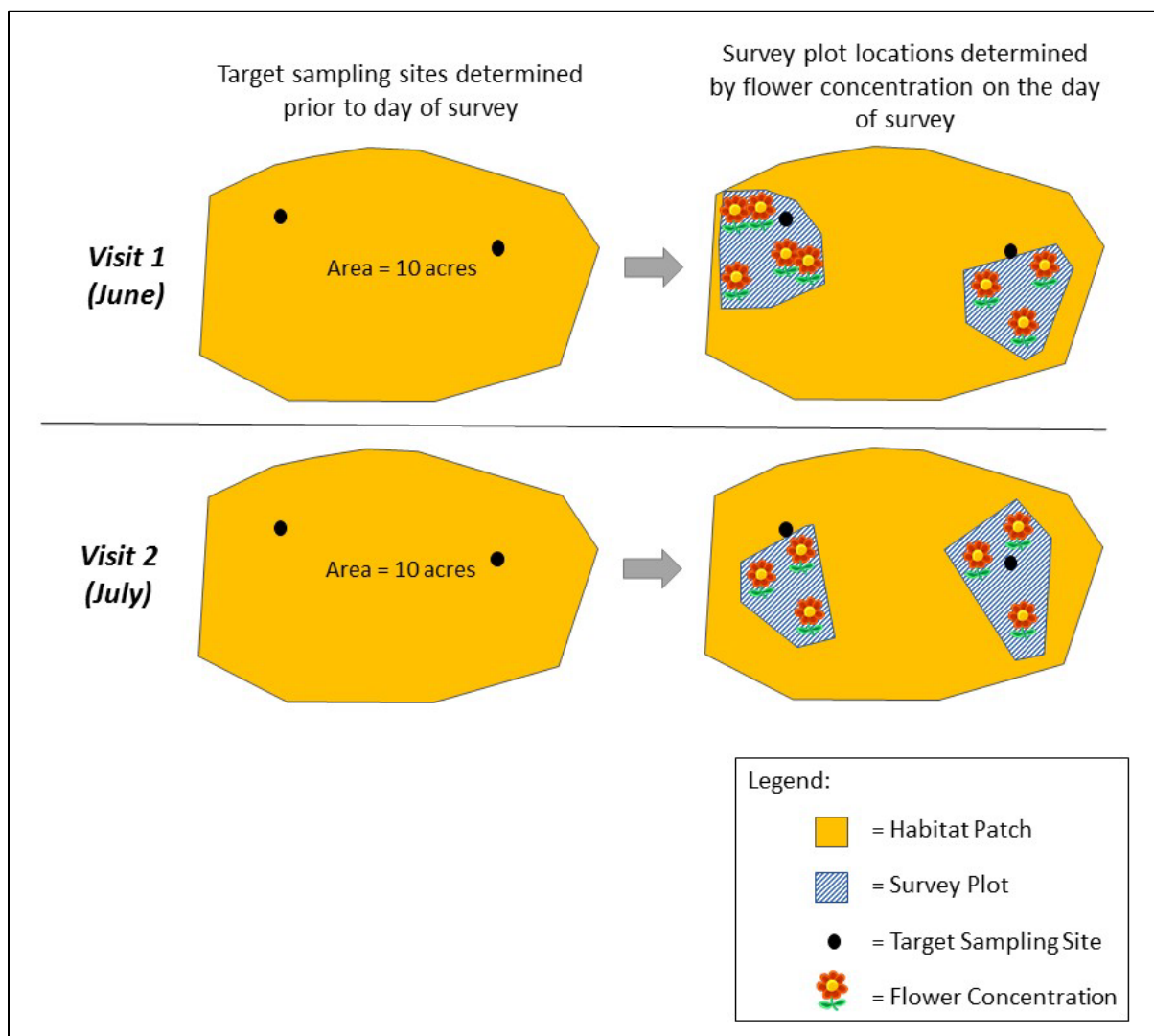


Figure 2. Illustration of the establishment of survey plots in refuge habitat patches on visits 1 (June) and 2 (July). Because the habitat patch is 10 acres in size, surveyors determined a priori that it would receive two survey plots, which are indicated by the target sampling site points. The survey plot perimeter is defined on each visit, based on the greatest concentration of flowering plants in the vicinity of the target sampling site at that time.

Survey plot naming convention

Each survey plot will receive a unique name using the following convention:

Refuge LIT Code -Patch Name-Target Sampling Site-Fiscal Year-Visit Number

Refuge LIT Code = 3 letter code unique to each Refuge

Patch Name = name of habitat patch (often the management unit name assigned by the Refuge).
See Tables 1-4.

Target Sampling Site = number assigned to each target sampling site in each habitat patch (range is 01 – 09).

Fiscal Year = 18 for all cases.

Visit Number = 1, 2, or 3.

For example, PMN-Field2-01-18-3 indicates the survey was done at Petit Manan NWR Field 2 at the first survey plot in that field. It was the third survey visit in 2018.

Habitat patches and target sampling sites for 2018

The final habitat patches and target sampling sites selected for this inventory are:

Table 1. Habitat patches and target sampling sites at John Heinz NWR to be surveyed for bumble bees in 2018.

<i>Refuge Name</i>	<i>Patch & Target Sampling Site Name (concatenated)</i>	<i>Patch Area (acres)</i>	<i>Latitude</i>	<i>Longitude</i>	<i># of Visits from June – August</i>	<i>Patch Description</i>	<i>Habitat Management Actions or Stressors</i>
John Heinz NWR	Corp Property-01	0.92	39.8782	-75.2691	3	Restored in 2007. Seeded with flowering plants, but now being invaded by groundsel.	- Habitat restoration (seeding)
	Five Acre Field-01	3.3	39.8940	-75.2566	3	High floral diversity and abundance, some grasses/sedges, spot application of pesticides on purple loosestrife. 400 perennial flowers were planted in 2017.	- Pesticides (spot application on purple loosestrife) - Habitat restoration (perennials planted in 2017)
	Frog Pond-01	1.0	39.8850	-75.2543	3	Phrag dominated, but some milkweed, ironweed, and other flowers	
	Sunoco Meadow-01	0.32	39.8839	-75.2543	3	N/A. Will only be sampled if time permits.	
	Teardrop-01	1.2	39.8927	-75.2570	3	High floral diversity and abundance, some grasses/sedges, spot application of pesticides on purple loosestrife	- Pesticides (spot application on purple loosestrife)



Figure 3. Habitat patches to be surveyed for bumble bees at John Heinz NWR in 2018. Green dots are target sampling sites (the approximate location of survey plots in each patch).

Table 2. Target sampling sites at Missisquoi NWR to be surveyed for bumble bees in 2018.

<i>Refuge Name</i>	<i>Patch & Target Sampling Site Name (concatenated)</i>	<i>Latitude</i>	<i>Longitude</i>	<i># of Visits from June – August</i>	<i>Patch Description</i>	<i>Habitat Management Actions or Stressors</i>
Missisquoi NWR	Center Island-01	44.9592	-73.1944	1	Upland forest island (oak)	
	Cranberry Dike Pool-01	44.9599	-73.1441	1	Emergent wetland vegetation	
	First Creek Trail-01	44.9406	-73.1545	1	Forest and wetland (trail)	
	Goose Bay Pool-01	44.9772	-73.1513	1	Emergent wetland vegetation	
	Louis's Landing-01	44.9626	-73.1674	3	Field	
	Mac's Bend-01	44.9720	-73.1686	3	Field/wetland	
	North Island-01	44.9671	-73.1948	1	Upland forest island	
	Rail Trail Wetland-01	44.9398	-73.1966	3	Dwarf shrubland bog	
	Rte 78 North-01	44.9523	-73.1634	3	Field	
	Rte 78 South-01	44.9449	-73.1530	1	Field	
	South Island-01	44.9536	-73.1980	1	Upland forest island (oak)	
	Steve Young Marsh-01	44.9524	-73.2076	3	Emergent vegetation/fields	
	Tabor East-01	44.9527	-73.2022	3	Managed grassland	
	Tabor East-02	44.9675	-73.1983	3	Managed grassland	
	Tabor East-03	44.9584	-73.2016	3	Managed grassland	
	Tabor West-01	44.9674	-73.2070	3	Managed grassland	Hayed
	Tabor West-02	44.9610	-73.2090	3	Managed grassland	Hayed

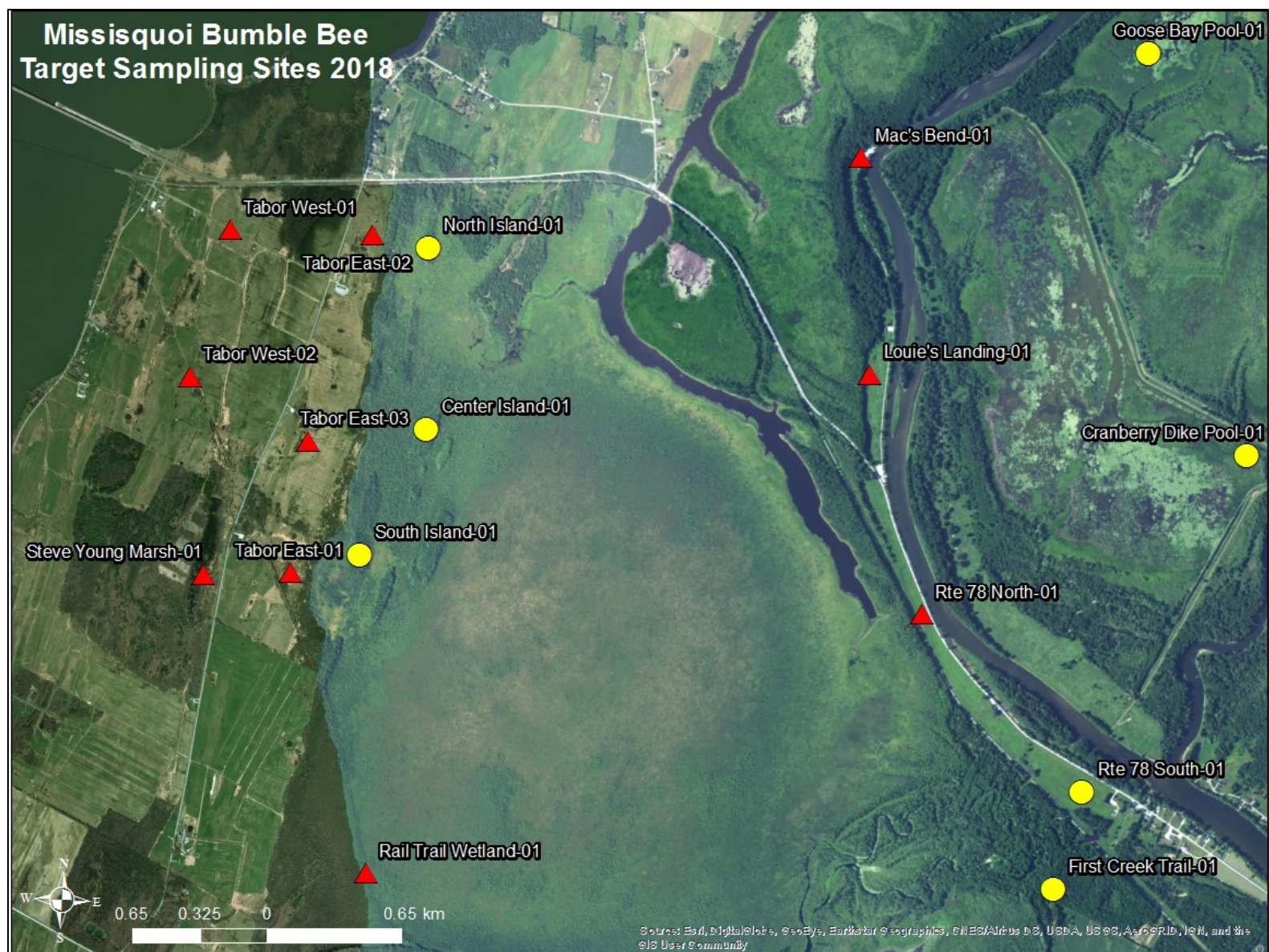


Figure 4. Target sampling sites (the approximate location of survey plots in each patch) to be surveyed for bumble bees at Missisquoi NWR in 2018. Red triangles = survey 3 times. Yellow dots = survey opportunistically.

Table 3. Habitat patches and target sampling sites at Petit Manan NWR to be surveyed for bumble bees in 2018.

<i>Refuge Name</i>	<i>Patch & Target Sampling Site Name (concatenated)</i>	<i>Patch Area (acres), if applicable</i>	<i>Latitude</i>	<i>Longitude</i>	<i># of Visits from June – August</i>	<i>Patch Description</i>	<i>Habitat Management Actions or Stressors</i>
Petit Manan NWR	Bear Cove-01	N/A	44.40812	-67.9060	1	Rugosa rose	
	Birch Point-01	N/A	44.45770	-67.9104	1	Forest edge	
	Dwarf Shrub 1-01	N/A	44.41045	-67.8990	1	Dwarf shrubland	
	Dwarf Shrub 2-01	N/A	44.40069	-67.9016	1	Dwarf shrubland	
	Dwarf Shrub 3-01	N/A	44.42427	-67.8934	1	Dwarf shrubland	
	Field-01	1.4	44.44443	-67.8976	3	Organic lowbush blueberry fields with diverse vegetation. Managed every 3-5 years with fire or mowing.	Burned in April 2018
	Field 2-01	2.7	44.41296	-67.9055	3	Organic lowbush blueberry fields with diverse vegetation. Managed every 3-5 years with fire or mowing.	Burned in April 2018
	Field 3-01	5.6	44.40841	-67.9036	3	Organic lowbush blueberry fields with diverse vegetation. Managed every 3-5 years with fire or mowing. A bit more woody than the other fields.	Mowed in Nov 2017
	Field 4-01	6.8	44.44334	-67.8984	3	Organic lowbush blueberry fields with diverse vegetation. Managed every 3-5 years with fire or mowing.	Mowed in Nov 2017
	Field 5-01	3.0	44.44013	-67.8945	3	Organic lowbush blueberry fields with diverse vegetation. Managed	Mowed in Nov 2017

<i>Refuge Name</i>	<i>Patch & Target Sampling Site Name (concatenated)</i>	<i>Patch Area (acres), if applicable</i>	<i>Latitude</i>	<i>Longitude</i>	<i># of Visits from June – August</i>	<i>Patch Description</i>	<i>Habitat Management Actions or Stressors</i>
						every 3-5 years with fire or mowing.	
	Field 7-01	5.1	44.43823	-67.8957	3	Organic lowbush blueberry fields with diverse vegetation. Managed every 3-5 years with fire or mowing. Rocky.	Burned in April 2018
	Field 8-01	1.8	44.43613	-67.8948	3	Organic lowbush blueberry fields with diverse vegetation. Managed every 3-5 years with fire or mowing. Rocky.	Burned in April 2018
	Field 9-01	7.3	44.43464	-67.8966	3	Organic lowbush blueberry fields with diverse vegetation. Managed every 3-5 years with fire or mowing. Vegetation is distinct from fields 1-8.	Mowed in October 2017
	Field 9-02		44.43239	-67.8991	3		
	Field 10-01	2.3	44.41608	-67.9072	3	Grass field	Mowed in October 2015
	Field 11-01	8.2	44.41733	-67.9074	3	Grass field	50% mowed in November 2017
	Hollingsworth Trail-01	N/A	44.43543	-67.8892	1	Forest/shoreline	
	Over's Point Road-01	N/A	44.42556	-67.9056	1	Forest edge/roadside	
	Petit Manan Rd WL-01	N/A	44.43094	-67.9014	1	Herbaceous wetland	
	Richards Field-01	2.8*	44.13118	-69.1012	3	Grass field with blueberry bushes. Old farmstead. Last mowed several years ago. Existing	

<i>Refuge Name</i>	<i>Patch & Target Sampling Site Name (concatenated)</i>	<i>Patch Area (acres), if applicable</i>	<i>Latitude</i>	<i>Longitude</i>	<i># of Visits from June – August</i>	<i>Patch Description</i>	<i>Habitat Management Actions or Stressors</i>
						management regime not established. Is within the “low potential” RPBB occurrence zone	
	South Wetland-01	N/A	44.41592	-67.9021	1	Herbaceous wetland	
	Wood Pond-01	N/A	44.40827	-67.8918	1	Forest/shoreline	

*Likely not a precise acreage because the polygon doesn’t trace the edges of the grassy field on the site.



