SUNY ESF Campus Bee Inventory Final Report

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A Bee Campus USA project

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Background

SUNY ESF has been an affiliate of the national Bee Campus USA program since April 2022. Bee Campus USA, along with its sister program Bee City USA, is an initiative of the Xerces Society for Invertebrate Conservation, and provides "a framework for campus communities to work together to conserve native pollinators by increasing the abundance of native plants, providing nest sites, and reducing the use of pesticides" (Xerces Society 2025). Affiliates form a committee composed of faculty, staff, members of the Grounds department, and students. Affiliates maintain membership through a pledge to annually create or enhance native habitat on campus, develop an Integrated Pest Management (IPM) plan to reduce pesticide use, offer course curriculum and service learning opportunities, produce a public website which hosts resources such as native plant recommendations and local native plant suppliers, display interpretive signage, and submit annual reporting on these activities. In addition, affiliates are generally expected to host outreach and educational events for students and the public to promote awareness and action related to native pollinator conservation.

The Bee Campus USA and Bee City USA programs, among many others nationwide, were developed in response to the widespread and in some cases precipitous declines that have been documented in wild pollinators globally in the past several decades (Potts et al. 2010, Cameron et al. 2011). Habitat loss, degradation, and fragmentation are acknowledged as primary threats to pollinators, along with pesticide use, disease, and climate change impacts, plus the compounding and emergent effects of these combined factors (González-Varo et al. 2013, Goulson 2015). Reduction in quantity or quality of habitat has occurred in large part due to agricultural expansion and intensification, as well as urban and industrial development, which have resulted in loss of native plant diversity and habitat connectivity on the landscape.

Shifting public attitudes towards pollinators and "habitat gardening" have spurred grassroots movements to encourage and facilitate the use of regionally or locally native plants in home gardens, community spaces (e.g., libraries, churches), schools, and state or city-owned properties (e.g., sidewalk medians, city parks, roadsides). While urban areas tend to frequently support common, adaptable generalists and non-native species due to low habitat quality, fragmentation, and high levels of disturbance and pesticide use, cities are also capable of hosting regionally rare species, especially in diverse green spaces (Matteson et al. 2008, Hernandez et al. 2009, Twerd and Banaszak-Cibicka 2019, Gruver and CaraDonna 2021). Even small patches can provide important resources to native pollinators in otherwise low-quality habitat matrices, with greater benefits when patches are connected into larger habitat corridors (Daniels et al. 2020, Graffigna et al. 2024).

As urban expansion continues and converts more remaining wildlands into areas of impermeable surface and manicured, exotic landscaping, subject to exacerbated climate change impacts (e.g., the "urban heat island" effect), cities will become increasingly important for the preservation of biodiversity and ecosystem services. Adapting urban design to embrace native landscape elements will be crucial for allowing native pollinators to persist, alongside other benefits of ecologically functional, biodiverse green spaces like climate resiliency, human health, and opportunities for human connections with nature (Wood et al. 2018, Derby Lewis et al. 2019, Kumar et al. 2025). Programs like Bee Campus USA seek to engage communities with pollinator conservation through the creation of urban habitat, empowering local action and laying the groundwork for more ecologically sound citywide landscaping practices.

Bees are diverse in New York State, with over 450 species known to occur here. All are tied to flowering plants in both larval and adult life stages, and many are highly specialized to specific plant species, soil types, habitats, or even other bees (nest parasites). Yet, the population trends and even basic biology of many of these species remain unknown, with a significant proportion still unranked statewide in conservation status assessments following the conclusion of the 2022 Empire State Native Pollinator Survey (White et al. 2022). Greater survey efforts are necessary to fill these critical information gaps, both to quantify present-day pollinator communities as well as detect shifts from the past and provide baseline data for research into the future. While many protected lands are of high priority for these surveys due to the prevalence of rare or imperiled habitat types that host unique bee species, conducting surveys in urban areas also offers insight into the species that can adapt to human disturbance, the expansion of introduced species, and whether urban habitat restoration efforts can support declining species or the functionally diverse pollinator communities needed for long-term ecosystem health.

While it is a requirement of the Bee Campus USA program for affiliates to continually create, enhance, or restore native habitat on their university campuses, monitoring those plantings to assess conservation outcomes is not. Yet without such followup, it is difficult to determine if the habitat is effective at providing key resources and refuge for species in need. Although it has not been possible for us to conduct pre-enhancement baseline surveys of bees on the ESF campus, we hope these initial inventorying efforts will impart valuable insights for future comparison.

We are aware of few other Bee Campuses at this time that have undertaken formal surveys to establish what bee species occur on their campus grounds. This discrepancy may be due in part to a lack of corresponding expertise in identifying bees – while survey methods are simple, identification can be tedious and fraught with error if not performed by qualified individuals. Likely, not all Bee Campuses have bee taxonomists, or perhaps any bee researchers, on staff; while this poses limitations on survey capabilities, it should be viewed as a net positive that non-subject matter experts are able to get involved and are committed to championing pollinator conservation at their universities and in their communities.

Here at SUNY ESF we are grateful to have the resources and expertise, through the ESF Bee Lab and Restoration Science Center, to conduct these surveys, which will not only provide valuable information for management of our campus grounds, but contribute to greater scientific understanding and conservation of native pollinators in New York State and beyond.

Methods

Focal Taxon

The aims of the Bee Campus USA program target all native insect pollinators, and so do our habitat creation efforts on the ESF campus. However, we limited our focal taxon to bees (Hymenoptera: Apoidea), for multiple reasons.

Firstly, bees are highly effective and important pollinators, of both wild plants and numerous crops, and as such are the subject of great concern and attention by scientists and laypeople alike. Efforts to establish baseline distributions of bee species are widespread and growing in popularity, in order to produce long-term datasets for comparisons of population trends over time and the decline, or expansion, of individual species (Droege et al. 2016). Surveys also seek to document rare and underrecorded species, and characterize the bee species community in different habitats, such as urban areas, for conservation purposes. Such efforts are not nearly as common, standardized, or popular with the public for most other pollinator groups (e.g., syrphid flies, wasps, or beetles), with the exception of Lepidoptera (butterflies and moths) – however, most members of this group are not generally considered critical pollinators of plants in the northeastern United States, and species richness on the ESF campus is limited based on existing citizen science data. Unlike bees, which can be collected directly from flowers, surveying most Lepidoptera (i.e., moths) generally requires nocturnal blacklighting, which can attract individuals from a wide radius of the landscape, making it more difficult to draw direct connections to campus plantings.

Additionally, bees are numerous and diverse, easy to collect, and straightforward to process in a lab setting. Student contributions comprise a substantial proportion of our survey data, and thus making the data collection process as simple and engaging as possible encourages student participation. While butterfly and moth specimens must be spread to be preserved properly, a time-consuming process that requires experience and extensive lab & storage space, large numbers of bee specimens can be pinned relatively quickly and space-efficiently with methods that are easy to teach to undergraduate technicians. We also have greater taxonomic expertise at the ESF Bee Lab to identify bees to the species level than other pollinator taxa, reducing the need to send specimens to external partners that would delay project results or accrue additional costs. Surveys performed to the species level can provide valuable information on floral preferences, distributions and ecology of poorly known species, and the quality of habitat being made through programs like Bee Campus USA, especially in degraded, fragmentated urban areas where habitat is most urgently needed.

Survey Design

Survey efforts took two approaches, to maximize documentation of bee diversity, promote student participation, and offer opportunities for students to learn bee survey methods.

