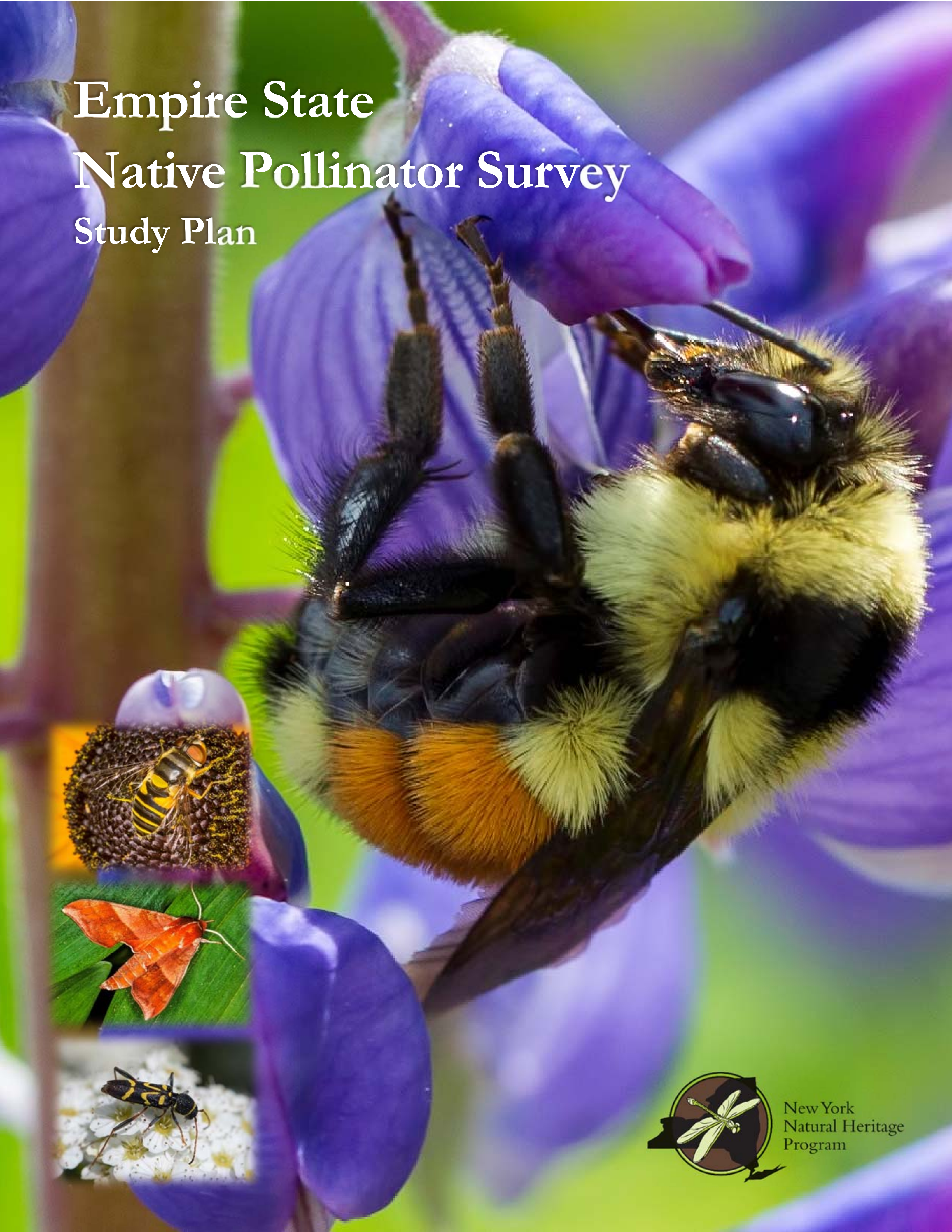
Empire State Native Pollinator Survey

Study Plan



New York Natural Heritage Program

Empire State Native Pollinator Survey
Study Plan

June 2017

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Cover photos: Tri-colored Bumble Bee (*Bombus ternarius*) and flower longhorn (*Clytus ruricola*) by Larry Master, www.masterimages.org; Azalea sphinx moth (*Darapsa choerilus*) and *Syrphus* fly by Stephen Diehl and Vici Zaremba.

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Introduction

Background: Rising Buzz and a Swarm of Pollinator Plans

A longstanding concern for pollinator populations and their importance to native ecosystems and agriculture worldwide (Buchmann and Nabhan 1996, Allen-Wardell *et al.* 1998, Kearns *et al.* 1998) ratcheted up in the early 2000s with news-making reports of declines in honeybees (vanEngelsdorp *et al.* 2009) and native pollinators (National Research Council 2007, Colla and Packer 2008, Cameron *et al.* 2011, Brower *et al.* 2012). The Federal Pollinator Task Force was established by President Obama in 2014, leading to two national strategies on pollinator management and research (Pollinator Health Task Force 2015a, 2015b). In New York, several species of bumble bees (*Bombus* spp.) were designated as High-priority Species of Greatest Conservation Need in the revised State Wildlife Action Plan (NYS DEC 2015). Also in 2015, New York Governor Andrew Cuomo assembled a Pollinator Task Force to recommend management practices, education, and research and monitoring strategies aimed at conserving wild and managed pollinator populations in New York. The resulting New York State Pollinator Protection Plan (NYS DEC and AGM 2016) included the following action item under Research:

"DEC…will begin a multi-year evaluation of New York's myriad native pollinator species. This assessment will show the current state and distribution of native pollinators and serve as the foundation for developing and implementing future conservation practices."

In October 2016, the New York Natural Heritage Program, a program of the State University of New York College of Environmental Science and Forestry (SUNY ESF), began work under a Memorandum of Understanding with the NYS DEC to design the native pollinator study described above. Our first step was to call on some experts to help us design the study.

Advisors and Taxonomic Experts

We assembled an advisory committee consisting of scientists and managers from the federal government, state government, academia, and non-profits. The committee consisted of 12 people:

Dr. Bryan Danforth, Cornell University
Sam Droege, Patuxent Wildlife Research Center, USGS
Dr. Melissa Fierke, SUNY ESF
Dr. Carmen Greenwood, SUNY Cobleskill
Rich Hatfield, Xerces Society for Invertebrate Conservation
Dr. Tim Howard, NY Natural Heritage Program
Dr. Jonathan Mawdsley, Association of Fish and Wildlife Agencies
Dr. Tim McCabe, NYS Museum
Kent McFarland, Vermont Center for Ecostudies
Robyn Niver, US Fish and Wildlife Service
Kathy O'Brien, NYS DEC
Dr. Jerry Rozen, American Museum of Natural History (retired)

The committee met via several conference calls from November 2016 to April 2017 and one in-person meeting in January 2017. While we sought the input of the committee for all major decisions, their participation does not suggest their or their organizations' endorsement of this study plan. We will continue to take advantage of the expertise and enthusiasm of our advisory committee for the life of the project. In addition, throughout the project, we will enlist the help of additional taxonomic experts to assist with species-level identification of photographic and specimen vouchers submitted with survey records.

Goal of the Survey

The goal of the Empire State Native Pollinator Survey is to determine the conservation status of a wide array of native insect pollinators in nonagricultural habitats.

Conservation status is typically determined from data on a species' rarity, trends, and threats. For the Natural Heritage network overseen by NatureServe, this is the S-rank for states and G-rank for the global population. Determining this status (Figure 1) ideally entails collecting current distributional data from recent field observations and new field surveys (rarity), historical distributional data from museums and other sources (trend), and reviews of literature and discussions with experts (threats). Status can be determined with a subset of this information when, for instance, information on historical distribution is unavailable.

Native insect pollinators are species native to the northeastern United States. This is specified mainly to distinguish the targets of this survey from *Apis mellifera*, the European honey bee, a managed pollinator that is the focus of many other conservation and management efforts.

General Sampling Design

The status of native pollinators will be assessed with three field sampling strategies and compilation of collection data. Combined with literature review and expert opinion, these data collection methods will enable the determination of conservation status (Figure 1).

An **Extensive Survey** throughout New York State will help determine the distribution of species within entire groups (i.e., families, subfamilies, certain genera) of pollinators in the state, such as leafcutter bees, hoverflies, and flower longhorn beetles.

Target Habitat Surveys are supplements to the Extensive Survey that will assess the focal taxa associated with rare habitat types not likely to be well sampled by the "broad-brush" Extensive Survey approach, but expected to support rare or at-risk species, using the same field methodology and targeting the same focal taxa.

Target Species Surveys will help determine the distribution of select pollinator species or species groups that require either geographical focus, specific sampling methodologies, or resurveys of historical records, such as oil bees and certain at-risk flower moths and bumble bees.

Compilation of collection data will occur throughout the life of the project and will bring together information on specimens collected in New York for the focal taxa in order to inform species' distributions and phenology and determine trends when possible.

The Role of Citizen Science

We hope for strong citizen science engagement in this project, which is what we experienced during the successful statewide odonate survey that we previously coordinated (White *et al.* 2010). We will recruit volunteers using print media, nature centers, social media, websites, and our existing volunteer network. We will hold workshops during the summers of 2018 and 2019 (and possibly 2020) in various regions of the state in order to train volunteers in our field protocol, pollinator identification, and data submission. Trained volunteers may participate in the extensive, targeted habitat, and/or targeted species surveys with specific guidance from the project team on where to survey, as well as help process specimens. Many of the pollinator species records will need to be submitted with some type of voucher for confirmation by taxonomic experts. Trained volunteers will receive guidance on whether a photograph or specimen is needed, depending on the species, as well as how to photograph identifying characters to confirm observations and how to process specimens they capture. We recognize that some participants may not want to collect and kill these insects, and we will offer instruction on how to document observations through photography. However, there are certain species groups that simply cannot be confirmed without a specimen voucher.

In addition to volunteer participation in the surveys described in our sampling design section below, we will host an online data submission platform, such as on the iNaturalist platform or a similar application, where individuals can submit observations of native pollinators. The observations submitted here will not necessarily come from trained volunteers, but may include observations from other members of the public who hear about the project. If a species can be identified by one of our experts from photos submitted to the data portal, these confirmed records will be included in the survey.