Figure 5. Habitat patch to be surveyed for bumble bees at Petit Manan NWR, Richards Division, in 2018. Triangle is the target sampling site (the approximate location of survey plot). Red triangles = survey 3 times. Yellow dots = survey opportunistically

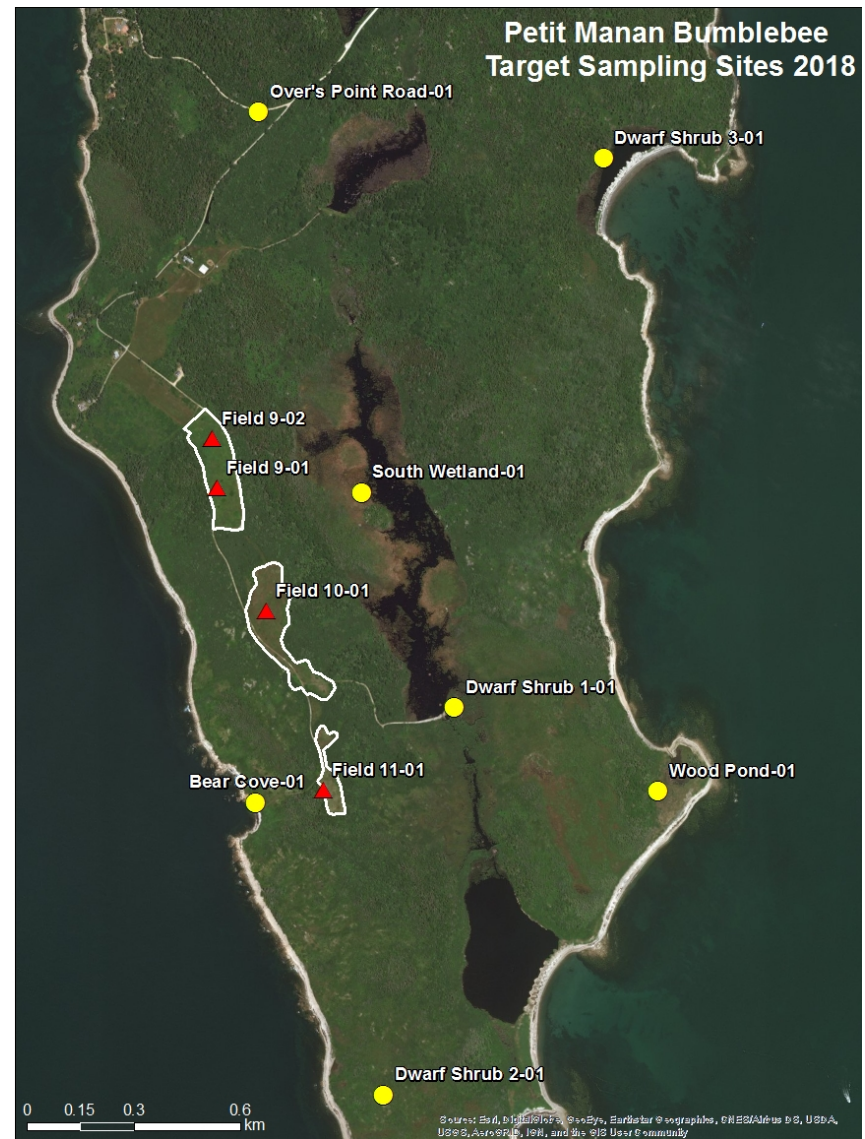
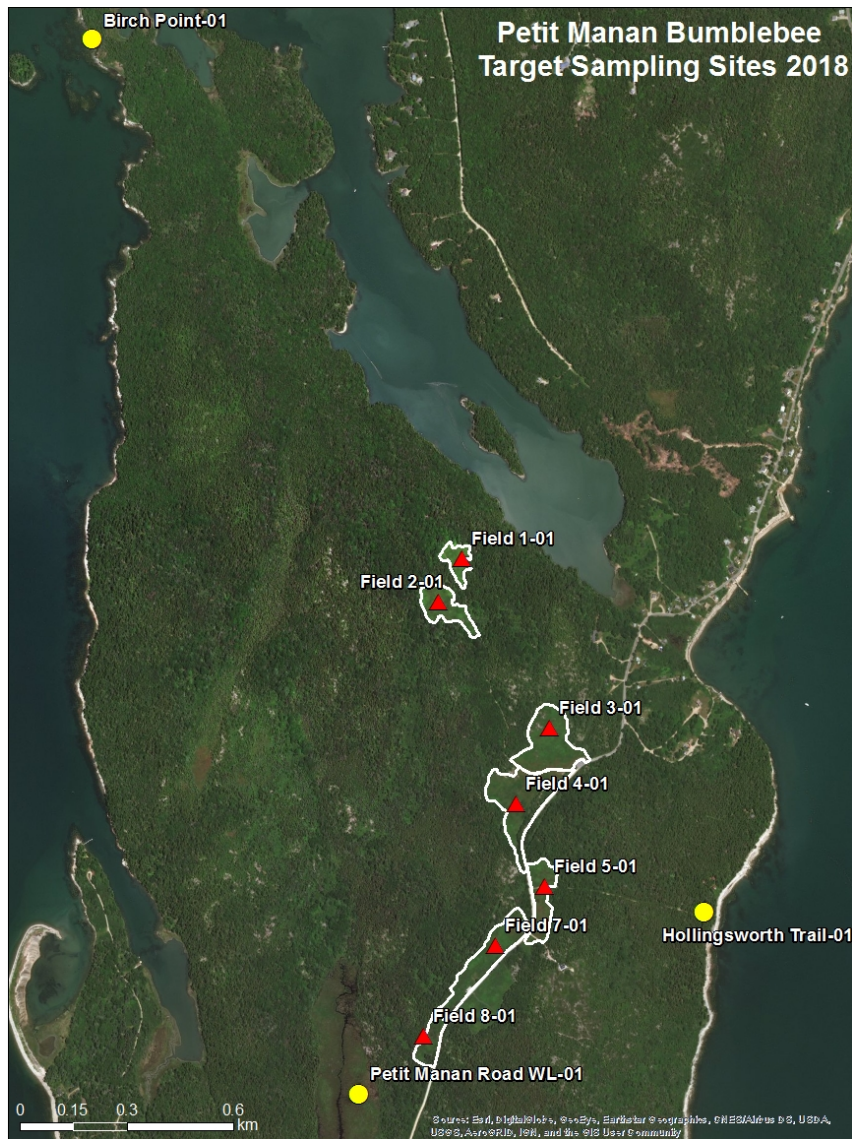


Figure 6. Target sampling sites (the approximate location of survey plots in each patch) to be surveyed for bumble bees at Petit Manan NWR, Petit Manan Point Division, in 2018. Red triangles = survey 3 times. Yellow dots = survey opportunistically.

Table 4. Habitat patches and target sampling sites at Supawna Meadows NWR to be surveyed for bumble bees in 2018.

<i>Refuge Name</i>	<i>Patch & Target Sampling Site Name (concatenated)</i>	<i>Patch Area (acres)</i>	<i>Latitude</i>	<i>Longitude</i>	<i># of Visits from June – August</i>	<i>Patch Description</i>	<i>Habitat Management Actions or Stressors</i>
Supawna Meadows NWR	Site 2-01	5.8	39.6135	-75.5260	3	Powerline right of way.	- Mowing
	Site 3-01	54.0	39.6097	-75.5262	3	Early successional habitat. Abundant goldenrod, heath aster. Portions were brush-hogged in winter 2015 and 2016. Portions were mowed in early 2018.	- Brush-hogging (2015 & 2016, portions) - Mowing (2018, portions)
	Site 3-02		39.6081	-75.5268	3		
	Site 3-03		39.6071	-75.5256	3		
	Site 3-04		39.6111	-75.5270	3		
	Site 4-01	73.6	39.6093	-75.5040	3	Grassland/early successional habitat. Converted from soybeans to native grasses/wildflowers 3 years ago. Portions were mowed in early 2018.	- Mowing (2018, portions) - Restored from soybeans in 2014
	Site 4-02		39.6089	-75.5013	3		
	Site 4-03		39.6082	-75.5023	3		
	Site 4-04		39.6073	-75.5039	3		
	Site 4-05		39.6062	-75.5000	3		
	Site 4-06		39.6058	-75.5038	3		
	Site 4-07		39.6053	-75.5018	3		
	Site 4-08		39.6042	-75.4994	3		



Figure 7. Habitat patches (Site 2, 3, and 4) to be surveyed for bumble bees at Supawna Meadows NWR in 2018. White dots are target sampling sites (the approximate location of survey plots in each patch), which are labeled by their ID number).

Data collection procedures

Follow the methods described in “Methods for Surveys within the High and Low Potential Zones” (RPBB Protocol v. 2.1 2018, pp. 9-11) and “Recovery Monitoring (*Bombus* Community) Survey Protocol” (RPBB Protocol pp. 14-15) with the following modifications. See **SOP 1: Field Data Collection** for step-by-step instructions of field methods.

- Conduct surveys during suitable conditions (p. 7) – follow directions.
- Site Selection (p. 9) – see *Sample size and selection* (above).
- Define the Survey Area (p. 9) – see *Establishment of sampling units* (above).
- In-Field Habitat Assessment (p. 9) – take representative photographs of each survey plot. Collect the habitat and environmental data listed below:
 - Identify all the habitat types in the plot
 - Estimate the percent of the plot that is vegetated
 - Estimate the percent cover of non-woody plants in flower (forbs or grasses)
 - Estimate the percent cover of flowering woody plants (shrubs or trees)
 - Describe dominant management practices in the survey plot. This information should be obtained from the refuge biologists and/or manager and does not need to occur on the day of the survey.
 - Describe observed or likely stressors in the survey plot (e.g., use of pesticides, tilling). This information should be obtained from the refuge biologists and/or manager and does not need to occur on the day of the survey.
 - Temperature (F), wind speed (miles per hour), and cloud cover (%)
- Record Floral Use (p. 10) – follow directions and in addition take representative photographs of plants used by all bumble bees observed (minimum one set of voucher photos per plant species).
 - Record this info for each bee captured on a flower.
 - Care should be taken in recording valid or accepted Latin scientific names of plants being used by bumble bees. Names should be written out in full without abbreviations. Care should be taken to use syntax accepted by the general taxonomic community for qualifiers such as subspecies, variety, hybrid etc. in scientific names. Do not include taxonomic authors and dates, or other artifacts such as the taxonomic qualifiers ‘nr.’, aff., cf., in the same database field where the scientific name is recorded. These notes may be recorded in the Comment field associated with an individual plant ID. The Survey123 form associated with this protocol has drop-down boxes with standardized scientific names for anticipated plants.
 - Plant common names are highly ambiguous but can be useful. Common names should be recorded in a separate database field and spelled out in full (no abbreviations). This field is optional unless the scientific name is unknown; then it is required.
- Photographs (p. 10; Appendix B p. 20) – follow directions and in addition take voucher photographs of all bumble bee species (minimum one set of voucher photos per species) in order to additionally document the presence of each species observed at the sampling location.
- Survey Methods and Technique (p. 10, 15) – follow directions, except:

- Hold all captured bumble bees in a cooler to identify at the end of the sampling period (1 hour), except for suspected *B. affinis*, which will be processed and released immediately after capture.
- Attempt to capture all bumble bees rather than using visual surveys/estimates only.
- Record the time that each bee is captured by writing it on the sticker or the vial lid.
- Don't put vials containing bumble bees directly on ice. Put a layer of plastic bags on top of the ice/ice packs so the vials of bees don't contact them directly. Do not hold bees in a cooler with ice for more than 2 hours (RPBB Protocol p. 7).
- Identify the caste of each bee, if possible. Caste includes: queen female, worker female, female, and male.
- Identification Verification (p. 10) – follow directions and in addition:
 - Identification will be at the species level. We will record the relative amount of confidence of each species identification on the survey form.
 - The Integrated Taxonomic Information System (ITIS, www.itis.gov) is the taxonomic authority of the U.S. Department of the Interior and as such should be used to ensure use of valid and accepted scientific names for bee species and plants wherever possible. These are the scientific names used in the NWRS Bee Database.
 - The World Bee Checklist (Ascher and Pickering 2015) (available online at www.discoverlife.org/mp/20q?act=x_checklist&guide=Apoidea_species&flags=HAS) should also be used as an additional taxonomic reference, especially for valid scientific names for bee species that are not yet represented in ITIS.
 - We acknowledge some uncertainty in visually discriminating between *B. vagans*, *sandersoni*, and *bimaculatus*.
 - In most cases, *bimaculatus* can be visually distinguished without difficulty. However, a small proportion of males present confusing color patterns and therefore will not be distinguishable from the other species.
 - It is often difficult to distinguish *vagans* and *sandersoni*. We will examine each potential *vagans/sandersoni* with a hand lens to search for distinguishing features of *vagans* (i.e., malar space is obviously longer than broad) and will call a specimen *vagans* only when those features are present. All other specimens will be called *vagans/sandersoni*.
 - We expect *B. vagans* to be very common at our sites, *B. bimaculatus* to be moderately common, and *B. sandersoni* to be very uncommon, based on prior survey data.
 - Care should be taken in recording valid or accepted Latin scientific names of captured bees. Names should be written out in full without abbreviations. Do not include taxonomic authors and dates, or other artifacts such as the taxonomic qualifiers 'nr.', aff., cf., in the same database field where the scientific name is recorded. These notes may be recorded in the Comment field associated with an individual *Bombus* ID. The Survey123 form

associated with this protocol has drop-down boxes with standardized scientific names for bees.

- Release (pp. 10-11) – follow directions.
- Survey Effort (pp. 14-15) – follow directions, except conduct one to three surveys, evenly spaced from June 1 – August 31, 2018. Also, do not continue sampling until 150 bumble bees are collected. See “*Sample selection and size*” and “*Survey effort*” (above).
 - Use *Option 2 - Surveys Without Transects*.
 - Surveys will not be repeated in consecutive years in this pilot project.
 - Survey each plot with a minimum effort of one person hour per three acres. Note that “person” in this case is considered to be an experienced bumble bee surveyor, not a novice collector.
 - Survey plot area should be three acres (a maximum of four acres is acceptable), unless more than one experienced bumble bee surveyor is present (at which time, the plot may be increased to 6 acres if space permits).
 - Survey time should be 1 hour.
 - Novice surveyors may assist with capturing bumble bees unless the survey plot is within a potential RPBB zone (Richards Division Field at Petit Manan NWR is the only site within an RPBB zone). Record which bees they collect and count them as observers.
 - No more than 4 observers (including experienced and novice) may collect within a 3-4 acre survey plot.
- Capturing a rusty patched bumble bee – in the event that a rusty patched bumble bee is positively identified by the observer, immediately at the conclusion of the survey contact the Refuge staff and Regional office team members (Becky Longenecker, Laura Eaton, Maritza Mallek). USFWS Ecological Services will then be informed about the discovery and requested to perform more in-depth assessments at the site.

Spatial data will be collecting using either the Collector app or with a GPS device that can capture polygons (see SOP 3). Tabular data will be collected using either Survey123 app, or by filling out paper data sheets (see SOP 3). Photographs may be collected using cameras or mobile devices that have cameras (see SOP 1).

Other general notes on recording data:

- Dates and times in Survey123 are automatically formatted. Dates on paper field forms should be recorded as MM/DD/YYYY. Times should be recorded as HH:MM in 24-hour time.

Guidance on novice observers

Novice observers (e.g., refuge staff, volunteers who have minimal experience capturing bumble bees by hand net) may participate in the surveys under certain conditions. There should be no more than 4 people surveying in a 3-4 acre survey plot, including experienced and novice observers. This is to minimize the impact to the bumble bees using the plot, which can be disturbed by people moving, casting shadows, etc.

Novice observers should be trained in safe netting and handling techniques by the experienced observer prior to the survey start. They should record which bees they capture by writing their initials on the vial, so that their effort can be account for later. Novice observers should not identify bumble bees without consulting the experienced observer.

End-of-season procedures

Refuge staff responsible for coordinating bumble surveys at a given refuge should enter Annual Activity data into PRIMR at this time. The Data Manager (Maritza Mallek) will extract information needed for populating the Monitoring and Management dataset and share it with the Regional GIS Specialist (Rick Schaufler).

Element 4: Data Management and Analysis

Data entry, verification and editing

Most data for this survey is collected and entered simultaneously. In the event that the apps Collector and Survey123 are not used for data collection, the survey plot boundaries must be added to the web map. Once a polygon is added to the web map, data entry of the tabular data can be completed (see SOP 3).

When all data entry for a site visit has been completed, the Survey Coordinator (Becky Longenecker) and Data Manager (Maritza Mallek) should be notified so that one of them can review the data and perform quality control on the values entered.

Photographic data collected during the surveys will be additionally entered into the iNaturalist database, following SOP 4.

Metadata

The following fields appear in the Survey123 form associated with this survey. There are 2 repeats associated with this survey that are stored as related tables on AGOL, one for bee ID and one for flower ID. Field lengths are set to 254 for text fields by default.