1) ***Citizen science – "ESF Pollinators" iNaturalist project***

The citizen science platform iNaturalist (available online and as a smartphone app) is used by millions of laypeople and scientists around the world to document the full breadth of living things. Users submit photographic or audio observations of any species, optionally adding their own proposed identification (at any taxonomic level), and the community-based verification system allows observations to reach 'Research Grade' (suitable for use in academic research) when multiple users 'agree' on the lowest possible taxon ID. Typically, subject matter experts will refine or correct IDs. Hundreds of peer-reviewed scientific journal articles have been published utilizing 'Research Grade' iNaturalist data. Unlike for some other taxa, a significant number of North American bee experts are active on iNaturalist to sort through the large quantity of observations, offer IDs quickly, and locate records of potential rarity or importance.

'Projects' are a valuable tool iNaturalist offers to compile observations that meet specified criteria, such as those of a certain taxon at a given time or place. Many agencies and non-profits use projects to conduct citizen science surveys and bioblitzes on a local, state-wide, or even global scale, to document behaviors (e.g., nest building, plant-pollinator associations), or answer narrow scientific questions. The process of data compilation can in most cases be automated, with observations fitting the criteria automatically being added to the project, including retroactively, allowing thousands of records to be immediately searched, filtered, and downloaded.

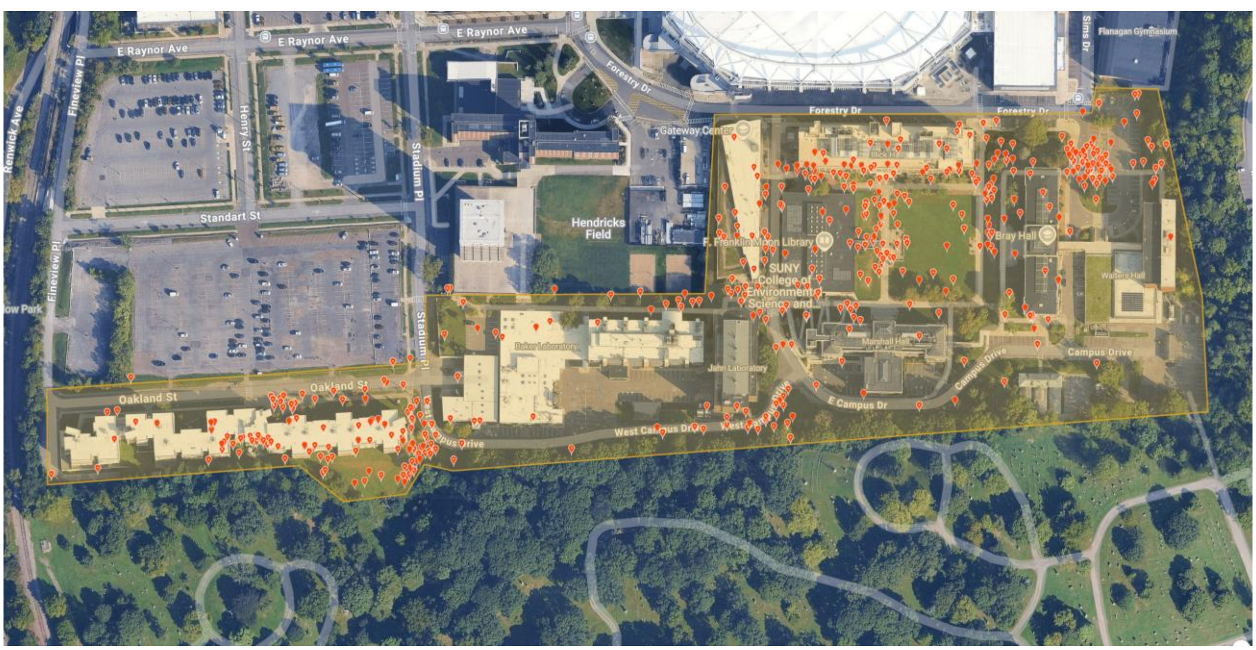

Figure 1. The map of iNaturalist observations on the ESF Pollinators project as it appeared in November 2025. Polygon boundaries approximate the perimeter of the SUNY ESF campus, as it is bordered by Syracuse University to the north and Oakwood Cemetery to the south.

We created an iNaturalist project, called "ESF Pollinators", soon after we became an affiliate of the Bee Campus USA program in 2022. This project collates observations of any pollinator observed by any user within the bounds of the ESF main campus in Syracuse. Google Earth was used to create a polygon around the approximate boundaries of the campus for use in the project (Fig. 1). This project is not limited to only bees, but it can easily be filtered to only show records of bees and in particular those that are 'Research Grade'. Through the project's journal feature, we also provide updates and seasonal search targets for those who have 'joined' the project using the 'Join' feature.

We have additionally created side projects for our Bee Campus moth blacklighting nights, which document the moth species observed by staff, students, and the public at our blacklighting events.

These data, and the projects, are public, and have been featured in iNaturalist's blog multiple times for our survey efforts and rare finds.

We continually encourage student participation by communicating with student organizations on campus about the existence of the project, including offering tutorials on how to collect and submit data, and target species for students to seek out. Many students at ESF already use iNaturalist, such as for the Entomology Club's annual bioblitz, so it is often simple to recruit new users to our project.

2) *Specimen collection – sweep netting and opportunistic collection*

In 2023, we expanded survey efforts to include the collection of physical specimens. Bees are diverse and often difficult to identify to species without examination under a microscope, thus lethal collection is typically necessary to obtain valuable data from community-level bee surveys. This method also produces physical collections which can be held by the university for display, education, or future research, or be distributed to museums.

Three primary lethal collection methods are utilized by researchers to catch bees. Pan traps, or 'bee bowls', are the most commonly employed method, and are a passive way to collect large numbers of bees with minimal effort and cost (Droege et al. 2016). Yellow, blue, and white painted small cups or bowls are placed along transects and filled with soapy water, attracting bees by mimicking the colors of flowers. Traps can be set out for lengths of time ranging from one afternoon to several weeks. Pan traps are simple to implement and standardize, thus reducing bias, but they are known to disproportionately collect certain taxa like halictid bees (sweat bees) which are difficult to identify and may lead to bottlenecks in processing specimens and obtaining useful results (Portman et al. 2020). Blue vane traps are also sometimes used in bee surveys; these traps consist of a blue four-sided panel ('vane') and funnel, which attracts and intercepts bees in flight, attached to a large collection receptacle (sometimes filled with liquid) and then usually affixed to a stand. These traps can collect large numbers of bees, especially bumblebees, which may lead to conservation concerns if used too extensively (Gibbs et al. 2017).

Sweep-netting is the method we chose to use for our surveys. Sweep-netting is the use of nets to sweep flowers in bloom to capture bees, and in larger-scale surveys is typically used in combination with pan traps (Droege et al. 2016). Netting can capture species and guilds of bees not well-represented with passive collecting methods (Prendergast et al. 2020, Pei et al. 2024). While sweep-netting can be done indiscriminately if the goal is to simply capture large quantities of bees, more often netting sessions are separated by flowering plant species – this allows important data on plant-pollinator associations to be collected with each specimen. Students must be trained on effective netting techniques, and must learn to distinguish the silhouettes and behaviors of bees in the net to avoid bycatch or the accidental release of target species. Specimens are collected directly into ethanol, and are then processed in the lab by our student technician.

Pan traps were not utilized for our campus surveys due to concerns they may get in the way of foot traffic, Grounds operations (e.g., mowing), or vehicles, or otherwise be disturbed or destroyed by these activities. Blue vane traps were not deemed necessary or useful in this case due to the limited survey area and desire to not catch large quantities of bumblebee specimens; bumblebees are well-represented on the iNaturalist project and can generally be identified from photos, thus there is no pertinent need to collect many physical specimens of them. Additionally, they may attract bees simply passing through campus, preventing us from being able to directly link their presence to floral resources on campus grounds.