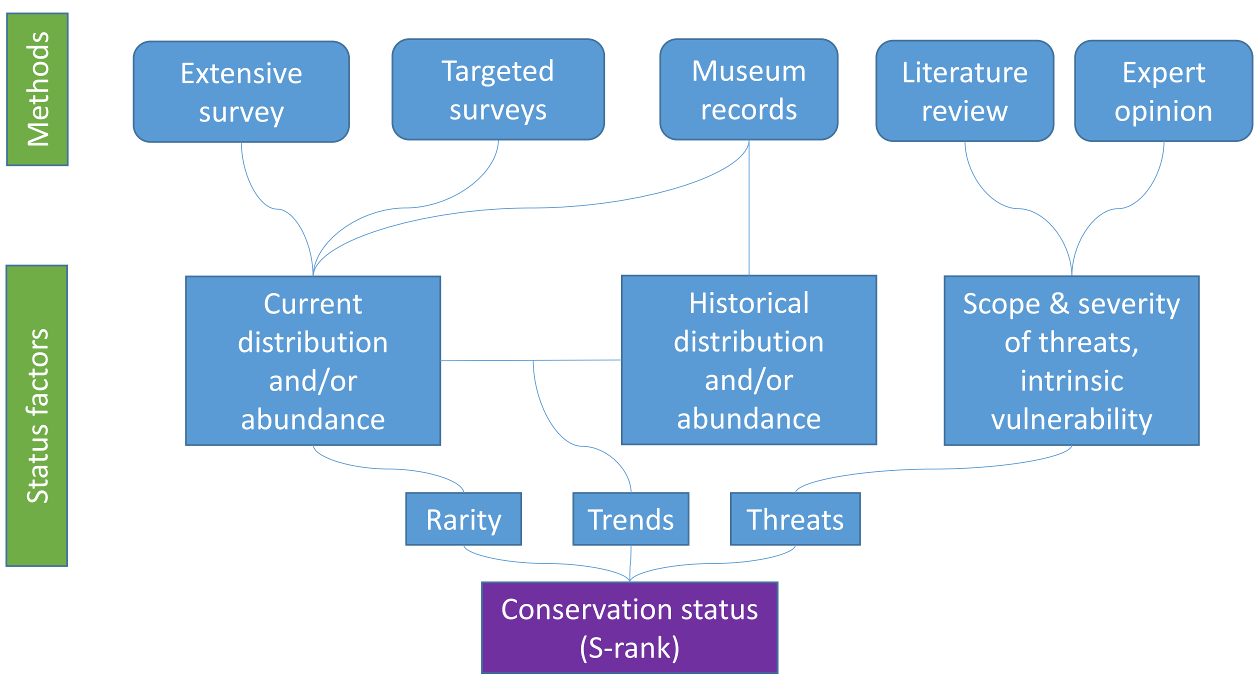

Figure 1. How methods proposed for the Empire State Native Pollinator Survey will inform the determination of species' conservation status ranks (S-ranks). After NatureServe methodology (Master *et al.* 2012, Faber-Langendoen *et al.* 2012).

Focal Taxa

Determining the conservation status of all native pollinators in one four-year project would be an untenable goal. We therefore developed a set of "focal taxa"—species or groups of species on which to concentrate our efforts. To highlight the important role a variety of native insects play in pollination, we wished to include at least one species group from each of the primary insect orders known to pollinate native plants: Hymenoptera (bees, ants, and wasps), Diptera (flies), Coleoptera (beetles), and Lepidoptera (butterflies and moths). Within these orders, we selected groups of species that 1) have been documented or are suspected to be important pollinators; 2) have poorly understood conservation status (although some knowledge of regional or global status is helpful for context, and see #3); 3) contain known or suspected at-risk species in the Northeast or elsewhere, including those that are naturally rare and those whose populations have declined or distributions have decreased; 4) are not so diverse that determining the conservation status of most of the species may be an unreachable goal; 5) may feasibly be identified to species by trained biologists, experts who may be project partners, and/or citizen scientists; and 6) may be appealing for a citizen-science effort. In addition, we identified individual species of known or suspected conservation concern for targeted surveys. Sometimes these focal species were also members of species groups selected as focal taxa, but for whom the Extensive Survey would not likely provide sufficient information. Final selection of focal taxa relied on literature review, conversations with taxonomic experts, and the input of our advisory committee.

The focal taxa have different inventory needs, and thus the primary data collection methods for them differ as well. We identified nine insect groups that lack basic distributional information that will be studied through both the Extensive Survey and Target Habitat Surveys: three groups of bees, two groups of flies, two groups of beetles, and two groups of moths (Table 1). The conservation status of most butterflies has previously been assessed (i.e., they have S-ranks) so that group was not selected for the statewide surveys. Known rare species, from any of the focal taxa, that are not expected to be detected with sufficient frequency using the extensive approaches, particularly those needing resurveys of specific locations, will be the focus of Target Species Surveys (below).

Designating specific focal taxa within the sampled groups informs which specimens will be prioritized for identification to species, as the sorting and identification of specimens represents the great majority of the time and costs involved in our project. Such prioritization is needed because sampling methods for many of the focal taxa will result in considerable "bycatch" of non-target insects. For example, we will certainly collect many non-focal species of bees and flies. We do not take the killing of large numbers of insects lightly, but we are aware that specimen collection is necessary for the identification of many species, is critical for taxonomic and other investigations (Rocha *et al.* 2014), and has been shown, in limited studies, to have negligible effects on insect populations (Pohl 2009, Gezon *et al.* 2015). Small, isolated populations of rare species that have life histories susceptible to the loss of reproducing individuals from the population may be treated differently, especially with large-scale declines in insects being reported (e.g., Vogel 2017). We will retain all bycatch and work to find partners in academia or other sectors that are interested in identifying the non-target insects and accessioning them to natural history collections.

Table 1. Focal taxa selected for the Empire State Native Pollinator Survey.

Common name	Scientific name	Survey type
Hymenoptera		
Bumble bees and long-horned bees	Apidae: *Bombus, Melissodes*	Extensive Survey
Bumble bees of known or potential conservation need	*Bombus affinis, B. terricola, B. pensylvanicus, B. fervidus, B. auricomus, B. borealis, B. ashtoni, B. insularis, B. fernaldae*	Targeted Surveys
Mining bees	Andrenidae: *Andrena, Calliopsis*	Extensive Survey
Leafcutter bees	Megachilidae: *Megachile* *Osmia*	Extensive Survey
Oil bees	*Macropis, Melitta*	Targeted Surveys
A cuckoo bee	*Epeoloides pilosula*	Targeted Surveys
Diptera		
Bee flies	Bombyliidae: *Bombylius*	Extensive Survey
Saproxylic (decaying wood) hover flies	Syrphidae: ~80 species in two subfamilies	Extensive Survey and Targeted Surveys
Eastern long-nosed fly	*Cynorhinella longinasus*	Targeted Surveys
Golden pine fly	*Callicera erratica*	Targeted Surveys
Coleoptera		
Flower longhorn beetles	Cerambycidae: Lepturinae	Extensive Survey
Hairy flower scarabs	Scarabeidae: *Trichiotinus*	Extensive Survey
Lepidoptera		
Hawk (sphinx) moths	Sphingidae: 26 species that feed as adults	Extensive Survey
Flower moths	Noctuidae: *Schinia*	Extensive Survey
Slender flower moth, golden aster flower moth	*Schinia bifascia*, *S. tuberculum*	Targeted Surveys
Monarch	*Danaus plexippus*	Targeted Surveys
Additional butterflies of known or potential conservation need	Examples in Table 7	Targeted Surveys

Extensive Survey

The goal of the Extensive Survey is to provide data on the distribution of individual species of pollinators within broad taxonomic or functional groups whose conservation status is poorly known. Multiple options exist for designing an extensive survey—for instance, in New York's most recent Breeding Bird Atlas (McGowan and Corwin 2008), citizen scientists were deployed over five years to document bird species and attempt to confirm breeding in over 5,332 "blocks" of 25 km^2 covering the state. In the New York Dragonfly and Damselfly Survey (NYDDS; White *et al.* 2010), an early example of building insect atlases, professional and citizen scientists were allowed to select their own survey sites, and effort was uncontrolled. Over 4,000 locations were surveyed over five years. Both efforts were highly successful at determining the current distributions of target taxa at the time, but the results did have certain limitations due to the sampling design. During the Breeding Bird Atlas, effort was documented as time spent per block, but citizen scientists vary widely in their skill level and dedication, so comparisons among individual blocks are challenging. In the NYDDS, site-by-site comparisons were not really possible due to the methodology.

Given sufficient resources, an ideal way to determine the distribution of a species throughout a geographic area that allows a rigorous statistical comparison across time and space is to implement a standard field protocol with consistent effort at a network of representative sampling locations. This is the approach we will take in the Extensive Survey in order to provide a solid baseline for current and future comparisons. In this section, we describe the Extensive Survey's sampling design and field methods.

Sampling Design

While a truly systematic or random sampling design may be best from a statistical perspective, we will concentrate our sampling on protected lands, including those owned by universities, land trusts, and federal, state, and local governments. We will explore sampling on private lands to supplement sampling in ecoregions not well represented by protected lands. This strategy has a number of advantages over a purely systematic or random approach: 1) These lands will typically be of higher biodiversity value to pollinators than random places in the landscape; 2) Owners and managers of protected lands are likely to be most interested in data on their pollinator fauna, and most likely to implement pollinator-friendly management; 3) They may have staff who can assist with sampling; 4) Access for sampling will be easier in most cases than contacting individual landowners; and 5) For the last two reasons, costs will be substantially lower than in a truly random design. Disadvantages include 1) Reduced ability to extrapolate to the entire state; 2) Greater likelihood of sampling in better habitats and areas already managed for pollinators, thus potentially overestimating the assessed health of the state's pollinator community.

Two facets of our sampling design serve the purpose of ensuring that we sample in many different kinds of habitats in all of New York's diverse landscapes. First, we will stratify our sampling by TNC terrestrial ecoregion (http://maps.tnc.org/gis_data.html). Ecoregions—large areas with similar geology, soils, climate, and vegetation (Bailey 1998)—are a coarse-scale reflection of habitat diversity, and ensuring that all ecoregions are represented adequately in the sampling design goes a long way toward ensuring that insects associated with a broad array of environmental conditions are sampled. Importantly, protected lands are well distributed throughout New York State in every major ecoregion (Table 2, Figure 2).