Table 5. Attribute field list for surveys. Most fields are required. Exceptions include *Comment*, *Other*, fields associated with photographs/images, and fields associated with additional observers. See Survey123 form for additional metadata details.

Field Name	Field Alias	Domain Name (if applicable)	Field Type	Selected or Calculated?
Bombus_GUID	Global Unique ID (GUID)		GUID	Calculated
Section 1: Basic Survey Details				
SurveyPlotAcres	Survey Plot Area in Acres		Decimal/Double	Entered
RefugeName	Refuge Name	Refuges	Text	Selected
LeadCooperator	Lead Cooperator		Text	Autofills based on Refuge
AdditionalObserverExpert1	Additional Expert Observer #1		Text	Entered
AdditionalObserverExpert2	Additional Expert Observer #2		Text	Entered
AdditionalObserverExpert3	Additional Expert Observer #3		Text	Entered

AdditionalObserverNovice1	Additional Novice Observer #1		Text	Entered
AdditionalObserverNovice2	Additional Novice Observer #2		Text	Entered
AdditionalObserverNovice3	Additional Novice Observer #3		Text	Entered
TotalObservers	Total Number of Observers		Integer/ Long	Entered
PatchNameTargetSite	Patch and Target Sampling Site	SurveyPatch	Text	Selected
OtherPatchNameTargetSite	Other Patch and Target Sampling Site		Text	Entered
VisitSequence	Which visit is this?		Integer/ Long	Entered
FiscalYear	Fiscal Year		Integer/ Long	Entered (default = 18)
SurveyID	Survey ID		Text	Calculated
TemperatureF	Temperature		Decimal/ Double	Entered
WindSpeedMph	Wind Speed		Decimal/ Double	Entered
CloudCover	Cloud Cover	PercentBlock1	Text	Selected
VisitStartDate	Survey Date		Date	Entered
VisitStartTime	Survey Start Time		Time	Entered
VisitEndTime	Survey End Time		Time	Selected Entered
TimeSurveying	Total Time Spent Surveying		Decimal/ Double	Entered
BasicSurveyComment	Comment		Text	Entered
Section 2: Bees! (this section is a <i>repeat</i> in Survey123)				
BeeCode	Bee Specimen Unique ID		Text	Autofills

BeeID ³	Bombus Species	BeeID	Text	Selected
BeeIDOther	Bombus species not on list		Text	Entered
BeeConfidence	Percent Confidence in ID	PercentBlock1	Text	Selected
BeeCaste	Caste	Caste	Text	Selected
BeeCapturedBy	Name of person who captured bee		Text	Entered
TimeCollected	Time Collected		Time	Entered
BeeComment	Bee Comment		Text	Selected
iNaturalistURL	iNaturalistURL		Text	Entered
SurveyPhoto1	Survey Photo 1		Image	NA
SurveyPhoto2	Survey Photo 2		Image	NA
SurveyPhoto3	Survey Photo 3		Image	NA
SurveyPhoto4	Survey Photo 4		Image	NA
DeviceUsed1	Camera Used		Text	Entered
FirstPhotoName1	First Image Name		Text	Entered
LastPhotoName1	Last Image Name		Text	Entered
DeviceUsed2	Camera Used		Text	Entered
FirstPhotoName2	First Image Name		Text	Entered
LastPhotoName2	Last Image Name		Text	Entered
DeviceUsed3	Camera Used		Text	Entered
FirstPhotoName3	First Image Name		Text	Entered
LastPhotoName3	Last Image Name		Text	Entered
FlowerIDSci	Flower species used by Bombus (scientific name)	FloralSppSci	Text	Selected
FlowerIDCommon	Flower species used by Bombus (common name)	FloralSppCommon	Text	Selected
FlowerComment	Other		Text	Selected

³ See **Element 3: Field Methods** for details on how this survey will handle species identification and uncertainty.

FlowerPhoto1	Flower Photo1		Image	NA
FlowerPhoto2	Flower Photo2		Image	NA
Section 3: Habitat Data				
HabitatType	Habitat Type	Habitat_Type	Text	Selected
PercVegCover	Vegetation Percent Cover	PercentBlock2	Text	Selected
PercFlowerNonWoody	Percent Cover of Flowering Forbs and Grasses	PercentBlock2	Integer/Long	Selected
PercFlowerWoody	Percent Cover of Flowering Shrubs and Trees	PercentBlock2	Integer/Long	Selected
HoneyBees	Are honey bees present at time of survey?	yes_no	Text	Selected
HabitatComment	Habitat Comment		Text	Entered
SurveyPlotPhoto1	Survey Plot Photo 1		Image	NA
SurveyPlotPhoto2	Survey Plot Photo 2		Image	NA
SurveyPlotPhoto3	Survey Plot Photo 3		Image	NA
Section 4: Handling Time Data				
HandlingYesNo	Did observers record handling times?	yes_no	Text	Selected
LeadCoopHandleTimep[1-10] (10 fields)	Lead Cooperator Handling Time #[1-10]		Integer/Long	Entered
Expert[1-3] HandleTime[1-10] (10x3 fields)	Additional Expert #[1-3] Handling Time #[1-10]		Integer/Long	Entered
Novice[1-3] HandleTime[1-10] (10x3 fields)	Additional Novice #[1-3] Handling Time #[1-10]		Integer/Long	Entered
Section 5: Additional questions from protocol				
DateDataEntryComplete	Date data entry completed		Date	Selected

Table 6. Domains used with Survey123 to create sets of choices for use with drop-down menus. Domain name identifies the group of values that are part of the domain. Name is

the value that is stored in the table. Label is the value that appears in the form. Refuge is used to enable cascading selects (limit second-level choices to those applicable to a given refuge).

DOMAIN NAME	NAME	LABEL	REFUGE
yes_no	yes	Yes	
yes_no	no	No	
Observer	Richardson	Leif Richardson	
Observer	Jean	Rob Jean	
Refuges	TCM	John Heinz National Wildlife Refuge At Tinicum	
Refuges	MSQ	Missisquoi National Wildlife Refuge	
Refuges	PMN	Petit Manan National Wildlife Refuge	
Refuges	SPM	Supawna Meadows National Wildlife Refuge	
SurveyPatch	Corp-01	Corp Property-01	TCM
SurveyPatch	FiveAcre-01	Five Acre Field-01	TCM
SurveyPatch	Frog-01	Frog Pond-01	TCM
SurveyPatch	Sunoco-01	Sunoco Meadow-01	TCM
SurveyPatch	Teardrop-01	Teardrop-01	TCM
SurveyPatch	CIsland-01	Center Island-01	MSQ
SurveyPatch	CranDikePool-01	Cranberry Dike Pool-01	MSQ
SurveyPatch	FirstCrTr-01	First Creek Trail-01	MSQ
SurveyPatch	GooseBayPool-01	Goose Bay Pool-01	MSQ
SurveyPatch	LouieLanding-01	Louie's Landing-01	MSQ
SurveyPatch	MacBend-01	Mac's Bend-01	MSQ
SurveyPatch	NIsland-01	North Island-01	MSQ
SurveyPatch	Rte78N-01	Rte 78 North-01	MSQ
SurveyPatch	Rte78S-01	Rte 78 South-01	MSQ
SurveyPatch	RTWetland-01	Rail Trail Wetland-01	MSQ
SurveyPatch	SIsland	South Island-01	MSQ
SurveyPatch	SYoungMarsh-01	Steve Young Marsh-01	MSQ
SurveyPatch	TaborE-01	Tabor East-01	MSQ
SurveyPatch	TaborE-02	Tabor East-02	MSQ
SurveyPatch	TaborE-03	Tabor East-03	MSQ
SurveyPatch	TaborW-01	Tabor West-01	MSQ
SurveyPatch	TaborW-02	Tabor West-02	MSQ
SurveyPatch	BearCove-01	Bear Cove-01	PMN
SurveyPatch	BirchPoint-01	Birch Point-01	PMN
SurveyPatch	DwarfShrub1-01	Dwarf Shrub 1-01	PMN
SurveyPatch	DwarfShrub2-01	Dwarf Shrub 2-01	PMN
SurveyPatch	DwarfShrub3-01	Dwarf Shrub 3-01	PMN
SurveyPatch	Field1-01	Field 1-01	PMN

SurveyPatch	Field2-01	Field 2-01	PMN
SurveyPatch	Field3-01	Field 3-01	PMN
SurveyPatch	Field4-01	Field 4-01	PMN
SurveyPatch	Field5-01	Field 5-01	PMN
SurveyPatch	Field7-01	Field 7-01	PMN
SurveyPatch	Field8-01	Field 8-01	PMN
SurveyPatch	Field9-01	Field 9-01	PMN
SurveyPatch	Field9-02	Field 9-02	PMN
SurveyPatch	Field10-01	Field 10-01	PMN
SurveyPatch	Field11-01	Field 11-01	PMN
SurveyPatch	HollingTrail-01	Hollingsworth Trail-01	PMN
SurveyPatch	OversPtRd-01	Over's Point Road-01	PMN
SurveyPatch	PMNRdWL-01	Petit Manan Road WL-01	PMN
SurveyPatch	RichardsField-01	Richards Field-01	PMN
SurveyPatch	SWetland-01	South Wetland-01	PMN
SurveyPatch	WoodPond-01	Wood Pond-01	PMN
SurveyPatch	Site3-01	Site 3-01	SPM
SurveyPatch	Site3-02	Site 3-02	SPM
SurveyPatch	Site3-03	Site 3-03	SPM
SurveyPatch	Site3-04	Site 3-04	SPM
SurveyPatch	Site4-01	Site 4-01	SPM
SurveyPatch	Site4-02	Site 4-02	SPM
SurveyPatch	Site4-03	Site 4-03	SPM
SurveyPatch	Site4-04	Site 4-04	SPM
SurveyPatch	Site4-05	Site 4-05	SPM
SurveyPatch	Site4-06	Site 4-06	SPM
SurveyPatch	Site4-07	Site 4-07	SPM
SurveyPatch	Site4-08	Site 4-08	SPM
SurveyPatch	Site2-01	Site 2-01	SPM
SurveyPatch	Other	Other	TCM
SurveyPatch	Other	Other	MSQ
SurveyPatch	Other	Other	PMN
SurveyPatch	Other	Other	SPM
Habitat_Type	OpenWater	Open Water	
Habitat_Type	DevelopedOpenSpace	Developed Open Space	
Habitat_Type	DevelopedLowIntensity	Developed Low Intensity	
Habitat_Type	DevelopedMediumIntensity	Developed Medium Intensity	
Habitat_Type	DevelopedHighIntensity	Developed High Intensity	
Habitat_Type	BarrenLand	Barren Land	
Habitat_Type	DeciduousForest	Deciduous Forest	
Habitat_Type	EvergreenForest	Evergreen Forest	
Habitat_Type	MixedForest	Mixed Forest	
Habitat_Type	DwarfScrubShrubland	Dwarf Scrub Shrubland	
Habitat_Type	ShrubShrubland	Shrub Shrubland	
Habitat_Type	GrasslandHerbaceous	Grassland Herbaceous	
Habitat_Type	Pasture/Hay	Pasture/Hay	

Habitat_Type	CultivatedCrops	Cultivated Crops	
Habitat_Type	WoodyWetlands	Woody Wetlands	
Habitat_Type	EmergentHerbaceousWetlands	Emergent Herbaceous Wetlands	
Habitat_Type	Other	Other	
PercentBlock1	Under10	<10%	
PercentBlock1	10-49	10-49%	
PercentBlock1	50-89	50-89%	
PercentBlock1	90Plus	>90%	
PercentBlock2	None	None	
PercentBlock2	Under5	<5%	
PercentBlock2	5-24	5-24%	
PercentBlock2	25-49	25-49%	
PercentBlock2	50-74	50-74%	
PercentBlock2	75-94	75-94%	
PercentBlock2	95Plus	>95%	
Caste	Queen	Queen Female	
Caste	Worker	Worker - female	
Caste	Female	Female	
BombusSpp	Bombus_affinis	affinis	
BombusSpp	Bombus_appositus	appositus	
BombusSpp	Bombus_auricomus	auricomus	
BombusSpp	Bombus_bifarius	bifarius	
BombusSpp	Bombus_bimaculatus	bimaculatus	
BombusSpp	Bombus_bohemicus	bohemicus	
BombusSpp	Bombus_borealis	borealis	
BombusSpp	Bombus_caliginosus	caliginosus	
BombusSpp	Bombus_centralis	centralis	
BombusSpp	Bombus_citrinus	citrinus	
BombusSpp	Bombus_cockerelli	cockerelli	
BombusSpp	Bombus_crotchii	crotchii	
BombusSpp	Bombus_cryptarum	cryptarum	
BombusSpp	Bombus_distinguendus	distinguendus	
BombusSpp	Bombus_fervidus	fervidus	
BombusSpp	Bombus_flavidus	flavidus	
BombusSpp	Bombus_flavifrons	flavifrons	
BombusSpp	Bombus_franklini	franklini	
BombusSpp	Bombus_fraternus	fraternus	
BombusSpp	Bombus_frigidus	frigidus	
BombusSpp	Bombus_griseocollis	griseocollis	
BombusSpp	Bombus_huntii	huntii	
BombusSpp	Bombus_impatiens	impatiens	
BombusSpp	Bombus_insularis	insularis	
BombusSpp	Bombus_jonellus	jonellus	

BombusSpp	Bombus_kirbiellus	kirbiellus	
BombusSpp	Bombus_kluanensis	kluanensis	
BombusSpp	Bombus_melanopygus	melanopygus	
BombusSpp	Bombus_mixtus	mixtus	
BombusSpp	Bombus_morrisoni	morrisoni	
BombusSpp	Bombus_natvigi	natvigi	
BombusSpp	Bombus_neoboreus	neoboreus	
BombusSpp	Bombus_nevadensis	nevadensis	
BombusSpp	Bombus_occidentalis	occidentalis	
BombusSpp	Bombus_pensylvanicus	pensylvanicus	
BombusSpp	Bombus_perplexus	perplexus	
BombusSpp	Bombus_polaris	polaris	
BombusSpp	Bombus_rufocinctus	rufocinctus	
BombusSpp	Bombus_sandersoni	sandersoni	
BombusSpp	Bombus_sitkensis	sitkensis	
BombusSpp	Bombus_suckleyi	suckleyi	
BombusSpp	Bombus_sylvicola	sylvicola	
BombusSpp	Bombus_ternarius	ternarius	
BombusSpp	Bombus_terricola	terricola	
BombusSpp	Bombus_vagans	vagans	
BombusSpp	Bombus_vagans_sandersoni	vagans/sandersoni	
BombusSpp	Bombus_vandykei	vandykei	
BombusSpp	Bombus_variabilis	variabilis	
BombusSpp	Bombus_vosnesenskii	vosnesenskii	
BombusSpp	Other	other	
FloralSppCommon ⁴	Birdsfoot_Trefoil	Birdsfoot Trefoil	
FloralSppCommon	Bishops_Weed	Bishop's Weed	
FloralSppCommon	Black_willow	Black willow	
FloralSppCommon	Black-eyed_Susan	Black-eyed Susan	
FloralSppCommon	Blue_Vervain	Blue Vervain	
FloralSppCommon	Blueberry_spp.	Blueberry spp.	
FloralSppCommon	Brown_Knapweed	Brown Knapweed	
FloralSppCommon	Bull_Thistle	Bull Thistle	
FloralSppCommon	Butter-and-Eggs	Butter-and-Eggs	
FloralSppCommon	Buttonbush	Buttonbush	
FloralSppCommon	Canada_Lily	Canada Lily	
FloralSppCommon	Canada_Thistle	Canada Thistle	
FloralSppCommon	Chicory	Chicory	
FloralSppCommon	Coltsfoot	Coltsfoot	
FloralSppCommon	Common_Arrowhead	Common Arrowhead	
FloralSppCommon	Common_Blackberry	Common Blackberry	
FloralSppCommon	Common_Burdock	Common Burdock	
FloralSppCommon	Common_Buttercup	Common Buttercup	
FloralSppCommon	Common_Fleabane	Common Fleabane	

⁴ The flower species lists will be updated throughout the field season to add species entered into the “other” field to the drop-down menu. This list represents a snapshot of the flower list as of 2018-06-19.