In addition to sweep-netting, which was primarily performed by ESF Bee Lab staff and trained student technicians, many specimens were collected opportunistically. This form of collection consists of capturing bees singly off of flowers, often when a target species is observed, sometimes directly into a vial instead of with a net. Most student volunteers not directly associated with the ESF Bee Lab provided us with specimens collected in this manner, as well as our pollinator ecologist Molly Jacobson, who mainly searched for unusual and new species. We provided vials of 70% ethanol to students who wished to collect for us, with a signout sheet to log the loan and return of these vials. We requested students provided the following information when submitting specimens to us, which is the same information we took down during sweep-netting events: Date, Location on Campus (e.g., Robin Hood Oak Garden, Quad Meadow), Flower Species, Collector Name. These specimens, received in ethanol, were then processed by the ESF Bee Lab along with other specimens.

To encourage participation and provide basic training to students to increase the likelihood of receiving specimens of target species (and avoid common ones), we hosted a Bee Identification workshop in spring 2024, attended by around 30 students. Our pollinator ecologist Molly Jacobson walked students through common bee genera and their diagnostic features, including which were targets, which had to be netted vs photographed, and how to effectively sweep flowers. Most students who volunteered for the survey did so as a result of this workshop.

Survey Effort

The "ESF Pollinators" iNaturalist project has been collecting observations since 2022, and includes many records from prior to this time dating back to September 2017, though search effort increased dramatically after ESF became a Bee Campus and began advertising the project to the campus community. As of November 2025, a total of 76 users have contributed observations to the project, ranging from 1 observation to 155 observations per user, and 1 species to 38 species per user.

In 2023, sweep-netting efforts were limited to targeted sweeps in April of the shrub willow plantings that were present in front of Moon Library until later that year, part of Dr. Timothy Volk's clean energy willow biomass research.

Comprehensive sweep-netting ran April – October 2024 and April – October 2025. The majority of collection events were carried out by ESF Bee Lab pollinator ecologist Molly Jacobson and Bee Campus technicians Brooke Shaw (2024) and Luella Johnson (2025). Specimens were contributed sporadically by other members of the ESF Bee Lab, Entomology Club, and miscellaneous students, primarily through opportunistic collection.

Figure 2. Two Bee Campus plantings on the ESF campus. a) the Bray Bioswale, located in the parking lot median behind Bray Hall. This area was previously heavily invaded by Phragmites *reed. It adjoins the Robin Hood Oak garden, seen in the background. b) the Quad Meadow, located in front of Bray Hall, next to the Quad. It was previously turf, cleared and reseeded in May 2024.*

Sweep-netting was not standardized (i.e., timed) nor was it exhaustive of all flowering plant species on campus, as this was logistically impractical; student technicians performed sweep-netting in between other job duties as time allowed, and contributions from other students were completely voluntary. However, we did aim to target all areas of campus, not just Bee Campus plantings (Fig. 2) or 'showy' flowers. We also did not always collect every specimen we captured; in general, we avoided collecting honeybees (*Apis mellifera*), common eastern bumblebees (*Bombus impatiens*), and eastern carpenter bees (*Xylocopa virginica*), among others, because these were numerous and easily identifiable. Target species, including pollen specialists expected for the plants occurring on campus, were sought out for opportunistic collection by sweeping and/or observing their host plants. When possible, we aimed to avoid unnecessary collection of well-represented species, and thus often singled out individuals from genera or species we believed to be new for our campus list.

It was neither our intent nor expectation for these surveys to be standardized in a manner that would allow statistical comparison between flowering plant species or of the relative abundances of different bee species on campus. Rather, our goal was to document as many different bee species as possible, and obtain valuable data on the flowers they frequently forage on here on ESF campus grounds. Caution is exercised, and combined with firsthand experience from our pollinator ecologist along with the scientific literature, when interpreting results and drawing conclusions about species commonness and preferred forage plants.

Specimen Processing and Identification

All bee specimens were processed in the ESF Bee Lab either by one of our student technicians or by pollinator ecologist Molly Jacobson, usually no more than two weeks after collection took place. Specimen preparation includes washing the specimens of ethanol, rinsing them in soapy water to remove debris or pollen, and blow-drying them in a mesh-covered mason jar to restore a lifelike appearance, important for identification and future display purposes (Fig. 3). Every specimen receives a unique identifier number and is entered into our Microsoft Excel spreadsheet database, which contains metadata from each collection event and a corresponding entry for each specimen.

The majority of bee specimens were identified by Molly Jacobson, either to the species level or to morphospecies, species group, or subgenus. Bees in the taxon *Lasioglossum* (subg. *Dialictus*) (often colloquially shortened just to *Dialictus*), a very common group known as metallic sweat bees, are exceptionally difficult to identify to species and with few exceptions require examination by a seasoned expert. In 2024, we brought our *Dialictus* specimens, along with our few *Nomada*, to Sam Droege, a foremost bee taxonomy and ecology expert located at the USGS Bee Lab at the Eastern Ecological Science Center in Patuxent, Maryland. In 2025, we sent our *Dialictus* to Michael Veit, another regional bee expert based in Massachusetts. Additionally, a handful of notable specimens were photographed and uploaded to iNaturalist for verification by experts like Dr. John Ascher and others. All bee specimen records will be uploaded to the Global Biodiversity Information Facility (GBIF) by spring 2026.

Plant-Pollinator Interaction Analysis

To visualize the plant-pollinator association data generated through our surveys, we created an interaction network using the ‘bipartite’ package in R (v4.3.2) (Dormann et al. 2008). We used host plant data from all sweeps and opportunistic collection events where it was recorded, with the exception of a few instances where multiple plants were swept at once. Additionally, we added to the dataset all Research Grade iNaturalist observations where the forage plant was listed or was identifiable at least to genus; there were <5 observations that had to be excluded for this reason.

Results & Discussion

Across all survey methods through November 2025, at least 104 species of bees, across 26 genera and 5 families, have been recorded on SUNY ESF’s main Syracuse campus (Table 1).

This value is a conservative estimate, as some specimens could not be taken to the species level, and were instead sorted to species group or subgenus, e.g., male *Dialictus*. However, by working with regional experts, we have made every effort to obtain species determinations on as many specimens as possible.

Comparison of Survey Methods

A total of 1137 specimens of ≥ 94 bee species were collected through formal survey methods (i.e., sweep-netting, opportunistic collection). Through the ESF Pollinators iNaturalist project, 30 bee species were observed at ‘Research Grade’ level. Note that, on the website, 41 Research Grade bee species are listed, but 11 of these are represented solely by pinned specimen photos uploaded from our netting surveys, thus we excluded these in our totals. 74 species were recorded only from formal collection, while 10 species were only observed through the iNaturalist project. 20 species (19.2%) were common to both survey methods.

Among physical specimens, the top five most commonly collected bee species were the slender-faced masked bee (*Hylaeus leptocephalus*, n=137), spurred small carpenter bee (*Ceratina calcarata*, n=88), golden sweat bee (*Augochlorella aurata*, n=63), western honeybee (*Apis mellifera*, n=60), and ligated furrow bee (*Halictus ligatus*, n=43). Together, these comprised 34.3% of all specimens. Two of these species, *H. leptocephalus* and *A. mellifera*, are not native to North America. Among Research Grade iNaturalist observations, the top five most commonly observed bee species were the common eastern bumblebee (*Bombus impatiens*, n=66), western honeybee (n=47), eastern carpenter bee (*Xylocopa virginica*, n=34), brown-belted bumblebee (*Bombus griseocollis*, n=25), and unequal cellophane bee (*Colletes inaequalis*, n=10). These made up 75.5% of all Research Grade bee observations for the project. Of these five, only the honeybee is non-native.

Figure 3. One collection drawer of specimens from our campus surveys. Student technicians and volunteers assist in the preparation and curation of these collections. Each specimen has a label and associated entry in a digital database.