Second, at each sample site, we will sample the same three broad habitat types. Because major habitat types have distinct pollinator faunas, we will sample each of the following habitat types at every sample site: 1) Meadow/grassland; 2) Forest; and 3) Wetland. Land cover data layers such as the National Land Cover Database (Fry *et al.* 2011) and Northeast Terrestrial Habitat Map (Ferree and Anderson 2013), combined with aerial photography interpretation and field reconnaissance, will help determine specific sampling locations within sites (Figure 3). Less well distributed habitat types important for our focal taxa, which will not be well covered by the Extensive Survey, will be the focus of Target Habitat Surveys (below).

Table 2. Area of each TNC terrestrial ecoregion and percent protected from the New York Protected Areas Database.

Ecoregion	Area (km^2)	Percent of state	Area protected (km^2)	Percent protected
North Atlantic Coast	3827	3%	508	13%
Northern Appalachian / Acadian	27053	21%	12003	44%
Great Lakes	29922	24%	1273	4%
High Allegheny Plateau	35248	28%	4124	12%
Lower New England / Northern Piedmont	15362	12%	1272	8%
St. Lawrence - Champlain Valley	11514	9%	1033	9%
Western Allegheny Plateau	3010	2%	114	4%

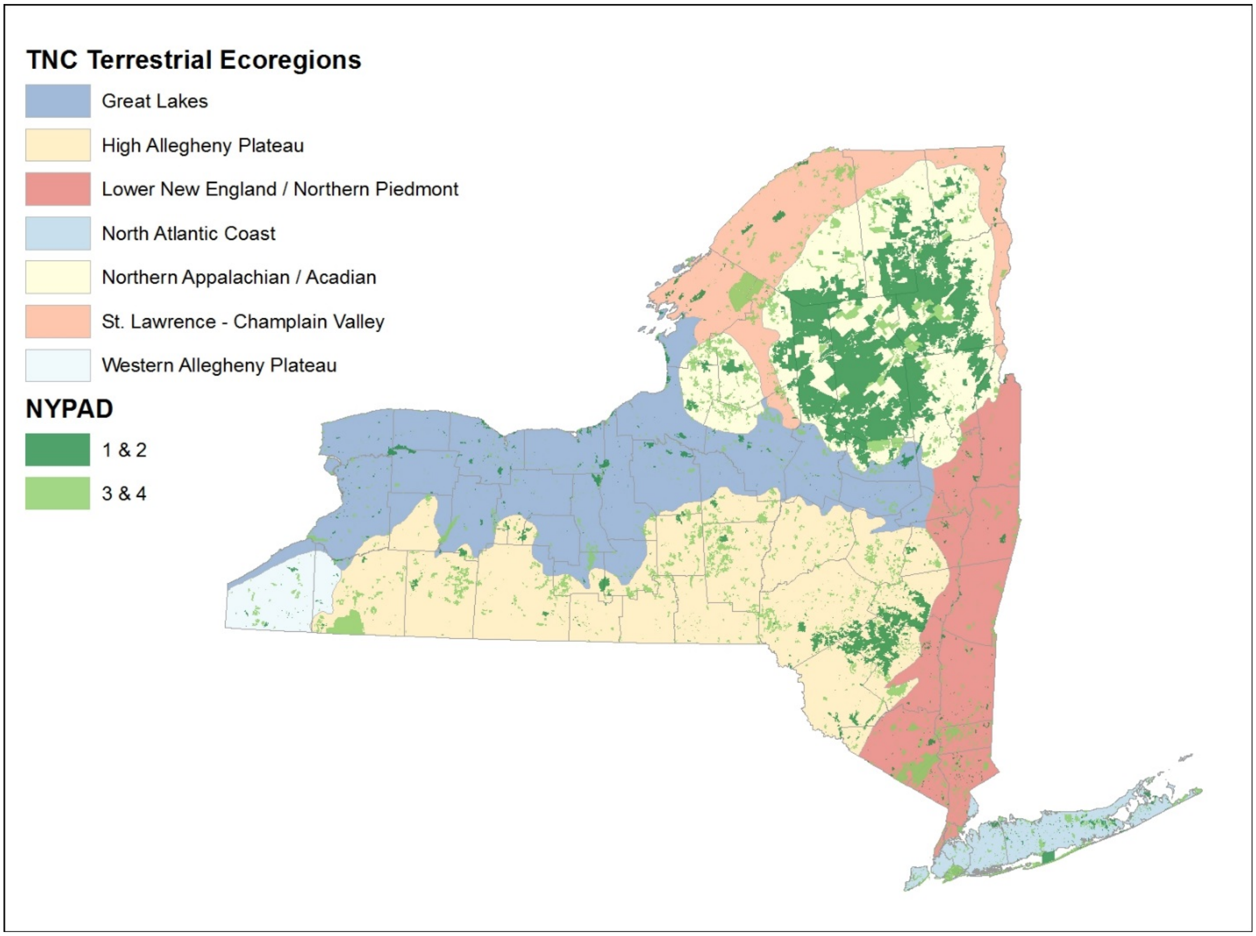

Figure 2. Protected land by GAP Status (1,2 = protected with conservation mandate; 3,4 = protected without conservation mandate) and TNC terrestrial ecoregion.

In addition to these three habitat types to be sampled at each Extensive Survey site, we will sample a roadside habitat. Roadsides are notably productive for pollinator sampling, in part because they are often kept open by mowing, creating miniature meadows, and in most cases they are easy to access without special permission.

Figure 3. Example of sample site selection and sampling locations. (Left) Grafton Lakes State Park in eastern New York, with a yellow dot marking a random sample point located within the park boundary. (Center) Land cover surrounding the sample point and within a 250-m radius; blue=wetlands; green=forests; brown=open, pink=developed. (Right) Aerial photo of same location, with red stars indicating potential sampling points in wetland, forest, open cover, and roadside.

We will use the Environmental Protection Agency's Generalized Random Tessellation Stratified (GRTS) spatially explicit sampling methodology (Stevens and Olsen 2003, 2004) to maximize the geographic spread of sample locations throughout each ecoregion. When implemented, the strategy will generate a specified number of spatially balanced random points per ecoregion within protected area polygons for the entire study, which will be subsampled each year for temporal balance. We have used this sampling methodology in selecting wetland sites for vegetation sampling (Shappell *et al.* 2016) and in generating background points for species distribution modeling (Howard and Schlesinger 2013). Selected points will hereafter be referred to as "sites." See Implementation—Distribution of Sampling Effort for more detail.

Field Methods

Two field protocols, pan trapping and a timed search (Droege 2015), will be employed at each site in each of four habitat types—meadow/grassland, forest, wetland, and roadside—during an April-October sampling window (actual sampling dates will depend on the ecoregions). In a typical day, a field crew will drive to a site, scout for the four habitats (let's call them A, B, C, and D), deploy a transect of bee bowls at each habitat, conduct timed searches at each of the habitats, and retrieve the bowls. To maximize travel efficiency and aim for equal sampling time for each bowl transect, the crew would likely deploy transects A, B, C, and D, conduct timed searches at D, C, B, and A, and then retrieve bowls from A, B, C, and D.

Final Selection of Habitats

To the degree possible, the four habitat types—grassland/meadow, forest, wetland, and roadside—will be identified in advance using land cover GIS data and aerial photography (Figure 3). However, the age of available imagery and some inaccuracy in land-cover classification means that final selection of specific locations will need to happen in the field. If all the habitat types are not available at a given site, field staff may use their judgment to place a transect in a habitat that "looks good" for pollinators. Wetland habitats will be sampled along edges to minimize turning traps into little boats. Coordinates will be noted at the start and end points of all transect locations.

Bee Bowls

Bee bowls (also called "pan traps") will be employed primarily to sample focal bees and flies. Simply put, they are pretend flowers that drown insects. We will use 3.25-oz. plastic bowls, alternating white, fluorescent blue, and fluorescent yellow, and filled with soapy water. Fifteen bowls per habitat type (60 per site) will be arrayed on the ground in a transect contained within the habitat type, with bowls spaced 3 m apart (Droege 2015), for a transect length of 42 m. Bowl transects will be deployed for at least the warmest part of the day, between 10 a.m. and 3 p.m. Captured specimens will be transferred to Whirl-Pak bags containing 70% ethanol.

Timed Search

A timed search will be conducted in each of the four habitats at each sample site. In a timed search, observers will spend 30 minutes walking throughout the sampling location, targeting flowering plants and looking for bees, flies, moths, and beetles. Aerial insect nets will be used to capture insects from the air and from flowers. The difficulty in identifying insects on the fly (so to speak) will lead to many non-focal taxa being collected. Non-focal taxa will be retained and collaborations with others interested in identifying and accessioning them to museums will be pursued.

Blacklighting and Nocturnal Search

A nocturnal protocol will be implemented to detect species much less likely to be encountered diurnally, primarily focal moths, although some focal beetles are also expected at lights. A two-person crew will visit a representative subset of selected sites and set up blacklights and sheets in the two of the target habitats (excluding roadsides). Starting at dusk, blacklights will be switched on and a timed nocturnal search will be conducted in between checks of the blacklight stations. Focal moths and beetles will be collected from sheets or photographed in place. Blacklight stations will run for 4-6 hours.

Target Habitat Surveys

Target Habitat Surveys will employ the same field protocols as the statewide Extensive Survey, but with up to four transects and timed searches at each site of the target habitat type. Target habitats are those expected to contain unique species whose distribution (and therefore, conservation status) will not be adequately documented using the Extensive Survey sample design:

- Alpine
- Barrens
- Coastal dunes
- Peatlands
- Late-successional forests

Maps of the best examples of these habitat types in New York will be generated from two primary sources: our element occurrence database (New York Natural Heritage Program 2017), which includes mapped occurrences of significant natural communities as defined by our state classification (Edinger *et al.* 2014), the Northeast Terrestrial Habitat Map (NETHM; Ferree and Anderson 2013), and the classification prepared for the New York State Wildlife Action Plan (Howard *et al.* 2015). Sample sites will be selected using the GRTS methodology, possibly stratified by ecoregion for the widespread habitats, and the field protocol will be conducted within a 250 m radius of the selected points. In late-successional forests, the focus will be on the saproxylic hoverflies in lieu of the full suite of focal taxa, owing to their dependence on dead and decaying wood.