FloralSppCommon	Common_Groundnut	Common Groundnut	
FloralSppCommon	Common_Milkweed	Common Milkweed	
FloralSppCommon	Common_Mullein	Common Mullein	
FloralSppCommon	Cow_Vetch	Cow Vetch	
FloralSppCommon	Crown_Vetch	Crown Vetch	
FloralSppCommon	Dandelion	Dandelion	
FloralSppCommon	Field_Bindweed	Field Bindweed	
FloralSppCommon	Flat-topped_White_Aster	Flat-topped White Aster	
FloralSppCommon	Fragrant_Water_Lily	Fragrant Water Lily	
FloralSppCommon	Golden_Alexanders	Golden Alexanders	
FloralSppCommon	Goldenrod_spp.	Goldenrod spp.	
FloralSppCommon	Great_Angelica	Great Angelica	
FloralSppCommon	Ground_Ivy	Ground Ivy	
FloralSppCommon	Highbush_blueberry	Highbush blueberry	
FloralSppCommon	Hog_Peanut	Hog Peanut	
FloralSppCommon	Honeysuckle_spp.	Honeysuckle spp.	
FloralSppCommon	Hop_Clover	Hop Clover	
FloralSppCommon	Larger_Blue_Flag	Larger Blue Flag	
FloralSppCommon	Lowbush_blueberry	Lowbush blueberry	
FloralSppCommon	Mayweed	Mayweed	
FloralSppCommon	New_England_Aster	New England Aster	
FloralSppCommon	Northern_Bedstraw	Northern Bedstraw	
FloralSppCommon	Northern_Pitcher_Plant	Northern Pitcher Plant	
FloralSppCommon	Ox-Eye_Daisy	Ox-Eye Daisy	
FloralSppCommon	Pickernelweed	Pickernelweed	
FloralSppCommon	Purple_Loosestrife	Purple Loosestrife	
FloralSppCommon	Purple-stemmed_Aster	Purple-stemmed Aster	
FloralSppCommon	Queen_Annes_Lace	Queen Anne's Lace	
FloralSppCommon	Rabbits_Foot_Clover	Rabbit's Foot Clover	
FloralSppCommon	Red_Clover	Red Clover	
FloralSppCommon	Rhodora	Rhodora	
FloralSppCommon	Rough-Fruited_Cinquefoil	Rough-Fruited Cinquefoil	
FloralSppCommon	Sheep_Laurel	Sheep Laurel	
FloralSppCommon	Spiny-leaved_Sow-Thistle	Spiny-leaved Sow-Thistle	
FloralSppCommon	Spotted_Joe-Pye_Weed	Spotted Joe-Pye Weed	
FloralSppCommon	Spotted_Knapweed	Spotted Knapweed	
FloralSppCommon	Spotted_Touch-Me-Not	Spotted Touch-Me-Not	
FloralSppCommon	Swamp_Loosestrife	Swamp Loosestrife	
FloralSppCommon	Tansy	Tansy	
FloralSppCommon	White_Campion	White Champion	
FloralSppCommon	White_Clover	White Clover	
FloralSppCommon	White_Sweet_Clover	White Sweet Clover	
FloralSppCommon	Wild_Columbine	Wild Columbine	
FloralSppCommon	Wild_Parsnip	Wild Parsnip	
FloralSppCommon	Winterberry	Winterberry	
FloralSppCommon	Wood_Lily	Wood Lily	
FloralSppCommon	Yarrow	Yarrow	

FloralSppCommon	Yellow_Flag_Iris	Yellow Flag Iris	
FloralSppCommon	Yellow_Pond_Lily	Yellow Pond Lily	
FloralSppCommon	Yellow_Rattle	Yellow Rattle	
FloralSppSci	Achillea_millefolium	Achillea millefolium	
FloralSppSci	Aegopodium_podagraria	Aegopodium podagraria	
FloralSppSci	Amphicarpaea_bracteata	Amphicarpaea bracteata	
FloralSppSci	Angelica_atropurpurea	Angelica atropurpurea	
FloralSppSci	Anthemis_cotula	Anthemis cotula	
FloralSppSci	Apios_americana	Apios americana	
FloralSppSci	Aquilegia_canadensis	Aquilegia canadensis	
FloralSppSci	Arctium_minus	Arctium minus	
FloralSppSci	Asclepias_syriaca	Asclepias syriaca	
FloralSppSci	Centaurea_jacea	Centaurea jacea	
FloralSppSci	Centaurea_maculosa	Centaurea maculosa	
FloralSppSci	Cephalanthus_occidentalis	Cephalanthus occidentalis	
FloralSppSci	Cichorium_intybus	Cichorium intybus	
FloralSppSci	Cirsium_arvense	Cirsium arvense	
FloralSppSci	Cirsium_vulgare	Cirsium vulgare	
FloralSppSci	Convolvulus_arvensis	Convolvulus arvensis	
FloralSppSci	Crataegus_spp.	Crataegus spp.	
FloralSppSci	Daucus_carota	Daucus carota	
FloralSppSci	Decodon_verticillatus	Decodon verticillatus	
FloralSppSci	Doellingeria_umbellata	Doellingeria umbellata	
FloralSppSci	Eutrochium_maculatum	Eutrochium maculatum	
FloralSppSci	Galium_boreale	Galium boreale	
FloralSppSci	Glechoma_hederacea	Glechoma hederacea	
FloralSppSci	Ilex_verticillata	Ilex verticillata	
FloralSppSci	Impatiens_capensis	Impatiens capensis	
FloralSppSci	Iris_pseudacorus	Iris pseudacorus	
FloralSppSci	Iris_versicolor	Iris versicolor	
FloralSppSci	Kalmia_angustifolia	Kalmia angustifolia	
FloralSppSci	Leucanthemum_vulgare	Leucanthemum vulgare	
FloralSppSci	Lilium_canadense	Lilium canadense	
FloralSppSci	Lilium_philadelphicum	Lilium philadelphicum	
FloralSppSci	Linaria_vulgaris	Linaria vulgaris	
FloralSppSci	Lonicera_spp.	Lonicera spp.	
FloralSppSci	Lotus_corniculatus	Lotus corniculatus	
FloralSppSci	Lythrum_salicaria	Lythrum salicaria	
FloralSppSci	Melilotus_albus	Melilotus albus	
FloralSppSci	Nuphar_lutea	Nuphar lutea	
FloralSppSci	Nymphaea_odorata	Nymphaea odorata	
FloralSppSci	Pastinaca_sativa	Pastinaca sativa	
FloralSppSci	Pontederia_cordata	Pontederia cordata	
FloralSppSci	Potentilla_recta	Potentilla recta	
FloralSppSci	Prunus_pensylvanicus	Prunus pensylvanica	
FloralSppSci	Pulicaria_dysenterica	Pulicaria dysenterica	
FloralSppSci	Pyrus_malus	Pyrus malus	

FloralSppSci	Ranunculus_acris	Ranunculus acris	
FloralSppSci	Rhinanthus_minor	Rhinanthus minor	
FloralSppSci	Rhododendron_canadense	Rhododendron canadense	
FloralSppSci	Rubus_alleghehiensis	Rubus allegheniensis	
FloralSppSci	Rudbeckia_hirta	Rudbeckia hirta	
FloralSppSci	Sagittaria_latifolia	Sagittaria latifolia	
FloralSppSci	Salix_nigra	Salix nigra	
FloralSppSci	Sarracenia_purpurea	Sarracenia purpurea	
FloralSppSci	Securigera_varia	Securigera varia	
FloralSppSci	Silene_latifolia	Silene latifolia	
FloralSppSci	Solidago_spp.	Solidago spp.	
FloralSppSci	Sonchus_asper	Sonchus asper	
FloralSppSci	Symphyotrichum_novae-angliae	Symphyotrichum novae-angliae	
FloralSppSci	Symphyotrichum_puniceum	Symphyotrichum puniceum	
FloralSppSci	Tanacetum_vulgare	Tanacetum vulgare	
FloralSppSci	Taraxacum_spp.	Taraxacum spp.	
FloralSppSci	Trifolium_arvense	Trifolium arvense	
FloralSppSci	Trifolium_campestre	Trifolium campestre	
FloralSppSci	Trifolium_pratense	Trifolium pratense	
FloralSppSci	Trifolium_repens	Trifolium repens	
FloralSppSci	Tussilago_farfara	Tussilago farfara	
FloralSppSci	Vaccinium_angustifolium	Vaccinium angustifolium	
FloralSppSci	Vaccinium_corymbosum	Vaccinium corymbosum	
FloralSppSci	Verbascum_thapsus	Verbascum thapsus	
FloralSppSci	Verbena_hastata	Verbena hastata	
FloralSppSci	Vicia_cracca	Vicia cracca	
FloralSppSci	Zizia_aurea	Zizia aurea	

Data security and archiving

The Survey Coordinator (Becky Longenecker) will archive raw survey data, field notes, and photographs in compliance with relevant USFWS data standards (www.fws.gov/stand) and pursuant to the USFWS Policy on Service Information and Technology Architecture (270 FW 1; www.fws.gov/policy/270fw1.html) and the USFWS Policy on Electronic Records (282 FW 4; www.fws.gov/policy/282fw4.html).

DOI Connect

The Bumble Bee Survey Team uses a DOI Connect site⁵ to share files and work collaboratively. It is backed up regularly and serves as a platform that those involved with the survey effort can access. It is an appropriate place to store draft data, interim reports, and other files that would be transferred to a database or collated before upload to a location such as ServCat. Files that should be uploaded include:

- Blank paper field forms (these are generated before sampling begins)
- Completed paper field forms, if used (scanned)
- Interim refuge reports

⁵ <https://connect.doi.gov/fws/Portal/dnrcp/beepoint/SitePages/Home.aspx>

51 Procedure for paper datasheets that were used in the field

- 52 1. Scan paper datasheets.
- 53 2. Merge datasheets into a single PDF if scan produces multiple files.
- 54 3. Upload datasheet PDF to the [DataTransfer](#) library on the DNRCP Refuge Bumble Bee
- 55 Survey Project site on DOI Connect, taking care to complete all metadata columns and
- 56 clearly identify the location, date, etc. for the document.
- 57 4. These uploaded datasheets are a backup of the original data collected and do not
- 58 substitute for completing data entry. **Data entry should still be completed using**
- 59 **Survey123.**
- 60 5. Mark date of upload to DOI Connect on paper data sheets and store locally.

61 Procedure for data from Survey123

- 62 1. When bumble bee surveys for a refuge are complete, the survey lead should send the
- 63 surveys to AGOL using the Survey123 for ArcGIS app.
- 64 2. Survey lead notifies the data manager that surveys have been sent to AGOL.
- 65 3. The data manager pulls a csv of the survey data from AGOL to their personal computer.
- 66 Then uploads the csv datasheet to the DataTransfer library on DOI Connect, taking care
- 67 to complete all metadata columns and clearly describe the sheet.

68 If they are trained in how to do so, the survey lead may also download data from AGOL and

69 upload it to DOI Connect.

70

71 **ServCat**

72 ServCat is an online repository and database for long-term storage and archiving within the

73 Service. Because ServCat can be accessed by anyone in the Service, it facilitates data sharing

74 and access across within and across regions. Access to ServCat and guidance on how to use it

75 can be found at <https://ecos.fws.gov/ServCat/>. ServCat is an appropriate place to store final

76 reports and data, such as:

- 77 • This survey instructions document
- 78 • Final reports from the cooperative agreement recipients (1 for each of the 4 refuges)
- 79 • Data from the effort
 - 80 ○ Zipped folder for each refuge containing all photos taken
 - 81 ○ If applicable, scans of field paper data forms compiled into a single PDF for each
 - 82 refuge containing all data sheets from the season
 - 83 ○ CSVs of tables populated through Survey123 forms (downloaded from AGOL)
 - 84 ○ Shapefiles of feature layers used in the study (downloaded from AGOL)
 - 85 ○ Any other relevant documentation of the survey effort

86

87 Once a copy of all the data associated with the survey that would be retained (raw and

88 summarized survey data, as well as associated maps, photographs, and field notes) is on ServCat,

89 only 1 additional copy is needed, which can be hard copy or electronic. After three years, all data

90 that is duplicated on ServCat may be discarded, as ServCat itself is backed up regularly.

91

92 Help and information about using ServCat is available from

93 <https://sites.google.com/a/fws.gov/servcat/help>.

94

Analysis methods

Data analysis is driven by the Sampling Objective of this survey:

In each habitat patch,

- *generate a species list (inventory);*
- *measure bumble bee species richness using raw counts (unadjusted for detection probability) with high confidence* that we will detect the majority of bumble bee species present;*
- *measure bumble bee relative abundance by species using raw counts (unadjusted for detection probability);*
- *explore habitat relationships with bumble bee richness and relative abundance.*

Data analysis will include:

- Calculate summary data:
 - # of bumble bee species detected in each survey
 - # of individuals of each bumble bee species detected in each survey
 - # of all individuals of all bumble bee species detected in each survey
 - Histograms (frequency of observations) of flowers used by foraging bumble bees at each habitat patch.
- Produce bumble bee species lists (inventory)
 - For each habitat patch on each visit (sum of samples from individual survey plots within each patch),
 - For each habitat patch across visits,
 - For each Refuge across habitat patches and visits.
- Estimate bumble bee species richness for each survey plot on each visit
 - If the order of bee capture was recorded, this survey used an Individual-based sampling protocol (Gotelli and Colwell 2001). The individual bumble bee is the unit of replication (individuals are generally captured one by one) and the order of capture was recorded.
 - Analysis should compute a rarefaction curve (Simberloff 1978), which is produced by repeatedly re-sampling the pool of N individuals at random, plotting the average number of species represented by 1, 2, ... N individuals. Rarefaction generates the expected number of species in a small collection of n individuals drawn at random from the large pool of N individuals. Rarefaction produces the most appropriate curves for comparing richness between habitat patches (Gotelli and Colwell 2001).
 - If the order of bee capture was not recorded, report species richness as the total # of species identified at the survey plot.
- Measure relative abundance by species \rightarrow (raw⁶) number of bumble bee individuals for each species divided by the total (raw⁶) number of individuals of all species
 - For each habitat patch on each visit,
 - For each habitat patch across visits
- Explore habitat relationships with species richness and relative abundance using linear models
 - Percent vegetated cover \sim bumble bee richness/relative abundance
 - Percent flowering non-woody cover \sim bumble bee richness/relative abundance
 - Percent flowering woody cover \sim bumble bee richness/relative abundance

⁶ Raw indicates data that has not been adjusted for detection probability.

Exploratory analyses

Because this is a pilot survey, we also plan to do certain exploratory data analysis that is not specifically related to the survey and sampling objectives. These may not be included in the refuge reports, but will be written in a supplementary document posted with this ISI on ServCat.

- Examine bumble bees by time collected during each survey. Are there any patterns in number of species, individuals, or species identity across the survey time?
- Examine rarefaction curves at each survey plot to see how our results may have changed had we surveyed for less time. How many species would we have missed if we had surveyed for half as much time? Or only surveyed for 2 visits instead of 3?
- Examine bumble bee richness and relative abundance by weather conditions (temperature, wind speed, cloud cover). Are there any significant relationships between these variables?

A note about other data analysis: This survey data may also be able to be used to estimate occupancy of bumble bee species at the habitat patch level. Estimating occupancy is not an explicit objective of this survey, but the data could be analyzed in that framework in the future, if desired.

Element 5: Reporting

Report content

Robert Jean and/or Leif Richardson will produce a report for each surveyed Refuge. Regional Office staff (Becky Longenecker, Laura Eaton, Maritza Mallek) will review each draft report and their comments will be incorporated by Jean and Richardson prior to the final version. Each report will contain the following:

1. Introduction: A brief overview of the background of the survey.
 - a. Describe why the survey was performed at this refuge (see Element 1)
 - b. Include the objectives as stated in this ISI.
2. Methods
 - a. Describe sampling design, field methods (see Elements 2 and 3)
 - b. Provide Habitat Patch names and locations, and survey plot locations with maps
 - c. Describe data analysis
3. Results
 - a. Describe weather conditions during surveys.
 - b. Include all analyses described above in Element 4: *Analysis methods*
 - c. Provide tables and/or figures as applicable
 - d. Compare species lists, relative abundance, and species richness between habitat patches
4. Discussion
 - a. Include detailed interpretation and application of results for refuge habitat management. Consider species status, current habitat, and current management conditions/stressors.
 - b. As applicable, provide recommendations for future surveys and how the habitat patch may be improved to support bumble bees.

Reporting schedule

Draft reports will be sent to the Regional Office in October 2018 and final reports in November 2018.

Report archiving

Reports will be archived in the USFWS Service Catalog (ServCat).

Data sharing with Region 5 Monitoring and Management Database

At the end of the field season, all search area polygons collected with Collector will be downloaded as a shapefile. Using ArcGIS, the data manager will populate the fields needed for Monitoring and Management (these fields are already present, but empty, in the shapefile). At minimum, the FeatureID (identical to our SurveyID) and PRIMR_ID (looked up in from the PRIMR database) will be populated for all rows. The shapefile with completed attribute table will be shared with Rick Schaufler for inclusion in the Monitoring and Management database.

Data sharing with USFWS Ecological Services

We will share our results with the Region 3 Ecological Services Rusty Patched Bumble Bee team (current species lead: Tamara Smith; tamara_smith@fws.gov).