The species most frequently observed on the iNaturalist project represent some of the most common bee species in the northeastern United States. Moreso, they are large in size, often quite conspicuous (e.g., bulky build, loud buzzing), and can sometimes be found in large numbers at once; these traits lend themselves to being encountered by passersby. In addition, these species are all straightforward to identify from photos, even poor ones taken at a distance or with a low-resolution phone camera, leading them to easily achieve Research Grade. The majority of species recorded on the iNat project are widespread habitat and diet generalists, which regrettably tell us little about the unique conditions on campus.

iNaturalist can be a useful tool to document rare bee species when implemented effectively. Many users make observations from private property (i.e., backyards) where scientists cannot easily sample, or small public properties (e.g., parks, campuses, local preserves) not often prioritized for surveys, leading to new records. Moreover, the number of users (nearly 4 million at time of writing) inevitably results in greater search coverage for scarce, specialized, or patchily distributed species than scientists could ever possibly achieve due to limitations in funding, personnel, and resources. Many pollinator-focused iNaturalist projects have experienced great success in documenting new state and county records (for an exceptional example, see the Vermont Wild Bee Survey, Hardy et al. 2025). While some automatically amass records without any specific sampling protocol (e.g., 'Bees of [State]' projects), the best results tend to be from those with a cohesive conceptual framework that provide training to citizen scientists, such as how to effectively photograph bees, target bees for the project and their host plants, and undersampled or high potential locations where search effort could be allocated.

Here at ESF, most iNat observations are contributed by students who incidentally encountered a pollinator while walking on campus, with the exception of focused groups such as the Entomology Club which hosts Bioblitzes and whose members are more likely to spend extended personal time searching for insects. This pattern is illustrated in the fact that the top five most commonly observed bee species on the project comprised three quarters of all observations, suggesting few observers were specifically looking for bees or perhaps did not know how to differentiate small bees from other insects. In 2024 we hosted a workshop for students that provided training on how to best photograph and catch bees, how to differentiate common genera, and the genera or species that were targets for our survey. While this did lead to more observations and donated specimens, it did not appear to improve the quality of those observations nor did specimens represent more of our targets. This leaves us to conclude that while the workshop increased visibility and participation for Bee Campus efforts, it was not particularly effective in imparting desired skills or knowledge. Future workshops may instead be held for a smaller but more dedicated group of students who wish to commit to becoming volunteer surveyors, with a greater interactive component, instead of the less formal and less personal lecture format that was held between mid-day classes.

While our iNaturalist project has only thus far produced 10 unique bee records for our survey, it is still an important outreach tool to engage students to notice insects on campus, interact with native plantings, and potentially lead them to volunteer further with Bee Campus. Additionally, it is a platform for us to share our efforts with the larger citizen science community; the ESF Pollinators project was featured in iNaturalist's official blog in December 2024, and one of our Bee Campus moth blacklighting projects was also featured in July 2024. This global exposure shines a positive light on SUNY ESF, while hopefully inspiring others, be they individuals or institutions, to take up similar efforts in their communities.

In contrast to iNaturalist, the bees most frequently collected through formal survey methods do not simply represent large, easily-collected species. As mentioned in the Methods, our collection efforts intentionally avoided well-represented and sight-identifiable species when possible. The abundance of honeybees, golden sweat bees, and ligated furrow bees despite this is mainly a product of sweeps where all netted pollinators were collected, versus targeted collection events where flowers were searched for focal species. Additionally, technicians were instructed to collect an insect when they were not sure whether it was a target or not, due to the similarity between many species, so undoubtedly some common bees were collected this way. Spurred small carpenter bees and slender-faced masked bees are both abundant on campus, but are small in size and can only be identified through microscopic examination or high resolution photos, thus these were collected in large numbers given the possibility of discovering other similar-looking species. This being said, although our methods were not standardized and thus species abundances cannot be statistically compared, our extensive time in the field would lead us to agree with the assessment that slender-faced masked bees are exceptionally abundant on the ESF campus – potentially as much as honeybees or common eastern bumblebees. Sweeps on some flowers in the campus gardens would collect dozens of these masked bees at a time, and due to these high densities and wanting to avoid unnecessary lethal capture, we paused sweeping certain flowers for a short period in midsummer until their numbers tapered. Further remarks on this species are given in the following section.

We posit that physical specimen collection is indispensable as a means of inventorying local bee populations. While it is not without its biases based on the methodology employed, the vast majority of species on campus have been recorded only through specimens, and it detects common, yet small-bodied or cryptic, species where incidental observation largely does not. At the same time, of the 74 species unique to specimen collection, 31 are represented only by a single specimen ('singletons'). The sustained search effort offered by regular collection events by trained students and staff allow these easily-missed and often regionally rare species to be documented, and having a physical specimen rather than a photo to examine can be critical in determining difficult IDs. Yet, in much the same way as sweep-netting is typically paired with pan-trapping to complement the taxa best caught by one or the other, the iNaturalist project provides us with valuable records of large-bodied and charismatic species like bumblebees which we then do not need to lethally collect. In fact, two bumblebee species have been observed on the project which we have never encountered in our collection events, including the yellow-banded bumblebee (*Bombus terricola*), ranked S3 and a high priority species of greatest conservation need in New York. Thus, both methods work synergistically to build a more complete picture of the bee community on the ESF campus.

Bee Community Composition & Notable Records

Our surveys revealed a rich and interesting wild bee community on the ESF campus. The bees we documented span a wide range of life histories, from stem-nesters to cleptoparasites to pollen specialists. Several species on campus are uncommon or rare for the region, and a few are at-risk in New York. We detected approximately 23% of the bee species and 58% of the bee genera known to occur in New York State. Of the species we found, 11.5% are pollen specialists, and 8.6% are parasitic (cleptoparasites or social parasites). Also, 63.5% are ground-nesters or parasites of ground-nesters, while 36.5% are cavity-nesters or parasites of cavity-nesters.

Eight species of bumblebees have been recorded on campus, which is more than we expected for a small urban site. Notably, the black-and-gold bumblebee (*Bombus auricomus*) has been occasionally observed (Fig. 4); this is an S2-ranked species and rare in the northeast with a patchy distribution that occurs primarily in parts of upstate New York like Onondaga county. We are aware of a population of *B. auricomus* occurring in the adjacent Oakwood Cemetery, which has abundant floral resources for long-tongued bees, particularly sweet-pea (*Laythrus*). These

*Figure 4. Black-and-gold bumblebee (*Bombus auricomus*) on swamp aster (*Symphyotrichum puniceum*) in the Bray Bioswale on campus.*

bumblebees are likely spilling over onto campus and utilizing our plantings to support their colonies, which is encouraging. As mentioned above as well, the yellow-banded bumblebee (*Bombus terricola*), another species of concern noted for range-wide declines, was observed a single time on iNaturalist. Among other species of interest was the lemon cuckoo bumblebee (*Bombus citrinus*); this is considered the most common of the socially parasitic bumblebees in New York, an enigmatic group that are nest parasites on other bumblebee species. Many cuckoo bumblebees have experienced severe declines due to their reliance on hosts that themselves have declined; however, *B. citrinus* is known to use common eastern bumblebees (*Bombus impatiens*) and half-black bumblebees (*B. vagans*) as hosts (both of which are present on campus) (Williams et al. 2014), likely making it more stable. Still, it is ranked S2S3, and it is certainly rewarding to observe this species. Many degraded habitats have depauperate bumblebee richness, with communities homogenized to just a few abundant species like common eastern bumblebees, brown-belted bumblebees (*B. griseocollis*), and two-spotted bumblebees (*B. bimaculatus*). It is a sign of quality habitat, and likely the product of connected habitat patches between campus, the cemetery, and other residential areas, that we see here a moderately diverse bumblebee assemblage, of short, medium, and long-tongued species.