Alpine

The open alpine community of the Adirondack High Peaks (Figure 4) is expected to contain a unique pollinator fauna that will not be well sampled in the Extensive Survey. The community is mapped in 20 occurrences ranging from 0.49 ac to 62.8 ac, totaling 235 ac (New York Natural Heritage Program 2017). This is a more complete and fine-scale representation of this community than is available in the NETHM (Ferree and Anderson 2013).

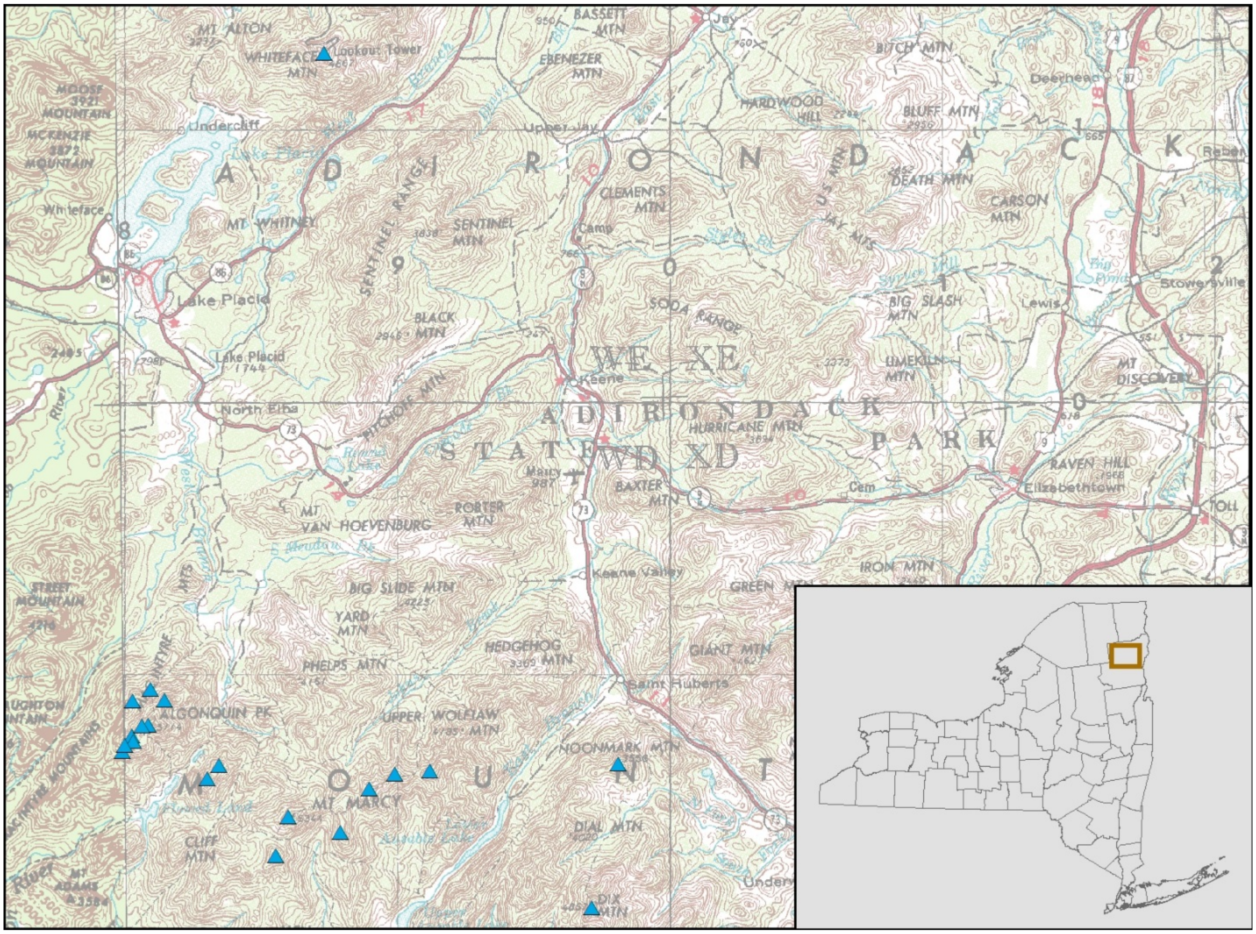

Figure 4. Open alpine communities (blue triangles) in the Adirondack High Peaks.

Barrens

Barrens are unvegetated or sparsely vegetated communities with large areas of bare rock or sand. They are grouped in the state classification (Edinger *et al.* 2014) with woodlands, which are sparsely treed communities but that may still have unvegetated openings. We included 12 natural community types comprising 63 patches ranging from 3 ac to 4935 ac (New York Natural Heritage Program 2017), totaling 27,782 ac (Figure 5). Our element occurrence database includes the best representation of barrens in the majority of the state, but underrepresents the entirety of coastal barrens as mapped in the NETHM.

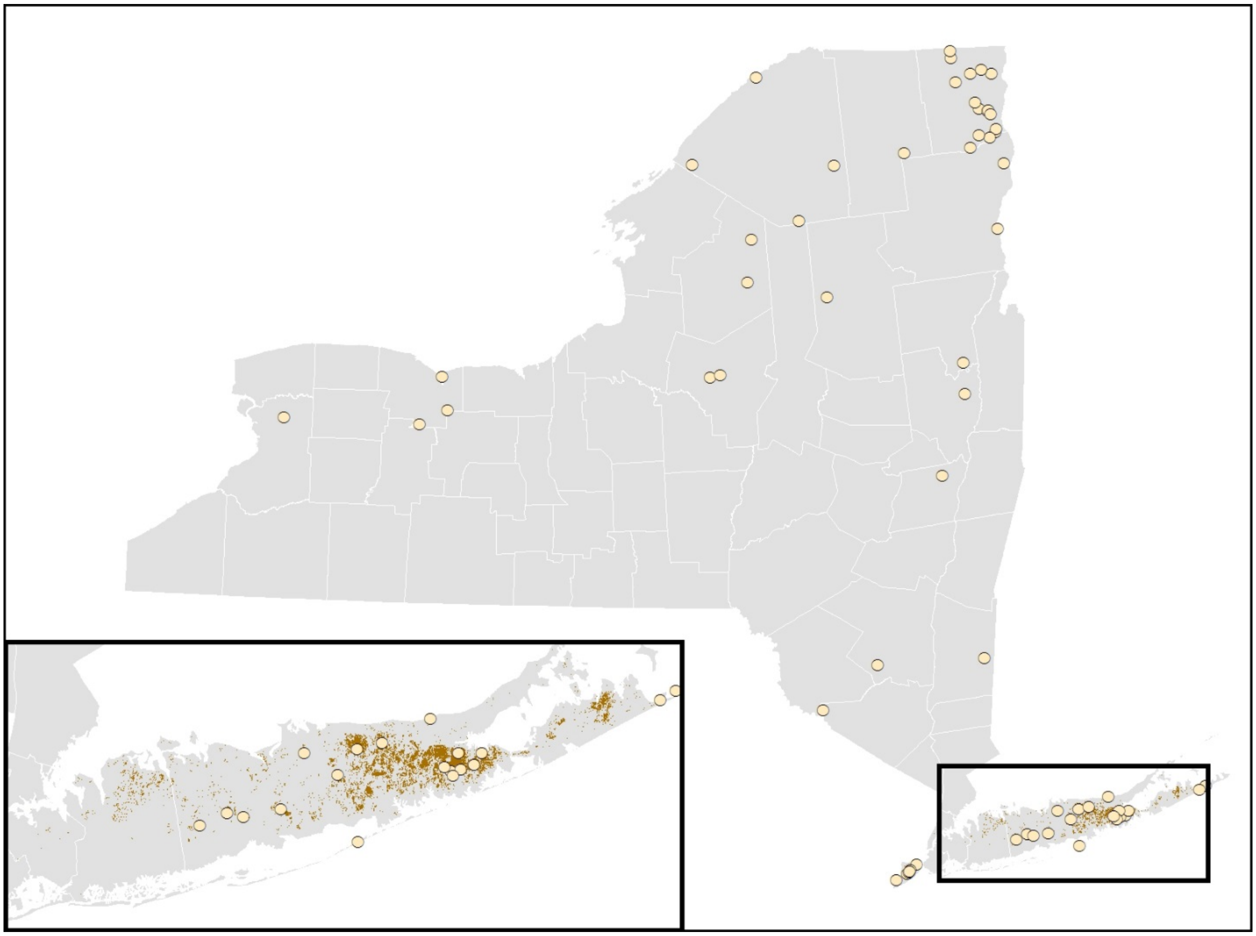

Figure 5. Barrens communities from the NYNHP element occurrence database (sand-colored circles) and coastal barrens grid cells from the Northeast Terrestrial Habitat Map (brown).

Dunes

Coastal dunes in New York include the Great Lakes dunes bordering Lake Ontario (Figure 6) and the maritime dunes bordering Long Island Sound and Atlantic Ocean (Figure 7). Great Lakes dunes are mapped in nine patches ranging from 5 to 253 ac, totaling 797 ac. Maritime dunes are mapped in 10 patches ranging from 11.32 ac to 905 ac, totaling 2175 ac.