Element 6: Personnel Requirements and Training

The Survey Coordinator and all field crew members will review this entire ISI, including all of the SOPs, before the field season. The equipment and supplies listed will be organized and made ready for the field season, and copies of the field maps and data forms (hard and digital) will be prepared.

Roles and responsibilities

Survey Coordinator/Regional Pollinator Coordinator

Becky Longenecker serves as Survey Coordinator and Region 5 Pollinator Coordinator. She will oversee and coordinate the implementation of the ISI at the specified refuges. She, in coordination with the Data Manager and Regional Biologist, will ensure that survey data are managed, analyzed, reported, and archived properly, and work with the Project Leaders, Refuge Biologists, and Cooperators to coordinate the field surveys. She will also share information about this survey with the other members of the USFWS Pollinator Work Group as appropriate.

Project Leader (Refuge Manager)

The Project Leaders will ensure USFWS policy compliance and will advise on locations to be included in this survey, as well as any required Special Use Permits.

Refuge Biologist

The Refuge Biologists will advise on locations to be included in this survey and will coordinate directly with the Cooperators on survey logistics (schedule, access, and any safety protocols). They will also provide the Cooperators with a description of management history and current management at the surveyed habitat patches.

Cooperators

Robert Jean and Leif Richardson serve as the Cooperators for this survey. They will be responsible for learning and implementing all Elements and SOPs in the ISI, including advising on locations to survey, performing field surveys, entering data into required databases and/or websites, performing data analysis and writing reports at the conclusion of the surveys. Dr. Jean will survey at John Heinz NWR and Supawna Meadows NWR. Dr. Richardson will survey at Missisquoi NWR and Petit Manan NWR.

Data Manager

Maritza Mallek serves as Data Manager for this survey and is responsible for establishing quality assurance standards for data collection and management; ensuring that I&M data are conserved and archived; and preparing electronic forms for data collection.

Regional Biologist

Laura Eaton serves as assistant Regional Biologist and will assist the Survey Coordinator with oversight and coordination of the ISI at the specified refuges.

Qualifications

- Cooperators performing field surveys are highly trained in live bee identification and plant identification.

Training

255 Cooperators performing field surveys are responsible for learning and correctly applying all
256 Elements and SOPs of this ISI, and will request assistance from the Survey Coordinator as
257 needed. The Data Manager will provide instruction on the use of electronic field data forms as
258 needed.

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Element 7: Operational Requirements

Budget

The budget for this project is \$53,733. These funds cover expenses incurred by the Cooperators, but do not include the salaries of USFWS Regional Office or Refuge staff.

[If we want to include an itemized budget, we will need to ask Rob and Leif. The budget in their application did not itemize the costs incurred by Leif].

Staff time

Table 7. Estimated time spent by the Cooperators (Robert Jean, Leif Richardson, and two field assistants) on the non-lethal bumble bee survey project in 2018.

COOPERATOR (ORGANIZATION)	TASK	TIME (HOURS)
Environmental Solutions Inc. (ESI) Personnel: Robert Jean, one field assistant, GIS staff	Preparation	8
	Travel to Refuges for surveys (from Indianapolis, IN)	132
	Travel between John Heinz and Supawana Meadows NWRs	6
	Conducting field work at John Heinz (2 persons)	19
	Conducting field work at Supawna Meadows (2 persons)	190
Stone Environmental, Inc. Personnel: Leif Richardson, one field assistant.	Preparation	8
	Travel to Refuges for surveys (from Montpelier, VT)	38
	Conducting field work at Missisquoi (2 persons)	92
	Conducting field work at Petit Manan (2 persons)	92
	Accounting and administrative	8

Coordination

No habitat management activities or other surveys are planned during the time of the bumble bee surveys in the Refuge habitat patches.

Element 8: References

(last updated 5/11)

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330 and Statistical Analyses, American Society for Testing and Materials, Philadelphia,
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332
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335

Standard Operating Procedures (SOPs)

SOP 1: Field Data Collection

The following are step-by-step instructions to be followed on the day of the survey. These instructions apply regardless of whether it is the first, second, or third survey visit.

Phase 1: Pre-Survey

1. Place one sticker on each vial or baggie (if using to record the time of capture).
2. Prior to arriving at Refuge,
 - a. Check the weather forecast to ensure that the proper conditions required for a survey will be met that day:
 - i. Temperature above 60° F (15.5 C)
 - ii. No precipitation should occur (fog, rain, or drizzle). If there is precipitation, wait at least 1 hour after it ends to begin a survey.
 - iii. Winds < 15 mph and cloud cover < 75% are ideal, but are not absolute thresholds for determining whether a survey should be done.
 - b. Obtain frozen ice packs or ice bags and place in cooler.
 - c. Verify that all information on the equipment checklist is in hand and that all electronic devices are fully charged.

Equipment Checklist	✓
Cloth aerial hand net with fairly transparent netting (Insect net that is 12 – 18 inches in diameter). Do not use sweep, beater, or wire nets	
Timer/stopwatch	
Weather station	
Cooler with cold packs or ice in a bag. Cooler should be ¼ to ½ full of cold packs or ice <ol style="list-style-type: none">1. Medium or large cooler with 4 cold packs can be used when driving to field sites.2. Small (six pack) cooler with 1-2 pint-sized cold packs can be used when hiking to field sites.	
Handheld weather station (such as Kestrel Weather Meter)	
At least 200 vials or baggies to contain live bumble bees <ul style="list-style-type: none">• Suggested vials from Bioquip:<ul style="list-style-type: none">○ #8813P, 9.5 drams, diameter 26.6x95 mm, length 1x3.75”, neck 17.4 mm○ #8814P, 11 drams, diameter 26.6x102 mm, length 1x4”, neck 17.4 mm• Vials should either have light-colored lids or a blank sticker attached to them so that observers can record data on them during the survey.	
Camera (e.g., Olympus TG-4 point and shoot) with fully-charged, backup battery	
Small photographers tent	

Copy of this Initial Survey Instructions document or at a minimum, maps and descriptions of habitat patches and target sampling sites (print out entirety of “ Habitat patches to be surveyed in 2018 ” section above)	
GPS-enabled device (e.g., iPad) that can be used with the apps Collector and Survey123. The apps should be installed and logged in, and the appropriate maps and surveys downloaded, before going into the field (see SOP 3) <ol style="list-style-type: none"> 1. If a GPS-enabled device for mapping the survey plot is not available, contact the Regional Project Lead. 2. Datasheets for Bombus surveys (as a backup in case of device failure) and clipboard 	
Portable charger for GPS-enabled device	
Pencils	
Sharpie markers	
Hand lens or loupe	
Permits	
Flagging or stake flags to mark the perimeter of survey plots	
Blank stickers to be placed on each vial or baggie	
Contact information for Refuge staff, and Regional Project Lead <ol style="list-style-type: none"> 1. Regional Project Lead = Becky Longenecker. 413-253-8636 (office). 413-404-3037 (cell) 2. Regional Data Manager = Maritza Mallek. 413-253-8786 (office) 3. John Heinz Biologist = Brendalee Phillips. 215-365-3118 ext. 3213 (office). 610-842-4363 (cell). 4. Missisquoi. Manager = Ken Sturm. 802-868-4781 ext.3236 (office). 802-393-3833 (cell); Biologist = Judy Sefchick-Edwards. 802-868-4781 ext. 3238 (office) 5. Petit Manan Biologists = Sara Williams. 207-546-2124, x13 (office). 207-557-7813 (cell); Linda Welch. 207-546-2124 x11 (office). 207-557-7810 (cell); Michael Langlois. 207-594-0600 ext.3 (office). 6. Supawana Meadows Biologist = Heidi Hanlon. 609-463-0994 Ex. 2372 (office) 	

354

- 355 3. Arrive at Refuge and check in with Refuge biologist and/or manager, if needed, to obtain
- 356 gate keys, gate codes, or other requirements for accessing the Refuge.
- 357 4. Review the habitat patch descriptions and schedule, and identify the target sites that will
- 358 be surveyed that day. Especially note the number of visits each site should receive; some
- 359 patches will only be surveyed once per summer due to their vegetation composition.
- 360 5. Navigate to the first target survey site. *If you are adding a new survey site, see naming*
- 361 *guidance in **Phase 3**.*

362 **Phase 2: Establish Survey Plots**

363 (Use both Collector and Survey123 to complete Phase 2)

364 1. Determine how many experienced bumble bee surveyors and novice surveyors will be
365 collecting bees, and how large your survey plot should be. Consult the guidance below to
366 ensure you use the correct survey effort and number of observers.


- 367 a. When one experienced bumble bee surveyor is present:
- 368 i. The target survey length is one hour
- 369 ii. The target survey plot size is three acres (a max of four acres is OK)
- 370 b. When more than one experienced surveyor is present:
- 371 i. The target survey length remains one hour
- 372 ii. The survey plot size may be increased to six acres, if space is available.
- 373 c. No more than 4 people (including experienced and novice) should survey in a 3-4
374 acre survey plot.
- 375 d. Novice observers may not collect bees if the survey plot is within a potential
376 RPBB zone (only Petit Manan NWR, Richards Field is within a zone).

377 2. The next step is to delineate the survey plot for that visit.


- 378 a. If the habitat patch is ≤ 3 acres:
- 379 i. The entire patch will be the survey plot.
- 380 ii. Record the plot boundary in Collector by either drawing it on the map or
381 recording your tracks as you walk the perimeter (see **Phase 2 Step 3**
382 below). This will create a digital record of the survey plot and will also
383 ensure that the surveyor(s) knows the boundary. Place stake flags to mark
384 any sections of the perimeter that are not easy to distinguish.
- 385 b. If the habitat patch is ≥ 3.1 acres:
- 386 i. Reference the habitat patch map and/or GPS-enabled device to identify
387 how many target sampling sites there are for the patch.
- 388 ii. Navigate to the first target sampling site using handheld device.
- 389 iii. Perform a visual inspection of the area in the vicinity of the sampling site.
390 You are looking to identify the area of the highest concentration of plants
391 in flower, which will serve as the survey plot.
- 392 1. Max survey plot size is 4 acres unless more than 1 experienced
393 observer is present and there is adequate space.
- 394 2. Remember to leave space for any other survey plots in that patch.
- 395 iv. Once you have identified the greatest concentration of flowering plants,
396 you will need to mark it and digitally record its location. Record the plot
397 boundary in Collector by either drawing it on the map or recording your
398 tracks as you walk the perimeter (see **Phase 2 Step 3** below). Place stake
399 flags to mark the perimeter, as necessary.


400 3. Creating the survey plot polygon with Collector

- 401 a. Click on the map downloaded to the device (see SOP 3 for details).

402 b. Select **Collect New**  to create a new survey plot polygon.

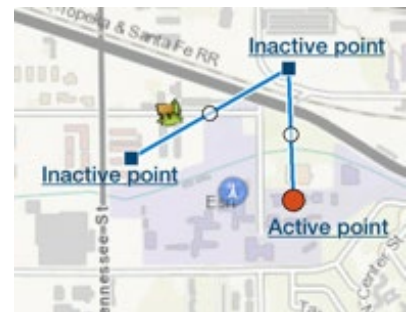
- c. A series of attributes are displayed on the data entry form (ORGRNAME, ORGCODE, etc). These will be populated in post-processing, so *you do not need to enter anything here.*

- d. Select **Map**  to view the current location. **Record the survey plot polygon using one of the options listed below:** (The following instructions are taken from <https://doc.arcgis.com/en/collector/ios/collect-data/draw-a-shape.htm>. Arcgis.com is the best resource for how to use Collector and Survey123, but some instructions are provided here.)

- e. To collect area features, you can draw a shape on the map. Use the map to add a point manually, or select **Use My Location**  to use the device's GPS to place a point. The points and lines connecting them are drawn. Continue adding points to complete your shape.

- f. When collecting features, you can also collect a shape automatically by using the stream option. Streaming automatically collects a shape, allowing you to walk or drive along a feature and capture its shape without manually dropping vertices.

- g. One of the points is the active point, highlighted in red. The other points you added are the blue squares in the following image. When you add a point, it becomes the active point.



- h. As you draw, the next point is placed into the shape following the active point. The point you add is joined to the shape with a line from the previously active point.

- i. Using the map adds a point after the active point, connecting the two with a line segment. In a basic measurement scenario, the active point is the last point added, and the new point is added at the end of the shape. The new point becomes the active point and is connected to the previously active point by a new line segment.

- j. To **update a shape**, select an existing point to make it the active point.



- k. When a point is active, you can move it. Long press to show the magnifier, and use the magnifier to place the active point in its new location.


- l. Use the map to add a point after the active point. When the active point is not the final point in the shape, lines are added to the shape that connect the newly added point to the active point you selected, and to the point that followed the selected active point. The newly added point becomes your active point.

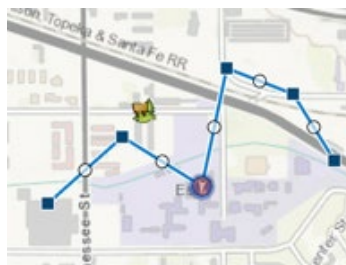
- m. You can also select the midpoint of a line to insert a point along that line.






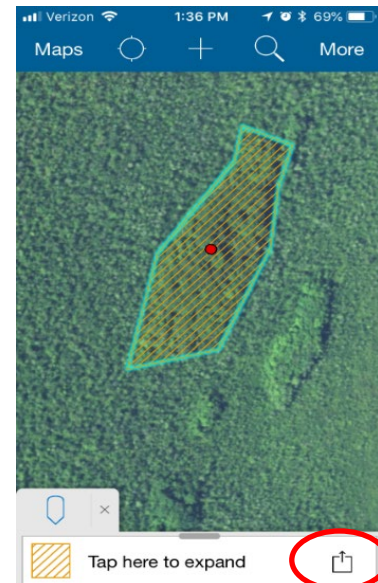
- n. In the previous image, the line is selected, and its midpoint is the active point; however, a point is not inserted. The point is inserted when you use the map to provide a location for the new point.



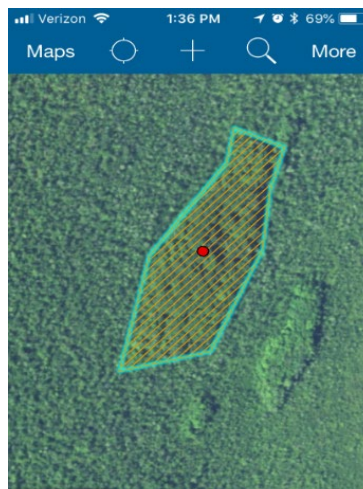
- o. Select **Use my location**  to use your location and insert a point following the active point.



- 448 p. You can undo changes to the points, and you can delete the shape to start drawing
449 from an empty shape. Select **Undo**  to cancel the last change (adding or
450 moving of a vertex). Select **Delete**  to clear the shape.
- 451 q. When editing a feature, you can also delete the currently active vertex, and you
452 can use streaming to create the feature. Delete the currently active vertex by
453 selecting **Delete Vertex** . Select **Stream** to create the feature using the GPS
454 while you move.
- 455 r. When the survey plot area has been collected, click the **Submit** button at the top
456 of the screen.
- 457 4. If you need to **edit** a survey plot after it has been submitted, follow the instructions
458 below. If you are satisfied with your polygon, continue to Step 5.
- 459 a. In the map screen, tap the polygon you wish to edit so that it is highlighted. A
460 small popup will appear at the bottom of the screen.
- 461 b. Tap the symbol on the right hand side of the
462 popup window (right).
- 463 c. A menu will appear. Choose “Edit”
- 464 d. The feature’s attributes display again. Choose
465 the map button at the top of the window.
- 466 e. Follow Step 3 items J and K (above) to select
467 individual vertices and edit their location.
- 468 f. When finished, click **Update**.



- 470 5. Back on the map screen, tap the shape just created. A
471 small popup will appear.
- 472 a. Tap on the square matching the color of the survey area, or on the text that says
473 “Tap here to expand.”



- b. The pop-up will expand. Note the area displayed at the top – it will be entered in the next step.
- c. Next click the link to Launch Survey123. Survey123 will open and load the Bombus survey form.