*Figure 5. Mock-orange scissor bee (*Chelostoma philadelphi*) male collected on campus.*

Many of the species we recorded are uncommon or even rare in the northeast, for a number of reasons. Some are pollen specialists, which only occur where there are sufficient populations of their host plants. For instance, the mock-orange scissor bee (*Chelostoma philadelphi*), relies on mock-orange (*Philadelphus* spp.), a plant we only recently installed on campus in 2025 *after* we found the bee (a male, nectaring on buttercup) – thus there must be ornamental mock-orange trees somewhere nearby. This genus of bees is not commonly encountered and was a surprising find (Fig. 5). Another example are the dogwood specialists; sweeps on the gray dogwood (*Cornus racemosa*) in the existing Illick bioswale have produced records of two of the four uncommon dogwood specialist bees in the state, *Andrena platyparia* and *Andrena integra*. We have since planted several more gray dogwoods to support these bees and hopefully attract the other two specialists. By virtue of depending on patchily distributed resources, many pollen specialists are rare across their range but can sometimes be abundant where they do occur. The relationships of pollen specialists to our native plantings are discussed further in the following section.

Other rare bees are such because they are recent introductions to North America, and are not yet widely established. While ~14% of campus bee species are non-native, most of these are ubiquitous (e.g., western honeybees, wool-carder bees [*Anthidium* spp.], Wilkes's mining bees [*Andrena wilkella*]), usually due to introductions occurring further in the past, allowing them ample time to colonize outwards from their points of origin. However, for recent arrivals we can track their dispersal in real-time. These include some interesting records for our campus; the European small-woolcarder bee (*Pseudoanthidium nanum*), the little masked bee (*Hylaeus pictipes*), and the hairy masked bee (*Hylaeus hyalinatus*) (Fig. 6). *P. nanum* was first detected in the United States in 2008 in New Jersey, and was found the following year in New York City (Matteson et al. 2013, Ascher et al. 2014). It continues to spread rapidly, being collected primarily from urban and disturbed sites (Portman et al. 2019). To our knowledge, our campus record is only the second record from Syracuse and from central New York as a whole. *H. pictipes* is another species likely introduced very recently yet expanding its range at a substantial pace. It was initially documented in Ontario, Ohio, and Pennsylvania in 2015 (Gibbs and Dathe 2017), then in Virginia just four years later (Ostrom and Grayson 2021). There appears to be only one other occurrence in New York, a 2019 record from the Albany Pine Barrens (Droege and Maffei 2025), making our campus record significant. Lastly, *H. hyalinatus* was likely introduced in the early 1990s, first detected in Ithaca, New York in the late 1990s (Ascher 2001) and later in Ontario (Sheffield et al. 2011); there are now records across the Great Lakes region though it is still tentatively absent from New England. This species is moderately abundant on the ESF campus, with 37 specimens collected. All three of these adventive, cavity-nesting species are clearly on the move, and will continue to establish themselves across North America via pathways through cities, ports, and other hubs of shipping and transportation. It is valuable to document new localities and track their pace of spread, to predict where they may next occur, determine their invasive potential, and better understand their ecology with regards to their adaptability to urban conditions. In addition, there are multiple other newly-introduced species that have a strong likelihood of appearing in Syracuse, and thus possibly ESF, in the next decade, such as the punctate masked bee (*Hylaeus punctatus*) and common masked bee (*Hylaeus communis*), both from Europe. Future surveys should target these species.

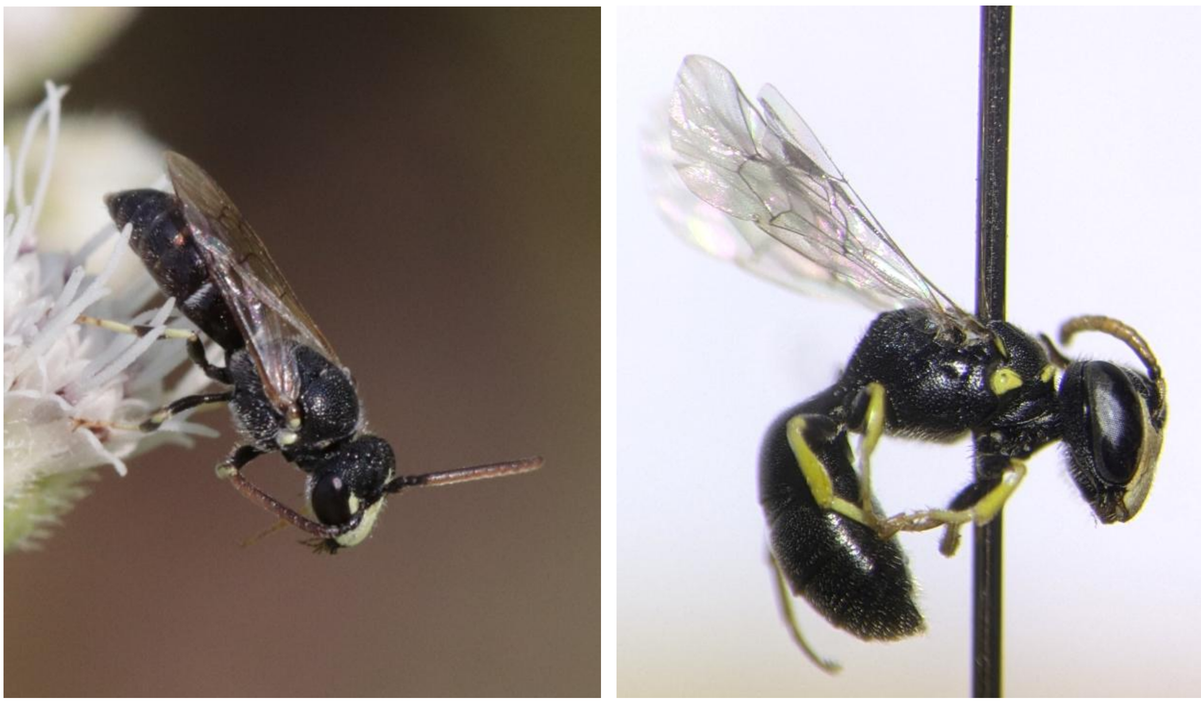

*Figure 6. a) hairy masked bee (*Hylaeus hyalinatus*) male on boneset (*Eupatorium perfoliatum*) in the Bray Bioswale. b) little masked bee (*Hylaeus pictipes*) collected on campus. Males are distinctive in having a white face contrasting with yellow leg markings, which are more extensive than in other species.*

Several more species documented on the ESF campus are uncommon or rare for less clear reasons, and their presence here cannot be confidently tied to specific plants or conditions on campus. Many bee species are not well understood in their habitat and resource needs, thus patterns in their distribution remain inscrutable at present. Likely, their occurrence is the product of many interacting factors, including soil type, patch size, core vs edge of geographic range, connectivity to other suitable habitat, land use history, climate, and floral diversity, among others. Leavitt's armored-resin bee (*Heriades leavitti*), cherry mining bee (*Andrena pruni*), perplexing mining bee (*Andrena perplexa*), and wide-mouthed sweat bee (*Lasioglossum heterognathus*) are just some of the regionally uncommon species we have recorded, all of which are diet generalists with wide distributions but generally low abundance in our area. While this lack of insight makes it difficult to judge exactly what aspects of our campus plantings might be supporting these species, finding uncommon and rare bees in built-up urban areas is promising evidence that even small-scale habitat restoration efforts can be effective and valuable for preserving our wild bee fauna, and that perhaps more species than we thought can adapt to disturbed landscapes when given pesticide-free connective corridors to forage and nest in.