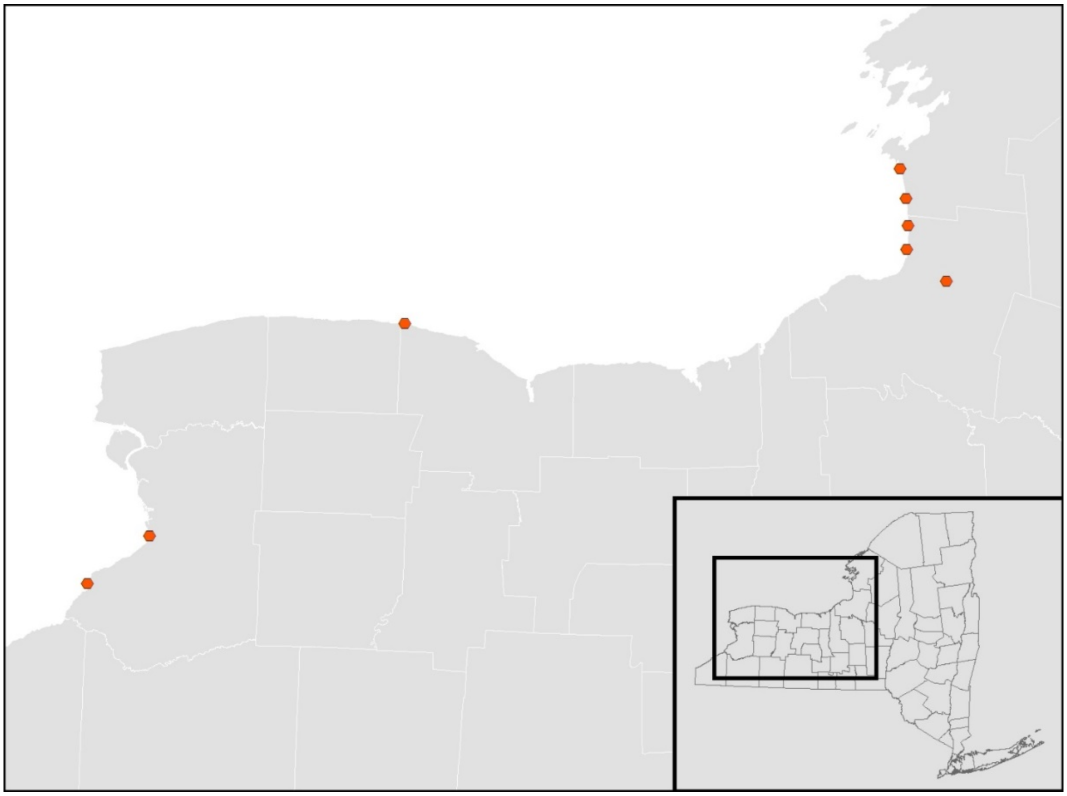

Figure 6. Lake Ontario dunes, including early post-glacial dunes east of the lake, as red hexagons. Locations from the NYNHP database.

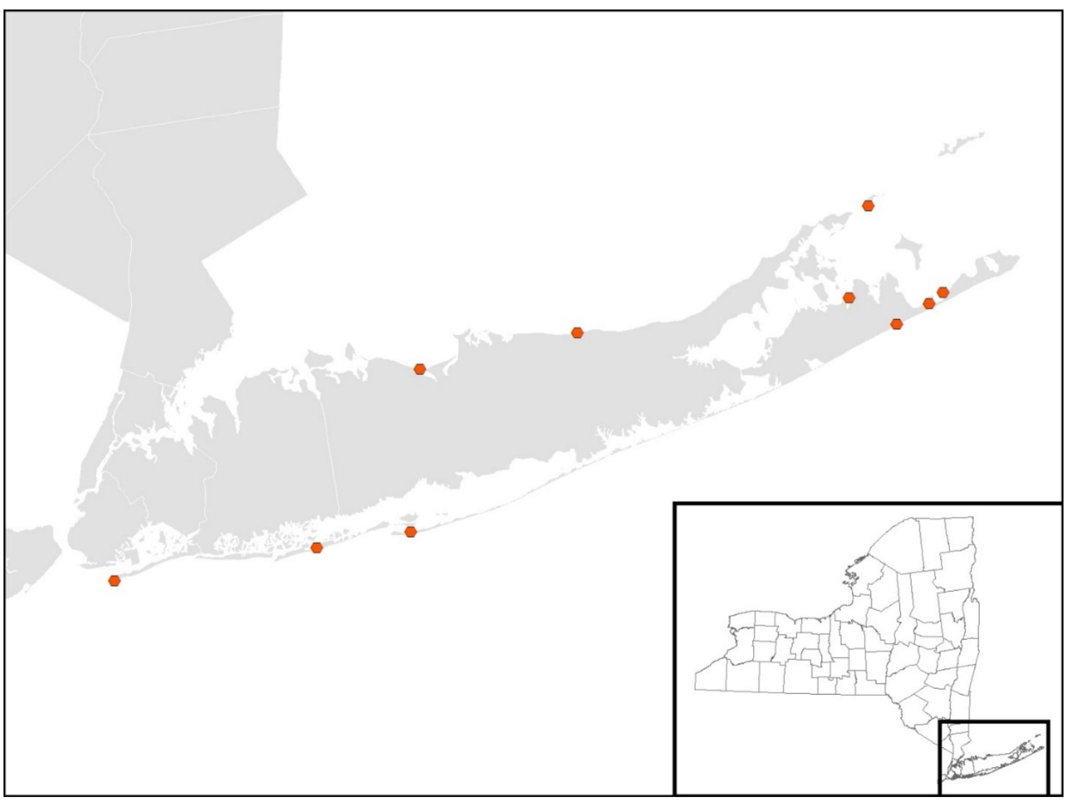

Figure 7. Long Island dunes as red hexagons. From the NYNHP database.

Open Peatlands

Open peatlands are all over New York State, and in consultation with our advisory committee and NYNHP ecologists, we will focus on seven natural community types: Black spruce-tamarack bog, Dwarf shrub bog, Highbush blueberry bog thicket, Inland poor fen, Medium fen, Patterned peatland, and Perched bog. These peatlands are mapped in 215 patches (Figure 8) ranging from 0.2 to 5848 ac, totaling 17,397 ac statewide. Additional leads for "open acidic peatlands" are available from the NETHM.

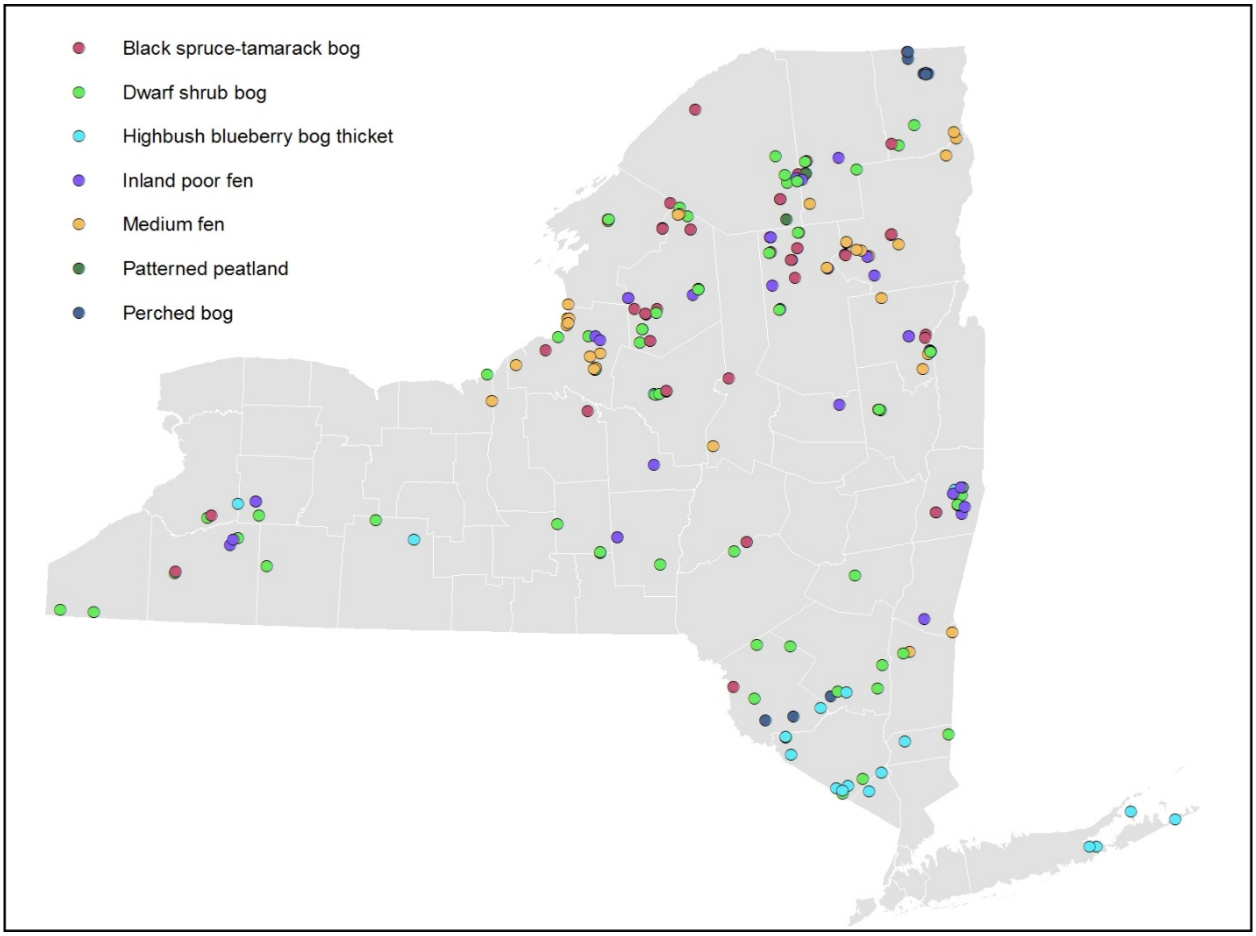

Figure 8. Open peatlands from the NYNHP significant natural community layer.

Late-successional Forests

Late-successional ("old growth") forests are centered primarily in three regions—Allegany, Adirondacks, and Catskills—but smaller, more isolated examples are scattered around the state. No comprehensive map of late-successional forests exists for New York. Our element occurrence database (New York Natural Heritage Program 2017) contains approximately 50 old growth occurrences ranging from 10-70,000 acres in many different forest community types, including Maple-basswood rich mesic forest, Hemlock-northern hardwood forest, Spruce-fir swamp, Floodplain forest, Spruce flats, Mountain spruce-fir forest, Maritime holly forest, Limestone woodland, Northern white cedar swamp, Coastal oak-laurel forest, Oak-tulip tree forest, Pine-northern hardwood forest, Balsam flats, Beech-maple mesic forest, and Hemlock-hardwood swamp

(Figure 9). These total at least 166,350 acres, with about one-third in Hemlock-northern hardwood stands. In addition, our files and other resources (e.g., McMartin 1994, McGee *et al.* 1999, Kudish 2000, Davis 2003, Kershner and Leverett 2004) contain leads for at least this much more acreage at many additional locations around the state. We will continue to add these sites to the database as they become mapped and ground-truthed.