6. In Survey123, enter the survey plot area. Verify that the plot is an acceptable size (you determined what size it should be in **Phase 2 Step 1**. 3-4 acres is the target, unless >1 experienced observer is present and space allows).
7. Select the name of the Refuge where the survey is occurring. The Lead Observer name (Jean or Richardson) will auto-populate based on the Refuge.
8. Record the names of any additional observers (people who are catching bumblebees) other than the Lead Observer. Record experts and novices separately.
9. Record the total number of observers (people who are catching bumblebees).
10. Select the name of the Patch and Target Sampling Site, and enter the Visit Number. Survey123 will automatically generate a Survey ID that looks like:
Refuge LIT Code-Patch Name Target Sampling Site-Fiscal Year-Visit Number
(e.g., PMN-Field2-01-18-3)
- a. Refuge LIT Code = 3 letter code unique to each Refuge.
- TCM = John Heinz NWR at Tinicum
 - MSQ = Missisquoi NWR
 - PMN = Petit Manan NWR
 - SPM = Supawna Meadows NWR

- b. Patch Name and Target Sampling Site = See Tables 1-4. *If you are adding a new sampling site (that is not in the dropdown list), choose “Other.” Another box called “Other Patch and Target Sampling Site” will appear. Enter the sampling site number in it. Number your new sites chronologically, beginning with 01.*
- c. Visit Number = 1, 2, or 3.
- d. Fiscal Year = 18 for all cases, and included as the default.
11. Record the temperature (in °F), wind speed (mph), cloud cover, and survey date.

Phase 3: Non-lethally Sample Bumble Bees

(Data collected in Phase 3 are recorded in Survey123)

1. Stage coolers, nets, vials/baggies, camera, and photographer’s tent near the survey plot. Ensure that a layer of plastic bags covers the ice or ice packs inside the cooler so that captured bumble bees do not directly contact the ice.
2. If novice observers will be capturing bees, the experienced observer should give a brief instruction on safe netting and handling techniques. Instruct the observers to record their initials, time of capture, and flower name on the vials, and to record their handling time.
3. Calculating observer handling time:
 - a. Each observer should record their handling time (in seconds) for up to 10 bees per year and report it to the lead observer.
 - b. Using a timer or by counting in your head, record the # of seconds that the net is “unavailable” to catch bees (beginning when a bee is in the net and ending when the bee is safely secured in a vial and the observer is free to capture another bee).
4. Ensure that all observers understand the survey plot boundaries.
5. Attempt to capture all bumble bees present in the survey plot for 1 hour.
 - a. Begin the timer/stopwatch and note the start time. (Hint: Click in the Start Time field in Survey123 when you begin the survey. It will default to the current time.)
 - b. Each observer should capture bumble bees, preferably one at a time, and place them in vials or baggies (1 bee per container).
 - c. Write observer initials, time of capture and name of flower species (if bumble bees are collected while foraging on flowers) on the vial.
 - d. Perform a quick visual inspection of each captured bee to screen for any rusty patched bumble bees.
 - e. If the bee is not a rusty patched, place the container in the cooler. If a rusty patched bumble bee is suspected, immediately pause the survey and stop collecting bees. Pause the timer/stopwatch, if using, or start a new timer to record how long the survey is paused for. Go to SOP 2 and follow the instructions.
6. Once the survey is complete, report the survey end time (Hint: Click in the End Time field in Survey123 and it defaults to the current time). Report the actual length of survey (which accounts for any pauses in the survey that occurred).

7. Process captured bumble bees as expediently as possible to minimize the time they are held. Do not hold them in a cooler with ice for more than 2 hours.
- Lead observer should visually identify the species of each bumble bee, using a hand lens if required. Note that it is acceptable to call a species *Bombus vagans/sandersoni* when the distinguishing features of *vagans* cannot be seen (i.e., malar space is obviously longer than broad). This is an option in the *Bombus* species list in Survey123.
 - Record the level of confidence in the species ID. It is acceptable to have a high level of confidence in the ID when choosing *vagans/sandersoni*.
 - Record the caste of the bee. “Female” should be chosen if the caste cannot be distinguished or the bee is attributed to a *Psithyrus* subgenus species.
 - Record the name of the observer who caught the bee.
 - Record the time the bee was captured.
 - Take a photographic voucher of each bumble bee species captured. Use the photographer’s tent as necessary to create the desired light conditions. Only use the device containing Survey123 or a digital camera that allows you to record the photo number.
 - If the photo is taken with the device containing Survey123, use the option that allows taking or adding an image from file. This automatically associates the photo with the bee record.
 - If photos are taken with a separate camera, complete the appropriate questions in Survey123, including entering the names of the image files created.
 - If the bee was collected while foraging, record the flower name (Latin or common) and take a representative photograph of the flower species using the device containing Survey123.
 - After processing, open the container and place in a shady area to allow the bee to warm up and fly away. Do not place bees in direct sunlight.

Phase 4: Collect Habitat Data

(Data collected in Phase 4 are recorded in Survey123)

- Collect habitat data **within the survey plot**. Walk through the plot, as needed, to observe the required features.
 - Identify all the habitat types within the plot using the dropdown menu.
 - Estimate the total percent vegetated cover within the plot and select the appropriate category (bin).
 - Estimate the percent cover of non-woody plants in flower (forbs and grasses)
 - Estimate the percent cover of woody plants in flower (shrubs and trees)
- Record whether honeybees were present during the survey.
- Collect habitat management and potential stressor information **within the survey plot**.

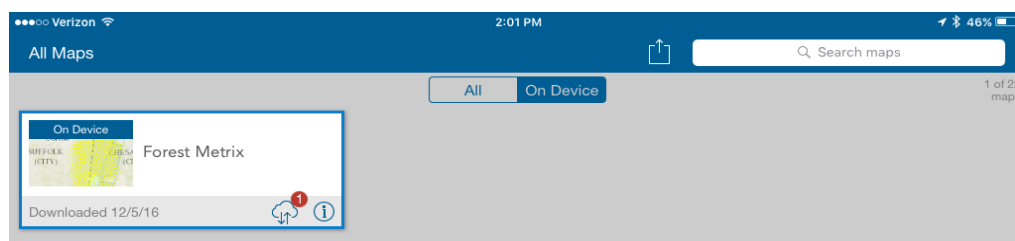
- a. Consult the list of known habitat management actions and stressors for the habitat patch (found in Element 3, habitat patch description tables 1-4).
 - b. If there is evidence in the survey plot of any new types of management or stressors that are not already known for that patch, surveyors should record them.
4. Take a representative photograph(s) of the survey plot using the device containing Survey123 (to record the notable features and surrounding landscape).

Phase 5: Field Survey Wrap-Up

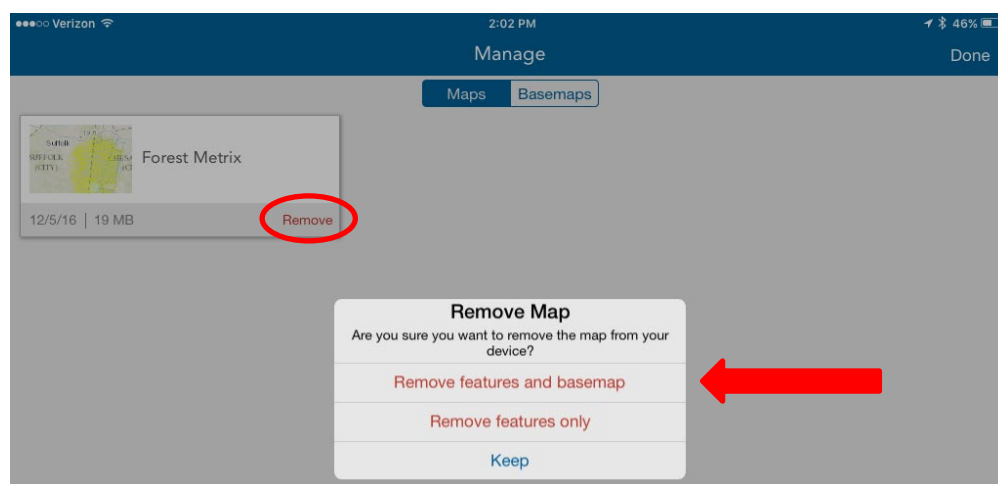
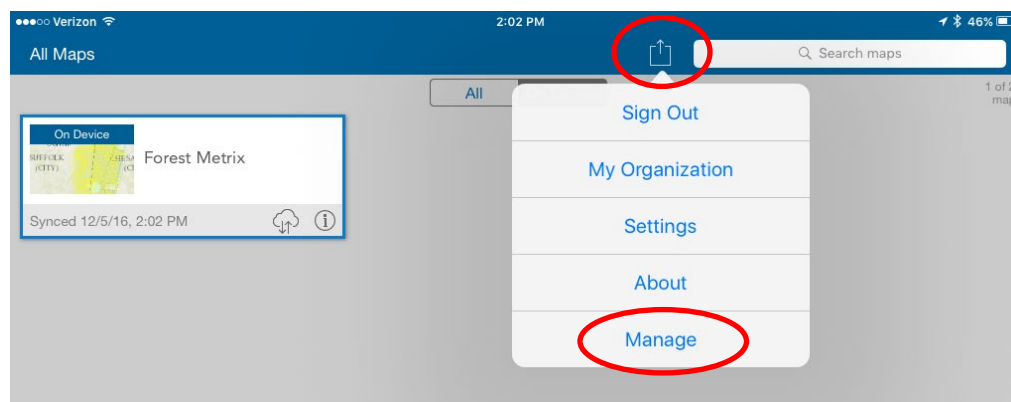
1. To save and close the Survey123 form, click the green checkmark in the lower right-hand corner of the screen. A pop-up will appear. Unless your device is Online, choose the option to “Save and Send Later.”
2. If a habitat patch contains multiple survey plots, you should survey them all on the same day or as close together in time as possible.
3. If the next survey plot you will visit is within the same habitat patch, leave the flagging/stake flags in place so that you do not accidentally establish overlapping plots. If the next survey plot is in a different patch, remove the flagging/stake flags.
4. Place new blank stickers on all vials or baggies so they are ready for the next survey.

Phase 6: Sync and Submit Field Data

1. Once you’ve completed the day’s plots, you’re ready for syncing your edits back to the web. **This step is to be completed on a daily basis back at the office or where there is solid wifi.**
2. For *Collector*, click the “Maps” tab in the upper left corner and make sure you’re on the “On Device” tab. You’ll notice a RED number icon next to the little cloud. This is the number of edited points you’ve done since downloading. Click the **cloud to start syncing your edits.**



3. After successfully syncing your edits, click the “**Manage**” tab and the “**Remove**” tab, and choose “**Remove Features and Basemaps**”. Once you’ve removed the “On Device” map, you should have no maps that are on your device.



4. If you didn’t complete all the plots for the day, you should still sync your edits. You can keep the “clipped” version on your device if you plan to go back the next day to finish plots within the “work area”.
5. For *Survey123*, open the app and tap on the bumble bee survey. On the survey page, tap on the “**Outbox: Send your completed survey data.**” You can then click on the “**Send**” button at the bottom of the screen to submit all completed surveys for the day. After submitting, you will get a message confirming success, and the Outbox will change to a Sent box (from which you can still access and edit the surveys, if necessary).

Post-survey data entry from paper field data sheets

If paper data sheets are used in the field, the electronic data collection will be done on a personal computer or mobile device in the office. It is only necessary to follow these steps if electronic data collection did not happen in the field.

- 631 1. The persons taking the data in the field must complete the data entry electronically using
632 Collector and Survey123.
- 633 2. Complete the pre-work procedures described in SOP 3 for installing Survey123 on a
634 personal computer.
- 635 3. Using the paper data sheets as reference, fill out surveys for each station visited.
- 636 4. Submit surveys to AGOL. This can be done after entering data for each station or once
637 after entering data for all stations (up to the user).
- 638 5. Note the date that electronic data entry is completed on the field data sheet.
- 639 6. When all data entry for a sampling event is complete, notify the data manager.
- 640 7. The data manager will verify and validate the data entry by downloading the surveys
641 from the cloud and reviewing them.

642 **SOP 2: Rusty Patched Bumble Bee Capture**

- 643 1. If you capture a suspected rusty patched bumble bee (ESA Endangered), place it in a vial
644 or baggie and immediately pause the survey timer.
- 645 2. Note the time it was collected.
- 646 3. Process the individual as expediently as possible.
 - 647 a. Place the vial or baggie in a cooler for a brief time if the bee is very active or else
648 in a shady spot.
 - 649 b. Record the level of confidence in the species ID.
 - 650 c. Take multiple photographic vouchers of the individual. Be sure to capture, at
651 minimum, the top side of the abdomen, the side of the thorax, and the face. A
652 video is also useful. Use the photographer's tent as necessary to create the desired
653 light conditions. Only use the device containing Survey123 or a digital camera
654 that allows you to record the photo number.
 - 655 d. Release the individual immediately after processing.
- 656 4. If the rusty patched was foraging while captured, be sure to record the species of the plant
657 and take a voucher photograph of it.
- 658 5. Resume the bumble bee survey by restarting the timer.
- 659 6. Try to avoid capturing the same rusty patched individual a second time! If there are
660 multiple RPBB individuals present, halt the survey and focus on estimating the number of
661 RPBB using the survey plot. (This is at the discretion of the surveyor).
- 662 7. At the end of the survey, immediately contact the Refuge point-of-contact
663 (biologist/manager) and Regional office team members (Becky Longenecker, Laura
664 Eaton, Maritza Mallek). USFWS Ecological Services will then be informed about the
665 discovery and requested to perform more in-depth assessments at the site.

666

SOP 3: Electronic Data Collection Preparation

Background

Electronic data collection is the preferred method when devices supporting Survey123 and Collector are available (smartphones or tablets) due to the reduction in the potential for human error from transcription. It does require advance preparation by a data manager to ensure surveys are available on the cloud and by field-going personnel to ensure devices have up-to-date copies of the app and of the survey. This SOP is designed for FWS personnel; users with accounts through other institutions may notice slight variations in how to complete the tasks.

The prework, installation, logging in, and downloading steps described below require either an internet connection or a data connection. Because some refuges may have spotty data service, we recommend downloading all maps and surveys before going out into the field to conduct the *Bombus* surveys so that work can proceed smoothly.

Obtain access to ArcGIS Online (AGOL)

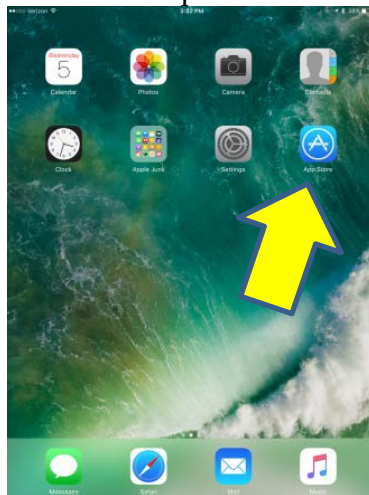
1. Go to https://fishnet.fws.doi.net/projects/gisnew/SitePages/AGOL_Get_Started.aspx.
2. Read the instructions to get on AGOL for the first time.

Join the R5 Bombus Surveys group

Contact the Regional Data Manager once successfully logged into AGOL so that your name can be added to the list of group members for the R5 Bombus Surveys. If this is not done, you will still be able to complete the survey, but you will not be able to upload your data to the cloud.

Install Collector

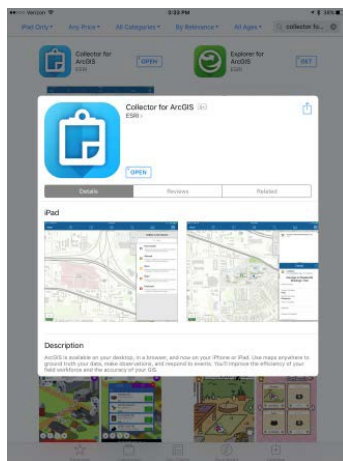
1. On your mobile device (iOS or Android OS) go to your application (app) store. This workflow will use examples from iOS on an iPad Pro.



2. Search for “Collector for ArcGIS” using the search window (Published by ESRI)

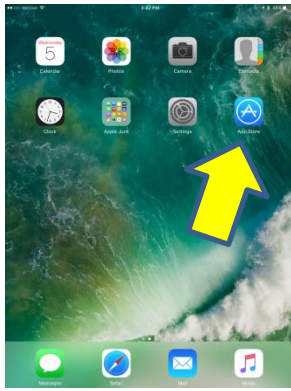


3. Install the application. This step may require a username and password such as AppleID and password.



Install Survey123

1. If it is not already installed, download and install Survey123 on the electronic data collection device (personal computer, tablet, or smartphone.)
 - a. To install on a personal computer:
 - i. Download executable from <http://doc.arcgis.com/en/survey123/download/>.
 - ii. Download the latest version for your operating system.
 - iii. Install the program.
 - b. To install on a smartphone or tablet:
 - i. On your mobile device (iOS or Android OS) go to your application (app) store. This workflow will use examples from iOS on an iPad Pro.