Due to the presence of these and other unusual species, the bee community on the ESF campus is richer and more varied than might be expected for a typical urban habitat patch, supporting more than just the region's most common, adaptable generalists. Many urban bee surveys over larger areas find far fewer species, particularly fewer ground-nesting solitary bees, than we have recorded here (Tommasi et al. 2004, Matteson et al. 2008, Hernandez et al. 2009, Molumby and Przybylowicz 2012). Our high percentage of exotic species is, however, consistent with other urban studies (Matteson et al. 2008, Fitch et al. 2019, Gruver and CaraDonna 2021). There are other notable absences as well, based on what we might expect for central New York. The two-spotted longhorned bee (*Melissodes bimaculatus*), for instance, is a common summer generalist that has not yet been detected, while the bicolored striped sweat bee (*Agapostemon virescens*), similarly common, has only been seen once on iNaturalist and no specimens have been taken. While the spurred small carpenter bee (*Ceratina calcarata*) was quite abundant, the three other possible species in this genus are thus far absent, which is somewhat unusual. There also remain many more common spring generalist mining bees (*Andrena* spp.) and mason bees (*Osmia* spp.) we have not found, although we did not sample forest canopies (e.g., oaks, maples) where they are known to occasionally forage (Urban-Mead et al. 2021). Despite intense search effort in 2025, several fairly common to uncommon diet specialists associated with plants abundant on campus have not been recorded either – this includes the eastern bare-miner (*Protandrena andrenoides*) and eight-spotted fairy bee (*Perdita octomaculata*) on goldenrods (*Solidago* spp.), aster cellophane bee (*Colletes compactus*) and aster mining bee (*Andrena asteris*) on asters (*Symphyotrichum* spp.), and frigid mining bee (*Andrena frigida*) on willows.

*Figure 7. Compressed dark bee (*Stelis coarctatus*), a nest parasite of armored-resin bees (*Heriades*), collected on campus.*

Very few species of cuckoo bees – cleptoparasites on other bees – have been detected thus far on campus; two common cuckoo bee genera (*Sphecodes*, *Triepeolus*) have no records, and those that do (*Nomada*, *Epeolus*, *Coelioxys*, *Bombus* [*Psithyrus*], *Lasioglossum* [*Dialictus*]) are represented only by one or two species each. *Coelioxys* and *Nomada* in particular should have more species here, given that their hosts are leafcutter bees (*Megachile*) and mining bees (*Andrena*) respectively, both of which are diverse on campus. However, it should be noted that *Stelis*, an uncommon to rare cleptoparasitic genus, has two species known from campus, including one that is quite scarce, *Stelis coarctatus*, which parasitizes armored-resin bees (*Heriades*) (Fig. 7). Thus, it is hoped that increased search effort will turn up more of these expected, and perhaps unexpected, parasitic bees. Cuckoo bees can be valuable indicators of diverse, robust bee communities, given their proclivity for specialized host-parasite relationships and general tendency to be less abundant than their hosts.

While not on the Syracuse main campus, a very notable bee record has come from ESF's Lafayette Rd. Experiment Station in Syracuse. This station holds numerous research plots of chestnut trees (*Castanea* spp.), namely American chestnuts (*C. dentata*) and their varieties, used by the American Chestnut Research and Restoration Project. In July of this year we were fortunate to collect two specimens of the chestnut mining bee (*Andrena rehni*) from these trees. This bee is among the rarest in the region, being a pollen specialist on chestnuts and chinquapins, which were devastated by chestnut blight, and in the case of American chestnuts, rendered functionally extinct. Only one other population of this bee is known in the entire state (Jacobson and Pilkey 2024; Fig. 8) and thus it is of great conservation interest. We did not include this species in our campus total, but it is undoubtedly the most important bee species to be documented on SUNY ESF property. The press release for this discovery can be read here.

*Figure 8. Chestnut mining bee (*Andrena rehni*).*

For bee surveys to be effective and capture a representative picture of the local bee community, they must account for the natural year-to-year fluctuations in bee populations and the random nature of collection events (Droege et al. 2016); this is typically achieved by running surveys for multiple years and utilizing multiple survey methods (Joshi et al. 2015, Goldstein and Ascher 2016, Rhoades et al. 2017), as we have done here. Even a site of limited size such as the ESF campus will experience a temporal turnover and spatial movement of bee species that results in a different subset of the total species pool being detected each sampling season. When examining collected specimens, in 2025, 29 species were collected that were found in neither of the other two sampling years; in 2024, there were 23 unique species, and in 2023, when sampling was limited just to willow trees in April, still 3 unique species were collected. Thus, it can be presumed that there still remain several more species of bees that have yet to be documented which use our campus for floral or nesting resources. The continual addition of new native plant species to campus landscaping will also likely attract and support more previously unrecorded bee species.

Plant-Pollinator Interactions

A primary goal of the Bee Campus USA program is to create native, pesticide-free pollinator habitat. Since 2022, we have added over 25,000 sq. ft of native plantings to the ESF main campus, including the Robin Hood Oak garden (Fig. 9), Bray bioswale, Quad Meadow, Campus Dr. bed, and Gateway hedgerow. These plantings have been designed to meet a number of criteria to support New York's native bees.

Figure 9. The Robin Hood Oak garden, June 2025. This planting is located in the parking lot median behind Bray Hall.

Firstly, we have sought to maximize native plant richness, with each planting showcasing a different natural community and suite of northeast natives. Greater taxonomic and morphological diversity in our flowering plants increases the number of possible pollinator species we might support, due to pollinators' varied traits like tongue length and body size, and possible coevolutionary relationships. Secondly, we have attempted to provide a bloom turnover, with an array of flowers with different attributes present at every point in the growing season, from April – October. Bee communities are highly seasonal, as most solitary bees live for only a few weeks as adults (Danforth et al. 2019), leading to frequent temporal community turnover. Social bees, like bumblebees, have annual colonies that must be constantly supplied with fresh food sources. Thus, a diverse set of pollen and nectar sources is crucial for supporting a rich local bee fauna. We design each planting to have its own bloom turnover, but moreso seek for our plantings to act synergistically to provide a campus-wide bloom turnover. For instance, most flowers in the Northern Hardwood Forest Demonstration Area bloom from April – June, and most in the Bray

Bioswale bloom July – September. Between all of our plantings, there is a vast selection of diverse floral resources to meet the needs of many bee species. And lastly, we have endeavored to cater to the needs of specialist and at-risk bee species by incorporating their required or preferred host plants in our plantings whenever possible. Understandably, many specialists need a large quantity of their host plants, which we may not be able to provide here, but when conditions are conducive to establishing populations of important host plants we try to do so. Conducting this survey to determine what bee species are using our plantings, and specifically which flowers are providing important resources to common and target species alike, will allow us to measure our successes and shortcomings, and tailor future plantings to fill resource gaps.

During our surveys, students and Bee Lab staff swept at least 88 species of flowering plants on campus, with an additional 13 species recorded as bee forage plants from Research Grade iNaturalist observations. These plant-pollinator associations can be viewed in full in our visual interaction network (Fig. 10). Note, as mentioned in Methods, that these results must be interpreted in context of the non-standardized methods by which the data were collected.

The five plant species that interacted with the greatest number of bee species included fragrant sumac (*Rhus aromatica*, 25 species; located outside of Bray Hall), shrub willow (*Salix caprea* cultivar, 20 species; previously in front of Moon Library), Virginia mountain mint (*Pycnanthemum virginianum*, 19 species; in the RHO garden), boneset (*Eupatorium perfoliatum*, 16 species; in the Bray Bioswale) and swamp vervain (*Verbena hastata*, 15 species; in the Bray Bioswale). Three of five were planted by Bee Campus; all five are/were part of intentional landscaping and do not grow wild on campus grounds. The plants from which the greatest number of individual bees were collected were fragrant sumac (n=114), shrub willow (n=88), flat-topped goldenrod (*Euthamia graminifolia*, n=85), Virginia mountain mint (n=71), and unidentified goldenrod sp. (*Solidago* sp., likely *canadensis*/*altissima*, n=59). While these are largely the same as those above, some, like the goldenrods, hosted a great abundance of bees and other insects but lower species richness. Since bumblebees and honeybees were largely avoided for collection, even with the addition of iNaturalist data, we expect that abundances for goldenrods and asters (*Symphyotrichum*) would otherwise be much greater as these are heavily visited by these two taxa in late summer and autumn. Abundance data are unavoidably biased by our collection methods, but firsthand observation from our pollinator ecologist and technicians corroborate the high bee visitation levels to all of these plant species. However, plants with few recorded interactions are not necessarily unpopular with bees – this may well be an artifact of uneven sampling effort, and plants expected to be attractive to pollinators that lack data should be the target of future collection events.