In addition to the standard bee bowl/timed search protocol we will explore obtaining the larval and puparial stages of saproxylic hoverflies using minimally destructive searches performed in accessible tree holes, sap runs, cavities, and rot holes. Live larvae can be stored in a small amount of detritus for short periods, and later identified to species level and/or reared in small terraria, while hand-captured adults can be kept in vials and frozen for later identification. Each two-person crew could adequately sample one or two (if close together) old growth stands in a field day.

Because so little is known of this functional group in New York we will almost certainly pick up new species not listed in Table 6. For example two recent small-scale cursory studies in Atlantic Canada (Klymko and Robinson 2012, Klymko 2015) detected 20 hoverflies new to the Maritimes in addition to many new provincial records. The great majority of these were collected using Malaise traps, which are known to yield copious amounts of Diptera. Therefore, we will target for enhanced saproxylic hoverfly sampling the three general concentrations of late-successional forest (Catskills, Adirondacks, Allegany) which are coincidentally located near state boundaries where new arrivals to New York or rare species on the edges of their ranges might be expected. We will seek out willing cooperators at one old growth forest site in each of the three sample years within the three general regions to run paired Malaise traps in selected stands. On-site staff (and/or trained local volunteers) will be responsible for maintaining and servicing the traps. The paired traps will be erected along an ecotone adjacent to the stand, or within a forest gap having good nectar and pollen-producing plants and will be emptied regularly. Traps will be left open for two ≥10-day periods timed to coincide with peak insect activity periods and controlled for phenology: one in early spring and one in midsummer. On-site handling will be minimized because the specimens can be stored in alcohol within collecting jars. These can be sent to us for initial sorting, then to specialists for final species determinations of any difficult focal taxa.

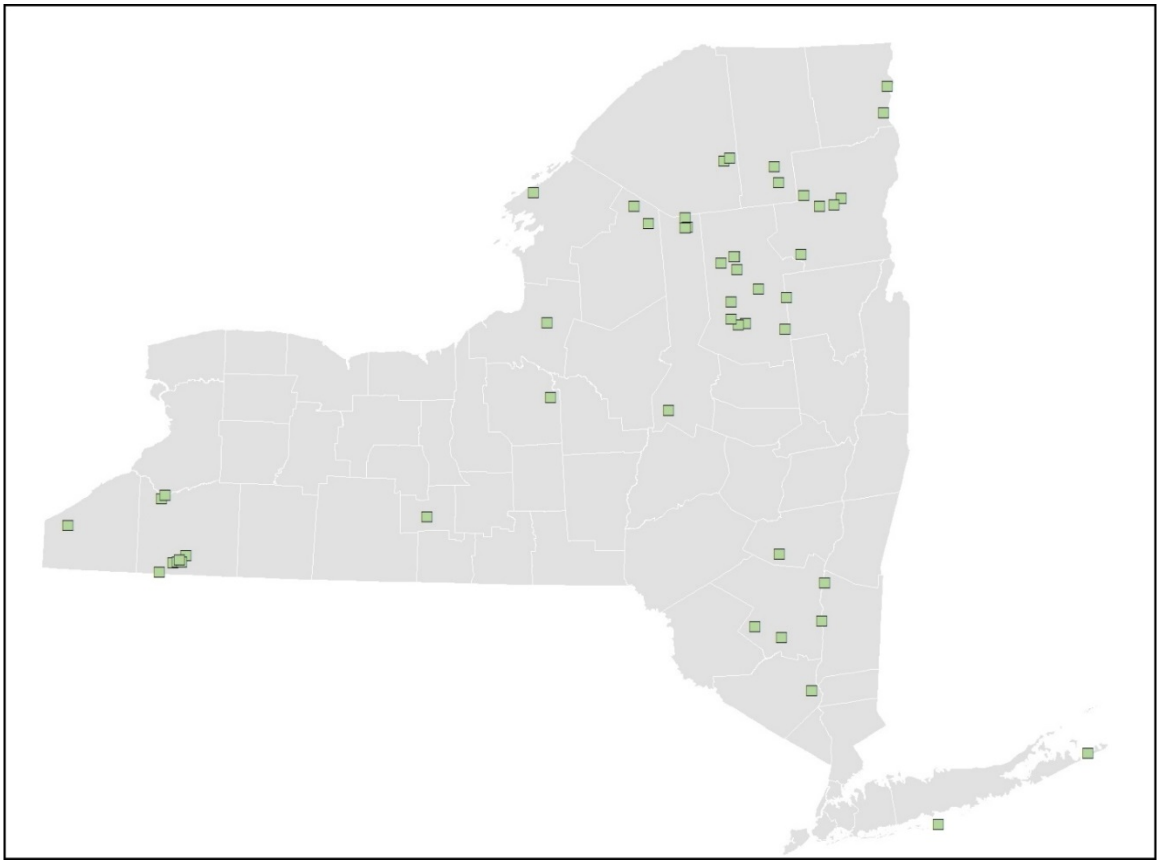

Figure 9. Late-successional ("old growth") forests from the NYNHP significant natural community layer.

Target Species Surveys

We identified several at-risk species and taxonomic groups (Table 1) that we expect would not be captured well by the Extensive Survey and Target Habitat Surveys. In this section we outline a plan for these survey efforts.

Apidae: *Bombus* spp.

While the Extensive Survey will provide a statewide effort of netting in appropriate habitats for many bumble bees (*Bombus* spp.), additional survey effort for SH and S1 species is warranted. Appropriate meadow and roadside habitats with nectaring plants in or near previously documented sites (although some locations are vague) will be surveyed for the following SH species: Rusty-patched Bumble Bee (*B. affinis*), Ashton Cuckoo Bumble Bee (*B. ashtoni/bohemicus*), Indiscriminate Cuckoo Bumble Bee (*B. insularis*), Fernald Cuckoo Bumble Bee (*B. fernaldae/flavidus*), and the following S1 species: Yellow-banded Bumble Bee (*B. terricola*), American Bumble Bee (*B. pensylvanicus*), Yellow Bumble Bee (*B. fervidus*), Black and Gold Bumble Bee (*B. auricomus*), and Northern Amber Bumble Bee (*B. borealis*). We will survey 10 or more previously known locations for each target species. Specimens captured via hand-netting may be collected for later identification.

Taxonomic note: *Bombus ashtoni* has been included in *B. bohemicus* in Williams *et al.* (2014) based on morphology and DNA barcodes supporting that these are the same species. Some bumble bee taxonomists keep *B. ashtoni* as a separate species currently. The same is true for *B. fernaldae*, which is combined with *B. flavidus* in Williams *et al* (2014).

Melittidae: *Macropis, Melitta* and Apidae: *Epeoloides pilosula*

Melitta americana specialize on pollen from blueberry and cranberry (Wilson and Carril 2015) and are known from just a single location in central NY. We will survey near this location as well as other areas in appropriate habitat within the distributional range for the species, which appears to be central and eastern NY. *Melitta eikworti* has also been documented from at least 3 locations in central NY and surveys for this species will focus on areas with deerberry (*Vaccinium stamineum*).

The oil bees *Macropis ciliata, M. nuda,* and *M. patellata* specialize in collecting oil from native loosestrife (*Lysimachia*). Previously known sites with records from 1980 to 2010 will be surveyed for these species and any historical locations (pre-1980) will be surveyed where possible (pending finding an appropriate habitat within an area with vague locality information and logistic feasibility). *Epeoloides pilosula* is an extremely rare cleptoparasite not known from the state since 1942 until it was recently documented at the Hyuck Preserve in 2014. We will extend our search to other areas where *Macropis nuda*, a host species, is known from as well as additional sites with native *Lysimachia* to look for both the host and cleptoparasite.

For these rare NY groups, we will use a combination of bowl traps and hand-netting and specimens will be retained for later identification.

Cynorhinella longinasus

Very little is known of the natural history of this northeastern endemic hoverfly, including its habitat preferences. However, it most likely inhabits some variant of northern hardwoods, flying in early to mid-spring. It is very difficult to detect with any survey methods so we intend to reach out to a BugGuide.net contributor in Ballston Spa, NY who posted photos of the only known New York record on the website in 2010. We hope to visit the locale with permission to assess habitat conditions, and search for the fly at flowers using hand nets in early Spring.

Callicera erratica

This syrphid species is extremely rare and local most likely to be discovered in late-successional old growth pine stands in southern New York. The arboreal adults fly from April to mid-June, feeding especially on *Rannunculus* (buttercups). Larvae live in water-filled rotholes and cavities of old living conifers. It could turn up in any of our targeted old growth surveys in southern NY, but might require extra effort using canopy malaise traps, emergence traps and/or larval searches earlier in the season.

Schinia bifascia

This moth species is known in New York from a single record on the privately owned Robins Island in 1997 (New York Natural Heritage Program 2017). If we can obtain access to the island, we will survey there using netting and blacklighting in August.

Schinia tuberculum

This species, the Golden Aster Flower Moth, is currently known from a single New York location, in the Dwarf Pine Barrens on Long Island, with historical records in Ithaca, Riverhead, Montauk, and Coram (NYS DEC 2015, New York Natural Heritage Program 2017). The Dwarf Pine Barrens occurrence was last documented in 1999. We will survey that occurrence with netting and perhaps blacklighting in September. The historical records have vague localities, so the remainder of special efforts for *S. tuberculum* will be added on to the pine barrens target habitat surveys.

Butterflies of known or potential conservation need

Historical and otherwise old records for several rare butterflies will be targeted for field surveys. The final list will be determined with the NYS DEC and the project advisory committee, but may include Regal Fritillary (*Speyeria idalia*), Arogos Skipper (*Atrytone arogos*), Appalachian/Southern Grizzled Skipper (*Pyrgus wyandot*), Persius Duskywing (*Erynnis persius persius*), Mottled Duskywing (*Erynnis martialis*), Frosted Elfin (*Callophrys irus*), and Olympia Marble (*Euchloe olympia*). In addition, identifying important migratory stopover locations for Monarch (*Danaus plexippus*) was identified as a key action in the SWAP (NYS DEC 2015) to help managers with habitat restoration. We will compile any existing data on Monarch stopovers in New York and possibly supplement that information with field work to better delineate stopovers used. Citizen scientists and local butterfly clubs may be very helpful with these surveys.