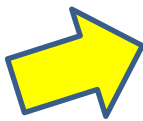


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- ii. Search for “**Survey123 for ArcGIS**” using the search window (Published by ESRI)

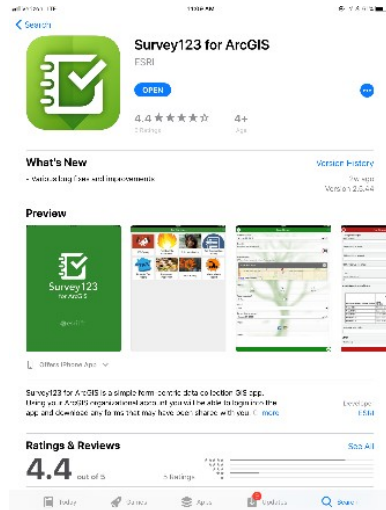


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- iii. Install the application. This step may require a username and password such as AppleID and password.



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Logging into Collector

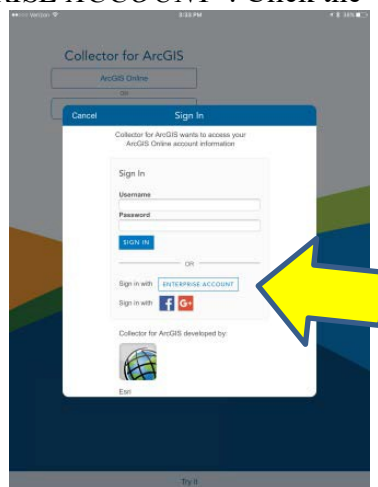
1. Open the application which is titled “**Collector**”



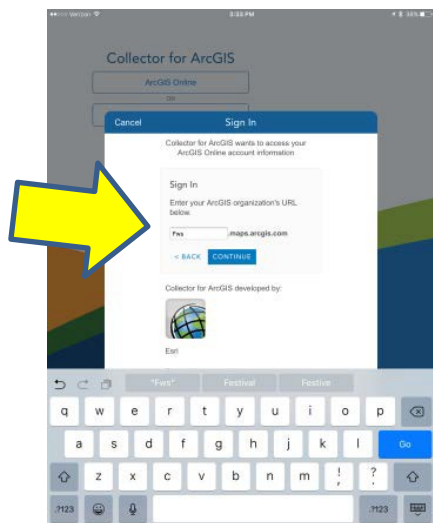
2. Sign in to the app:
 - a. You have 2 options for signing in. You need to know what platform the maps you want to use are stored on. We will be using “*ArcGIS Online*”



- b. You must already have a login created for the platform your logging into.
3. After picking the platform, a username and password splash screen shows. Under the “SIGN IN” button you should see “----- OR-----“ and below that “*Sign in with ENTERPRISE ACCOUNT*”. Click the “*ENTERPRISE ACCOUNT*” button.



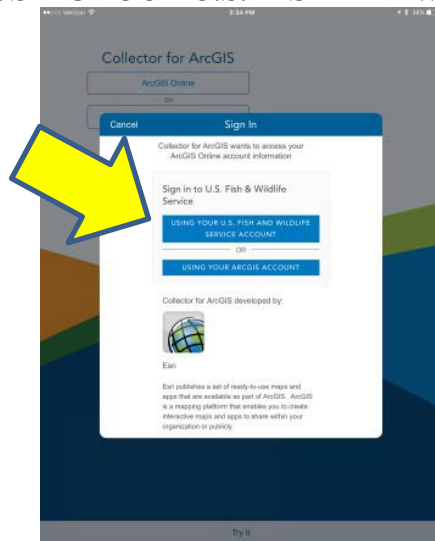
4. Enter the ArcGIS organization’s URL as “FWS”. Your results should be fws.maps.arcgis.com. click **Continue**



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5. Click “***USING YOUR U.S. FISH AND WILDLIFE SERVICE***” button

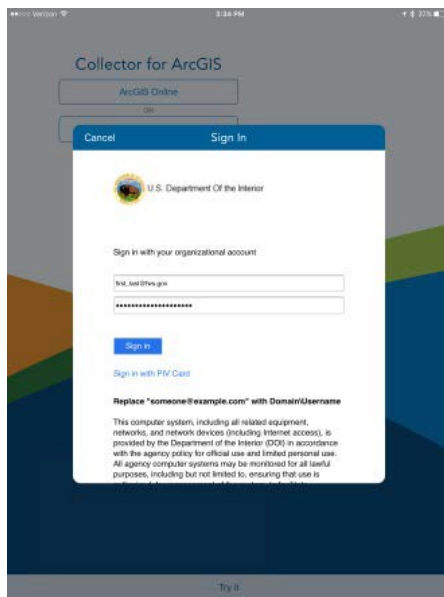


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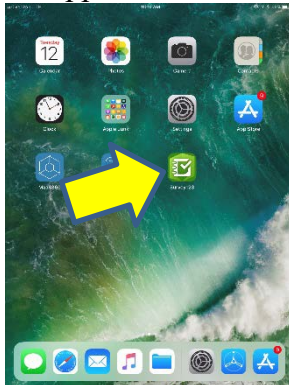
6. Now you enter you Active Directory account (first_last@fws.gov) and password. If that doesn't work, try ifw\shortname and Active Directory password.



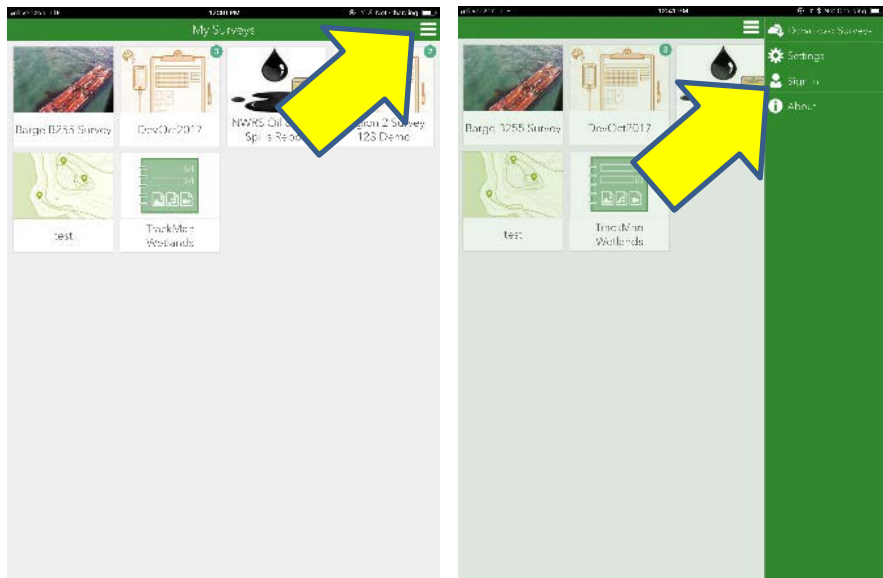
7. AND YOU'RE IN!!!!

Logging into Survey123

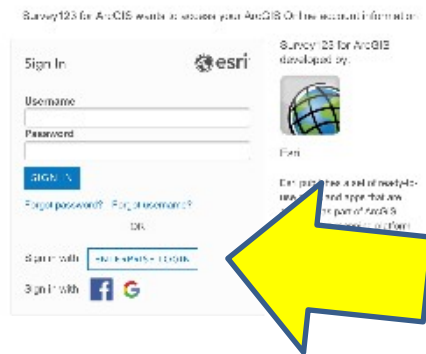
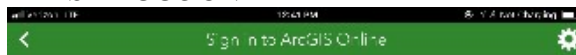
1. Open the application which is titled "Survey123"



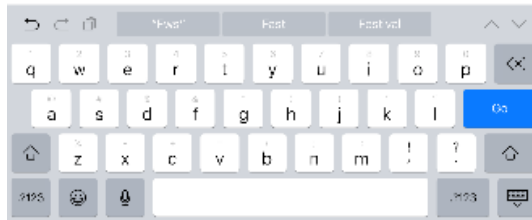
2. Sign in to the app.
 - a. After opening the app, you will see any surveys you have downloaded to the device, if any. In the top right corner, **click the 3 horizontal bars**. In the expanded window, select **Sign in**.



- b. You must already have a login create for the platform your logging into.
3. After clicking Sign in, a username and password splash screen shows. Under the “SIGN IN” button you should see “----- OR-----“ and below that “*Sign in with ENTERPRISE ACCOUNT*”. Click the “**ENTERPRISE ACCOUNT**” button.



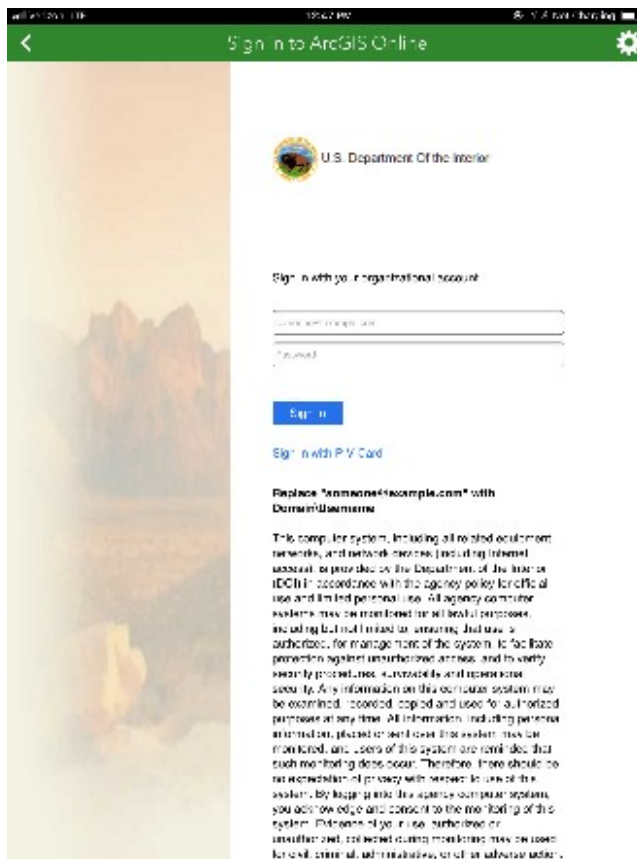
4. Enter the ArcGIS organization’s URL as “FWS”. Your results should be fws.maps.arcgis.com click **Continue**.



5. Click ***“USING YOUR U.S. FISH AND WILDLIFE SERVICE”*** button



6. Now you enter your Active Directory account (first_last@fws.gov) and password.



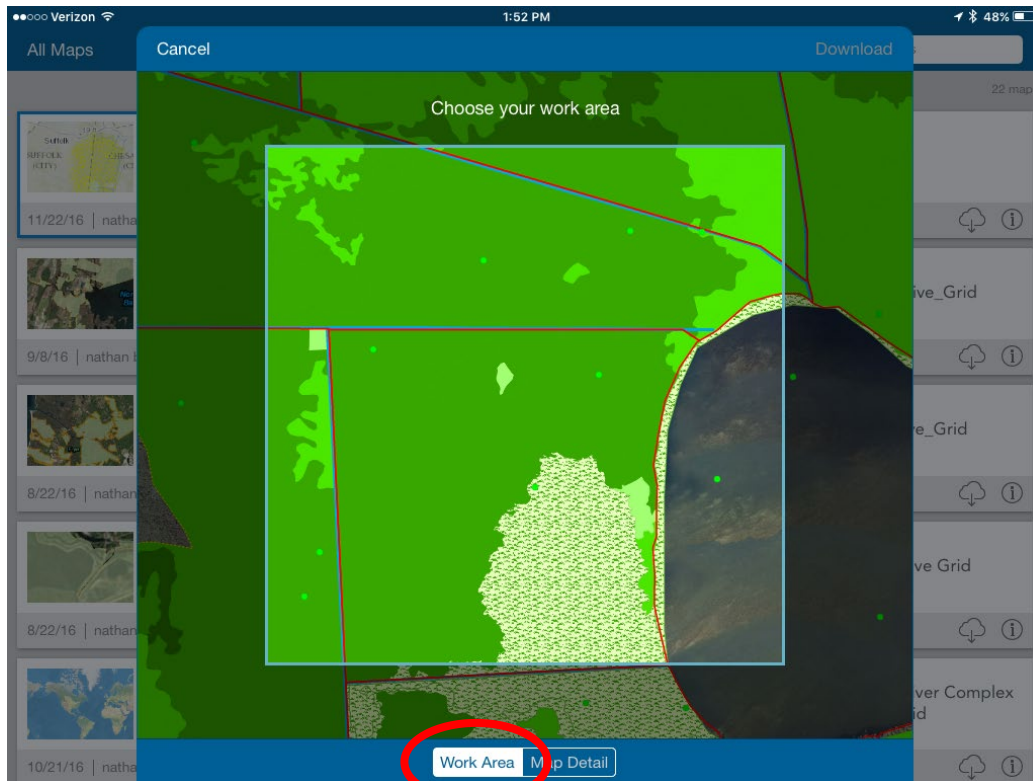
7. AND YOU'RE IN!!!!

Download Collector map for the refuge being surveyed

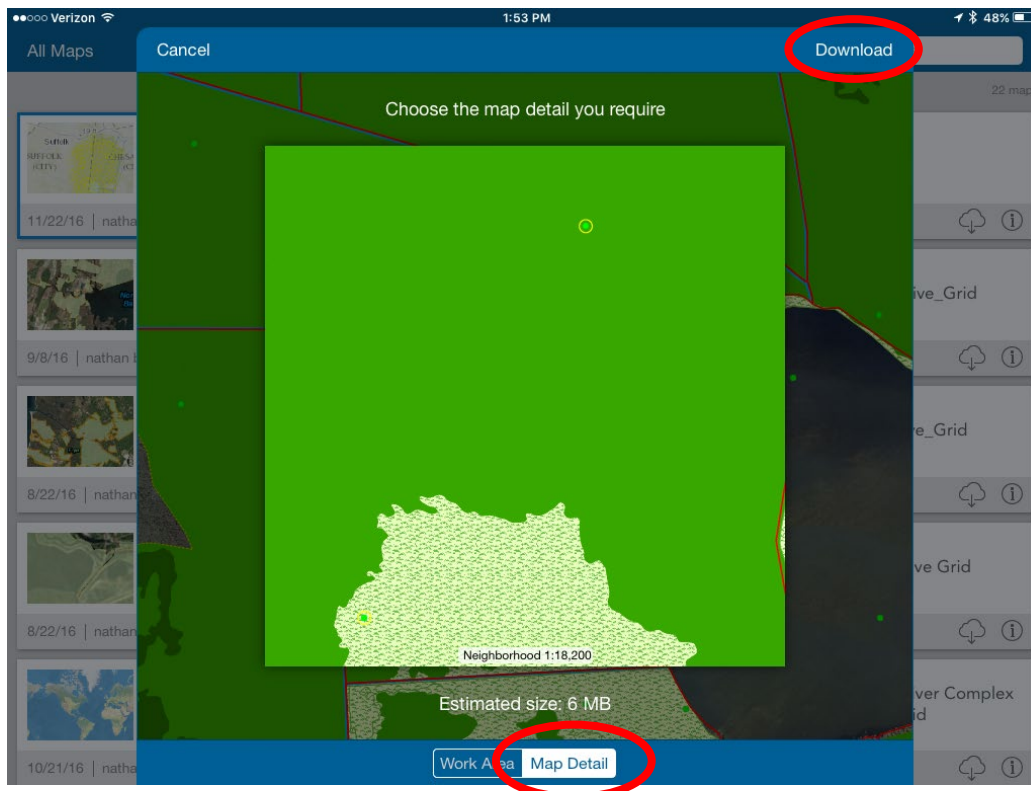
1. Open Collector
2. If prompted to log in, do so. Instructions for logging in, if needed, are above.
3. The default screen should say "All Maps" in the upper left hand corner. If it doesn't, click the word there to change the view.
4. Note: At this point you should be **on wifi or cellular data**. Since you will be going into the field where you're likely to out of wifi range, you need to clip to your "work area" and download the map to your device.
5. Browse the list to find the most current Bombus Map.
6. Find and press the icon that looks like a **cloud with a down-arrow**.



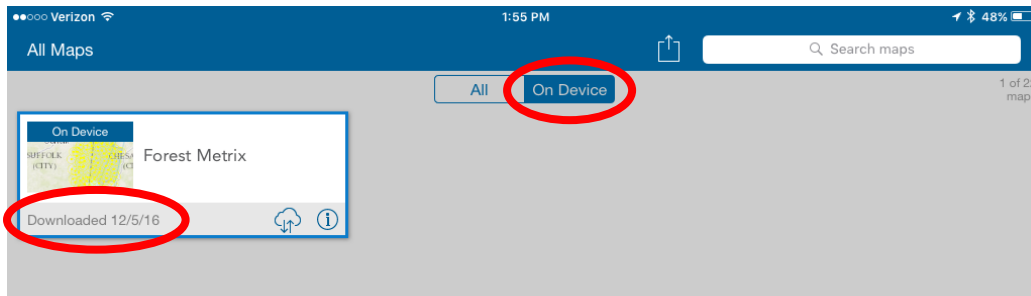
- 779 7. After the download icon is pressed, the map opens up to window where you will choose
780 your “**work area**”. You want to pan and zoom to the extent of the day’s work area. This
781 should be something like the 10,000ft scale.