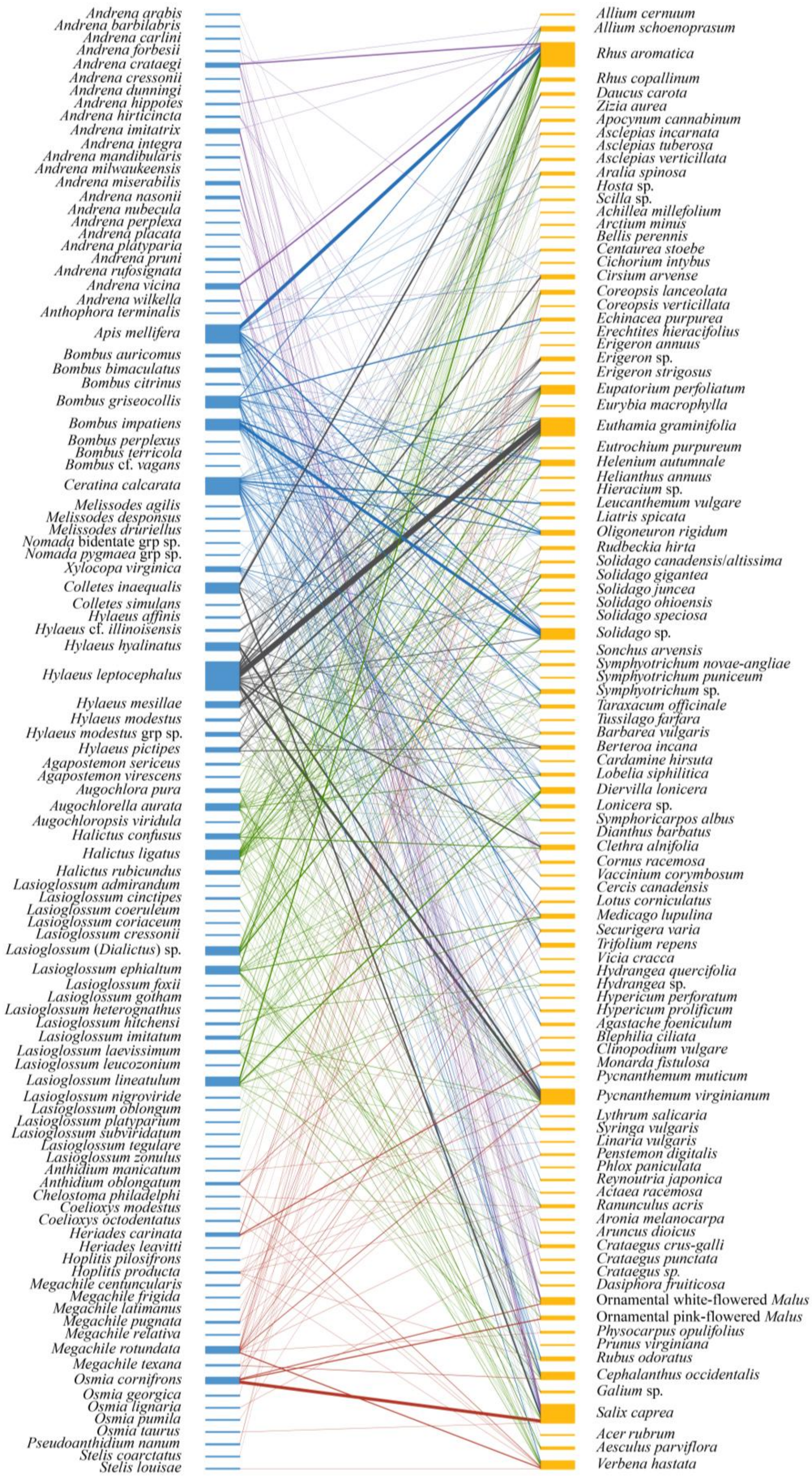

Figure 10. Plant-pollinator interaction network. Bees (left) and plants (right) arranged taxonomically by family. Interaction bars are color-coded by bee family. Width of bars indicates frequency of association.

The five bee species that interacted with the greatest number of plant species were the spurred small carpenter bee (*Ceratina calcarata*, 30 species), slender-faced masked bee (*Hylaeus leptocephalus*, 28 species), western honeybee (*Apis mellifera*, 23 species), ligated furrow bee (*Halictus ligatus*, 19 species), and golden sweat bee (*Augochlorella aurata*, 18 species). We suspect if honeybees were collected at true abundance, they would have many more interactions. Of these five, four are broad generalists, while the slender-faced masked bee is a specialist on introduced sweet-clover (*Melilotus* spp.). This genus of plants was never swept for bees on campus, as it was not encountered, but it is common in urban and disturbed areas and is likely in the vicinity. Typically, males of specialist species visit a broader range of plants than females; here, both sexes were collected from numerous plants (♀ 16 spp., ♂ 24 spp.), and both were particularly abundant on flat-topped goldenrod.

Our plant-pollinator interaction data revealed family- and genus-level floral preferences that largely align with current scientific understanding of these groups and affirm the actions we are taking to create campus habitat. Mining bees (*Andrena* spp.), of which over 90 species occur in New York and at least 24 on campus, are primarily spring-flying and many rely heavily on blooming shrubs and trees during this period. Our data show that on campus, mining bees were primarily collected from crabapples, willow, hawthorns, gray dogwood, and fragrant sumac, with the rose family (Rosaceae) overall being most frequented. A smaller cohort of Asteraceae specialists (e.g., *A. nubecula*, *A. placata*, *A. hirticincta*), appeared in late summer, and these were associated with goldenrods. Most of the woody plants supporting mining bees on campus predate Bee Campus plantings, either being part of previous landscaping, like the many ornamental crabapple trees, or part of surrounding wooded edges. In an effort to bolster these resources, in 2025 we added 20 species of native shrubs and trees to the hedgerow on the west side of the Gateway building, including chokecherry (*Prunus virginiana*), beach plum (*P. maritima*), pussy willow (*Salix discolor*), and gray dogwood (*Cornus racemosa*). In particular, willows are of great importance for native bees; among mining bees, there are as many as 10 willow specialists in the region, and the catkins are visited by a wide array of other bees as well – on campus, the non-native shrub willows attracted large numbers of unequal cellophane bees (*Colletes inaequalis*; Fig. 11), horn-faced mason bees (*Osmia cornifrons*), sweat bees (*Lasioglossum* spp.), and bumblebees (*Bombus* spp.) among others. However, none of the willow specialists have yet been detected on campus, and these willows have since been removed, thus new, native willows were planted in the hedgerow to avoid a lapse in this critical resource.