Additional Observations

Trained project participants and untrained members of the public will be able to submit observations of focal native pollinators that are made outside of our extensive surveys, targeted habitat, and targeted species surveys. Citizen science data of this sort have been successfully incorporated into other atlas-style projects (Ullmann *et al.* 2010, McFarland *et al.* 2015, Roy *et al.* 2016) and with the plight of pollinators making news worldwide, we expect tremendous interest. These data will supplement our planned survey work. Examples of such data may include road-killed specimens or pollinators photographed while a participant is not actively surveying for the project, but doing another activity (such as gardening or hiking). This could also be a way for members of the public who are not trained participants to get involved in the project through submission of their observation records. Only trained participants (through our 2018 and 2019 workshops) may conduct full surveys following our extensive or targeted survey protocols.

Additional observations will be collected in an online data submission platform such as iNaturalist or a similar application. We will develop a project page in this online platform prior to the 2018 field season where volunteers will submit their field observations and photographic vouchers. As previously noted, there may be certain species that simply cannot be confirmed without a specimen voucher. In these cases, a specimen may be mailed to us. If a specimen is not able to be collected, we may not be able to confirm the record submitted, but the observation could serve as a lead for follow-up field work. We also recognize that while some species can be confirmed by one of our project experts with a photo voucher, the photo may need to clearly show certain morphological characters for an expert to be able to identify it to species level. Project participants will be trained to take proper images, but we recognize this may not always be possible. We intend to post guidelines for photographing pollinators within the data portal or have a link to this information. We will also work with the project advisory committee to develop required data fields for the online data submission, which will likely include observer name and contact information (generally required through a login for online submission in most platforms), date, location coordinates, location description, and habitat information. In addition, we will develop a handbook for (trained) participants that will include the survey protocols contained in this document, data collection procedure, and instructions for taking photos and processing photo and specimen vouchers. We have successfully implemented a similar strategy for a statewide odonate atlas in the past (White *et al.* 2010).

Compiling collection data and analyzing distributional change

Museum and private collection data are the primary source of historical distributional data, which are important for detecting long-term change (Figure 1) and have been used in a variety of studies for similar purposes (e.g., Bartomeus *et al.* 2013). New York's bees have been catalogued previously (Bartomeus *et al.* 2013) but not completely (B. Danforth, personal communication), and hawk moths have been catalogued from several museums for a portion of the state (B. Young, unpublished data). At a minimum, for the beetles and flies we expect to visit and database specimens from the NYS Museum, Albany (completed winter '17), Cornell University Insect Collection, and the American Museum of Natural History. We also received a large dataset on hoverflies from the Canadian National Collection, widely regarded as the world's premier collection of North American Syrphidae. Other potential museums that might house good collections include the Smithsonian, Carnegie Museum, Buffalo Museum of Science, and Museum of Comparative Zoology at Harvard. With some collections, and certain taxa, we might need experts to confirm identifications. We think it is important to be as thorough as possible with this stage of the project, but recognize that we can't account for every NYS specimen in every Museum where one might be housed. Thus, we will implement a statistical approach similar to rarefaction where we can determine when a given level of databasing effort is not adding any new additional taxa (or county records) to the checklist. Further, we will focus on the rarest species to maximize the efficiency of museum work.

To calculate change over time we will likely follow an approach (Telfer *et al.* 2002) that we have used successfully in the past (White *et al.* 2015) to account for uneven survey effort between the historical era (museum records) and the data collected from our sampling strategy as outlined below. Because we lack information on species-specific population trends, we will create a surrogate metric for trend by calculating an index of the relative change in range size (Telfer *et al.* 2002) for each species based on the proportion of counties ($n = 62$) occupied historically (the museum data) compared to the proportion occupied during our project. This method uses the standardized residuals from a logit regression as a relative measure to assess the change in range size of a species in a defined area over the two periods. The standardized residual is an index of that species' change in range size relative to the trend in the entire species group rather than an absolute increase or decrease. Bias can arise from undue concentration on certain species or groups in the historical records and the biases in biological atlas data, including an increase in survey effort over time, are widely understood. Our method will minimize (but not eliminate) such biases.

We intend to mine online repositories of citizen science and other compiled data like BISON, iNaturalist, Bumble Bee Watch, Butterflies and Moths of North America, e-Butterfly, Moth Photographers Group, and BugGuide for additional confirmed species records.

Project Implementation

Personnel

We envision four teams of two field biologists being deployed each of three years to conduct most of the sampling. Field crews will consist of current NYNHP staff; hired interns, field technicians, and students; and/or citizen scientist volunteers. Any trained volunteers participating in the extensive surveys will be vetted by project leaders and advisors to ensure consistency with aerial netting techniques during the timed search portion of the protocol. Because the GRTS protocol calls for sampling sites in the order in which they are selected (to ensure that even subsets of the sites are spatially balanced), and because we do not wish to sample only one part of the state in a given time of year, these four crews will be geographically focused. Crews will be responsible for sampling in one of four broad geographic zones: 1) Long Island and the Lower Hudson Valley; 2) the Catskills and the Upper Hudson; 3) the Adirondacks, St. Lawrence Valley, and Eastern Lake Ontario; and 4) central and western New York. Exact zones would depend on the eventual distribution of sample sites.

We will have one two-person crew start in early spring and survey until early fall. The remaining three crews will start in mid-May and end at the end of August. Having at least one crew sampling in the early spring will allow early-season species to be detected, and that crew will sample statewide until the other crews start. To determine the best way to allocate sampling effort across Extensive Survey and Targeted Habitat Survey sites, we calculated the available field days based on these four crews working 5-day weeks with 70% of days having weather conducive to sampling (54 sampling days each for the 3.5-month crews, 91 days for the 6-month crew). The remainder of crew days will be spent processing and pinning specimens.

Distribution of Sampling Effort

With four crews over three years, we estimate just over 700 sites can be sampled, with one site per day sampled by a crew. We aimed for the Extensive Survey to use about 75% of the sampling effort (562 sites) and Target Habitat Surveys to use about 20% (150 sites), with the remaining field days reserved for special efforts like Target Species Surveys. Most Target Species Surveys will be conducted by NYNHP staff separately from the hired field crews.

For the Extensive Survey, sampling effort will be allocated among ecoregions based on a desired minimum sampling effort and loosely proportional to the area of the ecoregion. The full set of sample sites will be developed at the beginning of the project and approximately one-third sampled each year. No site is sampled more than once—thus, the Extensive Survey will not represent the full diversity of any particular place (see Options for Intensification, below). Among many possible ways of allocating sampling effort to the seven ecoregions, effort can be distributed evenly (same number of sampling locations per ecoregion) or in proportion to the ecoregion's area (larger ecoregions get sampled more). A balance between these two approaches should ensure that smaller ecoregions (North Atlantic Coast, Western Allegheny Plateau) are adequately sampled but that their faunas are not overrepresented in status assessments compared to those of larger ecoregions (High Allegheny Plateau, Great Lakes). In Table 3, we average the results of area-based and even-distribution methods to arrive at a target number of Extensive Survey sites per ecoregion.

Table 3. Distribution of sampling effort by ecoregion for the Extensive Survey. Results of a method based on the area of the ecoregion are averaged with results based on even distribution of sampling across ecoregions to yield a compromise between ensuring smaller ecoregions are adequately sampled and ecoregions are sampled roughly in proportion to their area. A total of 562 sampling days was used as the basis for the estimates. Numbers of sites are rounded down to be conservative with sampling effort.

Ecoregion	Area (km^2)	Percent of state	Area-based number of sites	Evenly distributed number of sites	Average of two approaches
Great Lakes	29922	24%	134	80	107
High Allegheny Plateau	35248	28%	157	80	118
Lower New England / N. Piedmont	15362	12%	69	80	74
North Atlantic Coast	3827	3%	17	80	48
Northern Appalachian / Acadian	27053	21%	121	80	100
St. Lawrence - Champlain Valley	11514	9%	51	80	65
Western Allegheny Plateau	3010	2%	13	80	46

For the Target Habitat Surveys, sampling effort will be allocated in a similar manner, with the allocation of effort across habitats based loosely on both the statewide area and importance of the habitat (Table 4).

Table 4. Distribution of sampling effort for the Target Habitat Surveys. Area estimates are based on known occurrences only and are far from a complete accounting. Results based on the approximate area within the state, and the habitat's importance to our survey, are averaged with results based on even distribution of sampling across target habitat types to yield a compromise. A total of 150 sampling days was used as the basis for the estimates. Numbers of sites are rounded down to be conservative with sampling effort.

Target habitat	Area (km^2)	Area/ importance allocation	Area-based number of sites	Evenly distributed number of sites	Average
Alpine	0.95	10%	15	30	22
Barrens	112.43	25%	37	30	33
Dunes	8.80	10%	15	30	22
Open peatlands	70.40	25%	37	30	33
Late-successional forests	673.20	30%	45	30	37

Specimen processing, identification, and storage

All specimens will be brought to the NYNHP lab space in Troy, NY. Specimens from bee bowls will be retained in 70% ethanol until they are washed and dried, using either a jar with a screen cap and a hair dryer (Droege 2015) or washing machine and clothes dryer (Droege, personal communication), and then pinned. Hand-captured specimens will be pinned immediately or kept frozen until being pinned (for instance, on days of poor weather). Pinned and sorted insects will be shared with project collaborators for identification or identified by NYNHP, who will also database all collected and identified insects. Identified insects will be accessioned to natural history collections, while unidentified or unwanted specimens will be stored in the NYNHP lab.

Adaptability

We hope to maintain engagement with our advisory committee throughout the project through an annual meeting and review of survey results. At these meetings, and in less formal consultations with the Committee throughout the project, we will determine whether the study plan is meeting the needs of the project or whether alterations might be necessary. Based on input from the Committee we may decide to allocate field effort differently in out-years of the project. For example, a discovery of a previously unknown rare species (e.g., one that is new to New York) may lead to a new target species survey. Or if peatland surveys are not generating species lists that are much different from those in the wetland portion of the Extensive Survey, we might drop that effort in subsequent years. Our goal is to manage an adaptable survey effort whose methodology and even focus may change depending on the early results.

Budget

Our budget (in development for NYS DEC) includes NYNHP administration of the project, staff time, field crews, travel, supplies, and contracts with taxonomic experts.

Timeline

We are planning a three-year field effort from 2018-2020 (Table 5). We will build on the preliminary field effort we are conducting in 2017 to test field protocols and start developing a work flow for specimen processing.