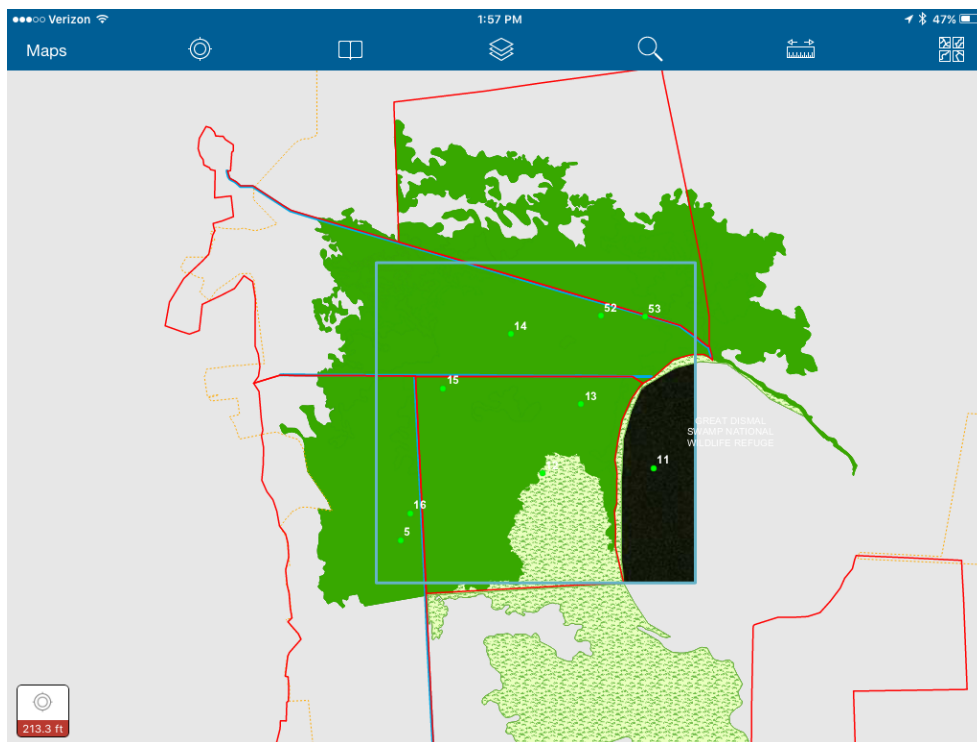
- 782 8. Once you’ve chosen the work area, you need to choose the “**Map Detail**”. This is how
783 close you will be able to zoom-in once you download the map to your device. In other
784 words, this is like the resolution that you will achieve. If you zoom-in too far, may lose
785 your image. Simply zoom-out to where you see the image. Once at the desired scale
786 (~500ft level), press the **download tab**. You will see your map downloading to your
787 device.



9. Once it's done downloading, press the **"On Device"** tab. This will display maps that are local (downloaded) to your device. Go ahead and open the map.

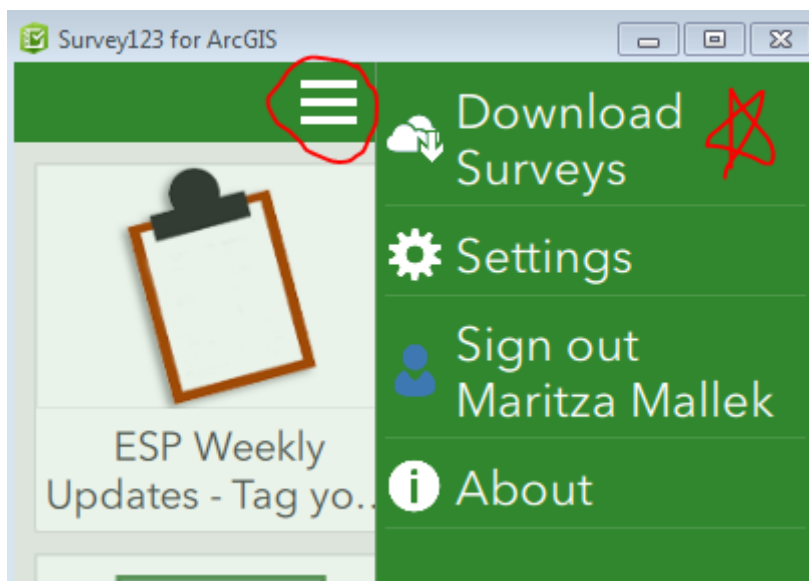


10. Once open, zoom out to see the full extent of your work area. Notice how the features are "clipped" to your work area. Features may extend past your "work area" because the clipping captures all features that are touching the bounding box of the "work area".



Download Survey123 form for *Bombus* surveys

1. Open Survey123
2. Sign into Survey123, if prompted. See “Logging into Survey123 above” if you need help
3. Select the menu dropdown, and choose to Download Surveys.



4. Select the most recent *Bombus* survey available. It will automatically download.
5. If no options are available, contact the Regional Data Manager and let them know. It may be necessary to modify permissions and memberships so that you can access the surveys.

SOP 4: Adding Photos to iNaturalist

Background

The USFWS has a project page on iNaturalist where bee photos taken on refuges can be uploaded and bee experts will periodically visit and attempt to identify the bees in the photos. Although bees captured during this survey will be identified in the field, iNaturalist also serves as a useful second opinion on those identifications and as a repository for our data that can easily be used by other scientists.

Brief Procedure for adding *Bombus* observations to iNaturalist

1. Log In or Sign Up for iNaturalist.
2. Navigate to the “[Bee & Wasp](#)” link on the [NWRS page](#).
3. Click the Add Observations button.
4. Add all photos taken of each captured *Bombus* to an observation. You should be able to upload multiple images at once. For help on completing this step, use the instructions provided at <https://www.inaturalist.org/pages/getting+started> or view the getting started video at <https://vimeo.com/167431843>.
5. In order to identify observations that were made as part of a formal survey (as opposed to casual observations of refuge visitors), please add the keyword “IMBeeSurvey” in the Tags field on the Observation Submission page. These observations can then be selected with a query using that tag.

A more detailed accounting of how to use iNaturalist and the USFWS National Wildlife Refuge System Project, including screenshots, can be accessed here:

<https://ecos.fws.gov/ServCat/Reference/Profile/81342>.

Brief Procedure for updating Survey123 responses with iNaturalist observation URL

For each *Bombus* observation added, add the iNaturalist observation URL to the iNaturalistURL field in the feature layer associated with the Survey123 data on AGOL.

1. To navigate to this feature layer, first log in to AGOL.
2. Then go to the R5 Bombus Surveys group.
3. From the Content tab, select the Feature Layer associated with the Survey123 data (begins with ‘R5_BombusSurveys’).
4. Click the Data tab.
5. Navigate to the survey row corresponding to the survey patch associated with the uploaded photos.
6. Click the ‘Show’ link under the field ‘Relationship_CollectedBees’ in the appropriate row.
7. Use the photos or the fields describing the camera photos to confirm that you are in the correct row for the photos uploaded to iNaturalist.
8. Navigate to the iNaturalistURL field and double-click in the row just identified.
9. Paste the iNaturalist observation URL here.
10. Hit return, and the edit will automatically save.

852 **Appendix**

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854 **Appendix A. Field Data Sheet**

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Section 1: Basic Survey Details	instructions	required	value
	Answer these questions before beginning area search.		
Survey Plot Area in Acres	Click on the submitted polygon in Collector for an auto-calculated acreage. Enter that number here. Only enter one digit following the decimal.	yes	
Refuge Name		yes	
Lead Cooperator			
Is there an additional observer, expert?		yes	yes / no
Additional Expert Observer #1	Write additional expert observer first and last name; e.g. "Leif Richardson."		
Is there an additional expert observer?			
Additional Expert Observer #2	List additional expert observer by first and last name; e.g. "Leif Richardson."		
Is there an additional expert observer?			
Additional Expert Observer #3	List additional expert observer by first and last name; e.g. "Leif Richardson."		
Is there an additional observer, novice?		yes	yes / no
Additional Novice Observer #1	Write novice observer first and last name; e.g. "Leif Richardson." These should be persons who assisted in bee capture.		
Is there an additional novice observer?			
Additional Novice Observer #2	Write novice observer first and last name; e.g. "Leif Richardson." These should be persons who assisted in bee capture.		
Is there an additional novice observer?			
Additional Novice Observer #3	Write novice observer first and last name; e.g. "Leif Richardson." These should be persons who assisted in bee capture.		
Total Number of Observers	Total number of observers capturing bees in the plot, including the lead cooperator, any additional experts, and any novices. There should be no more than 4 total observers per 3-4 acre plot.	yes	
Patch and Target Sampling Site	Name of the survey patch and number of the target sampling site. This info can be found by tapping the marker dot in Collector. If you are adding a new sampling site, write "Other."	yes	
Which visit is this?	Use 1 for first visit, 2 for second visit, etc.	yes	
Fiscal Year	Federal fiscal year.	yes	18
Survey ID	Format: [Refuge code]-[Patch and Target Sampling Site]-[Fiscal Year]-[Which visit?].	yes	
Temperature	Temperature at start of survey, in °F	yes	
Wind Speed	Wind speed at start of survey, in miles per hour	yes	
Cloud Cover	<10%, 10-49%, 50-89%, >90%	yes	
Survey Date		yes	
Survey Start Time		yes	
Survey End Time		yes	
Time spent surveying	Total time spent surveying (actual, in minutes) per person.	yes	
Comment	Use this space to record any notes regarding the questions in this section that are not otherwise accounted for. Also, note any major interruptions to the surveying effort here.		

Section 2: Collected Bees. Date:		Target Sampling Site ID:			
	Bombus Species	Percent Confidence in ID	Caste	Name of person who captured bee	Time Collected
	Select species from list. If species is not on list, choose "Other."	<10%, 10-49%, 50-89%, >90%	Queen Female, Worker Female, Female, Male	Use format of first name last initial, e.g. Leif R.	Enter time recorded on bee vial.
required	yes	yes	yes	yes	yes
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	Bombus Species	Percent Confidence in ID	Caste	Name of person who captured bee	Time Collected
	Select species from list. If species is not on list, choose "Other."	<10%, 10-49%, 50-89%, >90%	Queen Female, Worker Female, Female, Male	Use format of first name last initial, e.g. Leif R.	Enter time recorded on bee vial.
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	Bombus Species	Percent Confidence in ID	Caste	Name of person who captured bee	Time Collected
	Select species from list. If species is not on list, choose "Other."	<10%, 10-49%, 50-89%, >90%	Queen Female, Worker Female, Female, Male	Use format of first name last initial, e.g. Leif R.	Enter time recorded on bee vial.
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	Bombus Species	Percent Confidence in ID	Caste	Name of person who captured bee	Time Collected
	Select species from list. If species is not on list, choose "Other."	<10%, 10-49%, 50-89%, >90%	Queen Female, Worker Female, Female, Male	Use format of first name last initial, e.g. Leif R.	Enter time recorded on bee vial.
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Section 2: Collected Bees.		Date:	Target Sampling Site ID:			
	Flower Species Scientific Name	Flower Species Common Name	# of Bee Photos Taken (Main Device)	# of Bee Photos Taken (Second device)	Name of Second Device (if used)	# of Flower Photos Taken (Main Device)
	Flower species used by Bombus (scientific name)	Flower species used by Bombus (common name)	# of bee photos taken with device used to complete survey form	# of bee photos taken on a second device (phone, iPad, camera)	Name and model of camera - enough to identify the right one later. Note memory card details if relevant	# of representative photographs of plant species
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NWRS Bombus Survey 2018						

	Flower Species Scientific Name	Flower Species Common Name	# of Bee Photos Taken (Main Device)	# of Bee Photos Taken (Second device)	Name of Second Device (if used)	# of Flower Photos Taken (Main Device)
	Flower species used by Bombus (scientific name)	Flower species used by Bombus (common name)	# of bee photos taken with device used to complete survey form	# of bee photos taken on a second device (phone, iPad, camera)	Name and model of camera - enough to identify the right one later. Note memory card details if relevant	# of representative photographs of plant species
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	NWRS Bombus Survey 2018					Page 6

	Flower Species Scientific Name	Flower Species Common Name	# of Bee Photos Taken (Main Device)	# of Bee Photos Taken (Second device)	Name of Second Device (if used)	# of Flower Photos Taken (Main Device)
	Flower species used by Bombus (scientific name)	Flower species used by Bombus (common name)	# of bee photos taken with device used to complete survey form	# of bee photos taken on a second device (phone, iPad, camera)	Name and model of camera - enough to identify the right one later. Note memory card details if relevant	# of representative photographs of plant species
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	NWRS Bombus Survey 2018					

	Flower Species Scientific Name	Flower Species Common Name	# of Bee Photos Taken (Main Device)	# of Bee Photos Taken (Second device)	Name of Second Device (if used)	# of Flower Photos Taken (Main Device)
	Flower species used by Bombus (scientific name)	Flower species used by Bombus (common name)	# of bee photos taken with device used to complete survey form	# of bee photos taken on a second device (phone, iPad, camera)	Name and model of camera - enough to identify the right one later. Note memory card details if relevant	# of representative photographs of plant species
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	NWRS Bombus Survey 2018					

	Section 2: Collected Bees. Date: Target Sampling Site ID:
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Section 3: Habitat Data	Date:	Target Sampling Site ID:	
	hint	required	value
Habitat Type	Select all of these habitat types that are present in the survey plot.	yes	(Circle all that apply) <div> <div>Open Water</div> <div>Developed Open Space</div> <div>Developed Low Intensity</div> <div>Developed Medium Intensity</div> <div>Developed High Intensity</div> <div>Barren Land</div> <div>Deciduous Forest</div> <div>Evergreen Forest</div> <div>Mixed Forest</div> </div> <div> <div>Dwarf Scrub Shrubland</div> <div>Scrub Shrubland</div> <div>Grassland Herbaceous</div> <div>Pasture/Hay</div> <div>Cultivated Crops</div> <div>Woody Wetlands</div> <div>Emergent Herbaceous</div> <div>Wetlands</div> <div>Other</div> </div>
Vegetation Percent Cover	Percent of the survey area that is vegetated, regardless of habitat type.	yes	<div> <div>None</div> <div><5%</div> <div>5-24%</div> <div>25-49%</div> </div> <div> <div>50-74%</div> <div>75-94%</div> <div>>95%</div> </div>
Percent Cover of Flowering Forbs and Grasses	Estimate the percent cover of non-woody plants in flower (forbs and grasses)	yes	<div> <div>None</div> <div><5%</div> <div>5-24%</div> <div>25-49%</div> </div> <div> <div>50-74%</div> <div>75-94%</div> <div>>95%</div> </div>
Percent Cover of Flowering Shrubs and Trees	Estimate the percent cover of woody plants in flower (shrubs and trees)	yes	<div> <div>None</div> <div><5%</div> <div>5-24%</div> <div>25-49%</div> </div> <div> <div>50-74%</div> <div>75-94%</div> <div>>95%</div> </div>
Were honey bees present at time of survey?		yes	Yes / No
Habitat Comment	Note any habitat management or stressors that were not already known for the patch. For example, area sprayed with herbicide in recent past, unplanned mowing event, etc. See Tables 1--4 in Element 3 of the survey instructions for known management actions and stressors. Only enter additional information here.		
# of Survey Plot Photos Taken		yes	
Device used for Photos	Name of device	yes	

Section 4: Handling Time Data	Date:	Target Sampling Site ID:	
	hint	required	value
Did observers record handling times?		yes	Yes / No
Lead Cooperator			
Handling Entry Instructions	Enter handling time in seconds, beginning when a bee is in the net and ending when the bee is safely secured in a vial and the observer is free to capture another bee.		
Lead Cooperator Handling Time #1			
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Lead Cooperator Handling Time #3			
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Lead Cooperator Handling Time #10			
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Additional Expert #1 Handling Time #2			
Additional Expert #1 Handling Time #3			
Additional Expert #1 Handling Time #4			
Additional Expert #1 Handling Time #5			
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Additional Expert #1 Handling Time #7			
Additional Expert #1 Handling Time #8			
Additional Expert #1 Handling Time #9			
Additional Expert #1 Handling Time #10			
Additional Expert #2	Name:		
Additional Expert #2 Handling Time #1			
Additional Expert #2 Handling Time #2			
Additional Expert #2 Handling Time #3			
Additional Expert #2 Handling Time #4			
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Additional Expert #3	Name:		
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Additional Novice #1	Name:		
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U.S. Fish and Wildlife Service
U.S. Department of the Interior



National Wildlife Refuge System