Table 5. Timeline for the Empire State Native Pollinator Survey.

	2017, Fall	2018, Winter	2018, Spring	2018, Summer	2018, Fall	2019, Winter	2019, Spring	2019, Summer	2019, Fall	2020, Winter	2020, Spring	2020, Summer	2020, Fall	2021, Winter	2021, Spring	2021, Summer	2021, Fall
Develop citizen sci. protocol																	
Citizen sci. trainings											?						
Collection data compilations																	
Finalize field plan, hiring																	
Field surveys																	
Specimen identification																	
Advisory Comm. mtgs																	
Data analysis, papers, report																	

Options for Intensification

The survey outlined here is intended to yield information relevant to conservation and management for New York State as a whole—that is, the information generated will be relevant to statewide needs like the next iteration of the State Wildlife Action Plan, the state list of Threatened and Endangered species, and NYNHP databases. Because sampling effort is spread throughout the state and sample sites will be visited just once, the statewide study will not yield complete site-specific species lists. However, we can recommend some options for an *intensive* survey of the native pollinators of a park, preserve, state forest, or municipality that will provide information for conservation and management at the local level in the context of the statewide study.

Goals for an intensive survey might differ from those of the statewide effort. For example, managers may be interested in a species list for a park, or the relative abundances of various species, or a comparison of the pollinator fauna among sites within an area or across areas. Further, managers may wish to learn about additional species groups, or fewer. With no space, time, or brainpower to address every possible information need, we will focus below on the generation of a species list for a managed area like a State Park, with the same focal taxa used in the statewide survey.

The simplest approach to generating a species list for a park would be to conduct the Extensive Survey protocol—bee bowls and timed searches—at additional points within the area of interest. This approach would yield the most comparable data to the statewide study and would be the easiest to implement. Points could be chosen using the same spatially balanced, randomized design we are using for the Extensive Survey, with additional points placed in known unusual habitats if necessary, or in some cases could be less random, with local knowledge of habitats informing the selection of sampling locations expected to be especially productive. The key would be that all the major habitat types of the park be represented. Whereas in the Extensive Survey design, points are visited just once, in a park it might make sense to visit fewer points more often, as frequently as every two weeks from mid-April into October. Such sampling throughout the season will yield a more complete species list, with more chance of observing species with varying phenology. The size of the park would dictate whether it makes sense to deploy the statewide approach in miniature or have fewer points that could serve as long-term monitoring stations.

Additional field methods could be employed as desired and funding permitted in these smaller jurisdictions. For example, Malaise traps are known to be highly productive for sampling many of the focal bees and flies, but we determined that they were logistically too challenging and expensive to deploy to determine statewide distributions. To generate a species list for a single place, however, a few Malaise traps might be an ideal supplement to bee bowls and timed searches.

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Appendix: Notes on Focal Taxa

Table 6. Focal taxa for Extensive Survey and Target Habitat Surveys, with notes on the criteria justifying their inclusion.

Species group	Taxonomy	Pollination notes	NY diversity (species)	Conservation status knowledge	Identification	Field methods	Citizen science potential
Bumble bees	Hymenoptera: Apidae: *Bombus* spp., *Melissodes*	Significant portion of native pollinator community (Schweitzer *et al.* 2012)	18	4 SH, 5-9 are rare or in decline) ; G-ranks completed	easier than other bee groups, guides, photography enough sometimes	Hand netting/ capturing in cups, vials, or jars, roadside counts	Sampling, photography, and some identification
Mining bees	Hymenoptera: Andrenidae: *Andrena, Calliopsis*	Generalists and specialists to wildflowers, trees, and some commercial shrub crops	86	18-19 rare or in decline; G-ranks not completed for most species	Relatively easy to genus, highly diverse genus	Pan traps and hand netting at host plants	Sampling but not identification
Leafcutter bees	Hymenoptera: Megachilidae: *Megachile* *Osmia*	Efficient pollinators in some ecosystems, poorly known in others (Young *et al.* 2016); highly managed in the US (Wilson and Carril 2015)	40-43	8-11 spp. in decline (Bartomeus *et al.* 2013); G-ranks completed	Difficult to species, requires assistance of a specialist for species level ID	Pan traps, trap-nests, netting, standardized transect counts; *Osmia* females only lay 30 eggs in life-special collecting consideration?	Sampling but not identification
Bee flies	Diptera: Bombyliidae: *Bombylius*	Besides syrphids within flies, this genera seems to be of greatest significance; can display a high degree of flower-	8	Very little known; certain Ontario species have been categorized as: not recorded, rare,	Conspicuous; taxonomy relatively well resolved and very stable in	Hand netting, Malaise traps, pan traps	Charismatic; Sampling, photography, and some identification

Species group	Taxonomy	Pollination notes	NY diversity (species)	Conservation status knowledge	Identification	Field methods	Citizen science potential
		constancy; common flower visitors/pollen consumers of many boreal forest herbs and spring wildflowers		widespread; 5/8 species appear to have restricted distributions in NYS and few historical records; Maritime Provinces S ranks (either SU or S4,S5)	NE US; recent key available for species of eastern Canada (Kits *et al.* 2008)		
Saproxylic Hover (flower) flies	Diptera: Syrphidae; Syrphinae; Syrphini: *Doros* *Xanthogramma* Eristalinae; Merodontini: *Psilota* Rhingiini: *Ferdinandea* Vollucellini: *Brachyopa, Myolepta, Sphegina,* Callicerini: *Callicera* Ceriodini: *Sphiximorpha* Milesiini: *Xylota, Brachypalpus, Chalcosyrphus,*	Behind bees this is the second-most important group; both males and females require pollen for maturation of reproductive organs and nectar to power flight; flowering plants known in many cases	80	Ontario species have been S- ranked using NatureServe rank calculator; also categorized as: rare, common, very common (J. Skevington field guide). Maritime Provinces S ranks (either SU or S4,S5). NatureServe is scoping a project to G-rank all NA syrphids	Conspicuous, taxonomy fairly well resolved; recent key available for all taxa but id to species for non-specialists can be difficult and time consuming; an E. Canada field guide will be published in 2017; keys available for larval id	Hand netting, emergence traps; Malaise traps, larval searches; pan traps	Charismatic; Sampling but not likely identification

Species group	Taxonomy	Pollination notes	NY diversity (species)	Conservation status knowledge	Identification	Field methods	Citizen science potential
	Sphecomyia, Criorhina, Somula, Cynorhinella, Blera, Lejota, Spilomyia, Teuchocnemis, Temnostoma Eristalini: *Mallota*						
Flower longhorn beetles	Coleoptera: Cerambycidae: Lepturinae	Among 20 families of beetles with pollinators; this subfamily contains confirmed flower visitors	~100	Very little	Field guide, online resources	Netting, beating	Sampling, photography, and some identification
Hairy flower scarabs	Coleoptera: Scarabeidae: *Trichiotinus*	Frequent flower visitors, hairs catch pollen	5	Very little	BugGuide	Netting, beating, lights	Sampling, photography, and some identification
Hawk (sphinx) moths	Lepidoptera: Sphingidae	Important in tropics, very little information about NE US	47; 27 feed as adults	Poorly known; most species without S-ranks; but all are G-ranked and several have recent regional declines (Young et al. unpublished)	Mostly straightforward; field guides, online resources	Lights, nocturnal netting	Sampling, photography, and some identification
Flower moths	Lepidoptera: Noctuidae: *Schinia*		12-13	Very little; 3 spp tracked by NYNHP		Lights, diurnal and nocturnal netting	Sampling, photography, and some identification

Table 7. Focal taxa for Targeted Species Surveys.

Order	Family	Scientific name	Common name	Conservation status	Need	Collecting methods
Hymenoptera	Apidae	*Bombus affinis, B. terricola, B. pensylvanicus, B. fervidus, B. auricomus, B. borealis, B. ashtoni, B. insularis, B. fernaldae*	Rare bumble bees	S1 or SH	Surveys of historical and recent locations	Netting
Hymenoptera	Melittidae: Melittinae	*Macropis, Melitta*	Oil bees	All rare or endangered, all 3 *Macropis* are declining in NY; G-ranks not completed	Surveys of historical and recent locations	Netting and pan traps
Hymenoptera	Apidae	*Epeoloides pilosula*	A cuckoo bee	Extremely rare	Distribution in NY	Traps and nets near host nest sites
Lepidoptera	Lycaeinidae	*Callophrys irus*	Frosted elfin	HPSGCN	Surveys of historical locations	Netting
Lepidoptera	Nymphalidae	*Danaus plexippus*	Monarch	SPCN	Identification of migration routes and stopovers	Visual
Lepidoptera	Nymphalidae	*Speyeria idalia*	Regal fritillary	Extirpated	Surveys of historical locations	Visual
Lepidoptera	Hesperidae	*Atrytone arogos*	Arogos skipper	Extirpated	Surveys of historical locations	Netting
Lepidoptera	Hesperidae	*Pyrgus wyandot*	Appalachian/southern grizzled skipper	HPSGCN	Surveys of historical locations	Netting
Lepidoptera	Hesperidae	*Erynnis persius persius*	Persius duskywing	HPSGCN	Surveys of historical locations	Netting
Lepidoptera	Hesperidae	*Erynnis martialis*	Mottled duskywing	HPSGCN	Surveys of historical locations	Netting

Order	Family	Scientific name	Common name	Conservation status	Need	Collecting methods
Lepidoptera	Pieridae	*Euchloe olympia*	Olympia marble	SPCN	Surveys of historical locations	Netting
Lepidoptera	Noctuidae	*Schinia bifascia*, *S. tuberculum*	Slender flower moth, golden aster flower moth	SPCN	Surveys of historical locations	Netting; *S. tuberculum* diurnal
Diptera	Syrphidae	*Cynorhinella longinasus*	Eastern long-nosed fly	Northeastern endemic; relict species; extremely rare; poorly known	Recently detected in Ballston Spa, NY and Hampshire Co., MA (Bugguide)	Netting at flowers; or at hilltops
Diptera	Syrphidae	*Callicera erratica*	Golden pine fly	Extremely rare, local in late-successional Pine stands in southern NYS	Only 2 old records in NY	May turn up in canopy malaise traps, but would require emergence traps, larval searches