*Figure 11. Unequal cellophane bee (*Colletes inaequalis*) foraging on the shrub willows formerly in front of Moon Library.*

Other visible patterns in floral resource usage include the partitioning of long- and short-tongued bees. Bees in the family Megachilidae, a long-tongued group which includes leafcutter bees, mason bees, wool-carder bees, and others, tended to visit plants with deep corollas in the mint (Lamiaceae) and legume (Fabaceae) families; some were non-native or otherwise not purposefully planted, such as birds-foot-trefoil (*Lotus corniculatus*, strongly associated with *Anthidium oblongatum*), while others were a part of intentional plantings, like Virginia mountain mint and wild bergamot (*Monarda fistulosa*). Although none of the three wild indigo species (*Baptisia* spp.) in the RHO garden were swept, we suspect long-tongued bees are visiting these as well, and as these currently small plants continue to grow into their larger shrub-like forms, they will produce hundreds of pea-like flowers for these bees. However, some shallow flowers were also frequented by megachilid bees, especially lanceleaf coreopsis (*Coreopsis lanceolata*) and swamp vervain, the former producing both of our records of the uncommon Georgia mason bee (*Osmia georgica*). Similarly, long-tongued bumblebees, such as the black-and-gold bumblebee, half-black bumblebee, and two-spotted bumblebee, tended towards legumes, foxglove beardtongue (*Penstemon digitalis*), and wild bergamot, but this association was not as strong as expected, with many shallow flowers from multiple plant families being visited as well. Conversely, short-tongued bumblebees like the brown-belted bumblebee (*Bombus griseocollis*), heavily preferred the composite flowers in the Asteraceae like purple coneflower (*Echinacea purpurea*), purple Joe-Pye (*Eutrochium purpureum*), and sneezeweed (*Helenium autumnale*), as well as shallow members of the mint family like Virginia mountain mint and anise hyssop (*Agastache foeniculum*). We found that the green roof atop Walters Hall, containing mainly of ornamental chives, was a hotspot for brown-belted bumblebee queens as well as potentially yellow-banded bumblebees, another short-tongued species, though we were unable to capture any of the latter to confirm. Short-tongued sweat bees (family Halictidae), were, as predicted, broadly generalist, visiting a wide variety of plant families, their small size often allowing them to crawl into flowers otherwise too deep for their mouthparts to access.

One of our goals in planting habitat and conducting our surveys was to attract and document pollen specialist bees. Upwards of 25% of northeastern bees are pollen specialists, either at the plant family, genus, or species level (Fowler and Droege 2020), and many can be supported in urban habitat corridors. Specialists are likely more prone to population declines due to narrow host plant associations limiting their range, habitat occupancy, and/or adaptability to human disturbance. For these same reasons, they can also often be useful indicators of habitat quality. As mentioned previously, we have endeavored to establish specialist bee host plants where possible on campus, and we have had some success in attracting certain specialists, such as two of the dogwood specialists and some Asteraceae specialists (Table 2). The simple addition of annual sunflowers (*Helianthus annuus*) around campus was enough to draw in one of our sunflower specialists, the agile longhorned bee (*Melissodes agilis*). We discovered that multiple *Solidago* specialists were willing to use the closely related genus *Oligoneuron*, which provides valuable knowledge for future planning. However, as also discussed, many possible and even expected specialists remain absent to our knowledge.

Some of this discrepancy can be explained by limitations in our ability to foster large enough populations of specialist host plants. For instance, while blueberries (*Vaccinium* spp.) have several specialists, none have been detected, not surprisingly because we only have a handful of blueberry bushes on campus. These and other ericads require acidic soils, precluding the easy establishment and maintenance of large populations in an area without these soil types. The same goes for most of the host plants we have installed in the Northern Hardwood Forest Demonstration Area, including spring-beauty (*Claytonia virginica*), bellworts (*Uvularia* spp.), and Virginia waterleaf (*Hydrophyllum virginianum*), of which there are only a few individuals each and are unlikely to spread to form sufficiently large colonies due to unsuitable conditions. At the same time, some specialist bees require particular nesting substrates like sandy soils, thus these species are unlikely to show up on campus unless these soils are added alongside the host plants.

*Fig 12. a) Eight-spotted fairy bee (*Perdita octomaculata*), a goldenrod specialist we have been unable to locate on campus so far. b) Wilkes's mining bee (*Andrena wilkella*), a non-native clover specialist we documented using white clover (*Trifolium repens*) on the Quad lawn (pictured here on red clover,* T. pratense*).*

However, in other cases, such as many of the not-uncommon aster and goldenrod specialists (Fig. 12), it was unclear why we could not locate them. These plant genera are abundant both on campus, wild or planted, and in the surrounding landscape, which should support existing populations of specialists that would make use of campus plantings. We made effort to sweep patches of goldenrods and asters across campus and over multiple months, for spatial and temporal coverage, and yet still after two years these species remain elusive. A few specialists seem to be associated with weedy plants on campus: the thistle longhorned bee (*Melissodes desponsus*), likely present due to the invasive creeping thistle (*Cirsium arvense*) and bull thistle (*C. vulgare*) near the Quad; Wilkes's mining bee (*Andrena wilkella*), associated with the white clover (*Trifolium repens*) on the Quad (Fig. 12); and the mustard mining bee (*Andrena arabis*), an uncommon specialist normally found on brassicas like rock-cress (*Arabis* spp.) and toothwort (*Cardamine* spp.), the latter we have planted but in negligible quantity – here collected on non-native yellow rocket (*Barbarea vulgaris*), again near the Quad. Lastly, the possibility always exists that we have thus far missed the presence of some specialists due to uneven search effort. Technicians often preferentially collected from easily accessible and easily sweepable plants; some, such as foxglove beardtongue or golden-alexanders (*Zizia aurea*), are delicate and difficult to catch bees from with a net, so prolonged observation and careful hand-capture is necessary to collect bee visitors. Thus, some species surely have evaded us. The driving factors behind the distribution of specialist bees can be difficult to disentangle, and we hope that as plantings mature and time passes, more specialists will find and use our campus habitat. Clearly, some 'weedy' plants occupying corners and edges of campus landscaping have value, both for specialists and other generalists making use of the resources they offer. Moving forward, establishing larger populations of native host plants where feasible may help support these often rare, enigmatic, and at-risk members of our regional bee fauna.

Recommendations & Future Directions

The extensive bee inventory we have conducted at ESF has shed light on the diverse pollinator community co-existing with us on campus. Not only do we now have a list of, at minimum, 104 species of bees inhabiting our campus grounds, but detailed information about the floral resources they have been utilizing here – some of which grow wild along our edges, but most being those we, humans, have intentionally fostered. We should make use of this information as much as possible moving forward to thoughtfully plan how to effectively create more habitat with the limited space we have.

Planting Recommendations

In our Bee Campus plantings we have tried to balance a desire for species richness with the need for species abundance, that is, having enough individuals of a plant for it to be useful to bees, as many locate and assess quality of resources visually and specialists often need large patches of host plants. We believe that thus far we have achieved exceptional plant richness, having installed over 130 native species in the last 3 years, but for many species their quantity is few, limiting their usefulness to pollinators. Adding more species served the additional goal of providing 'living classroom' opportunities for students and professors, offering accessible examples of a wide array of plant species native to the northeast for course studies. However, looking forward, we should attempt to foster larger populations of key floral resources, so they might serve their greatest potential ecological role instead of existing primarily for display.

Examples include spring ephemerals like those in our Northern Hardwood Forest Demonstration Area, for which there may be other pockets of shady conditions on campus more conducive to their persistence, gracing us with colorful drifts of spring-blooming woodland flowers (Fig. 13). Moreover, additional flowering shrubs and trees, which support a wide array of spring-flying generalist and specialist bees, would be beneficial – when opportunities present themselves to fill landscaping gaps, native willows, cherries, hawthorns, sumacs, dogwoods, blueberries, chokeberries, and maples are among those that should be increased in number. The ongoing removal of invasive woody plants, such as common buckthorn, will create ample space to repopulate with robust natives like these to create habitat corridors along campus edges. Low-lying areas with potential to be used as rain gardens or bioswales can be a rich source of late-blooming flowers, and our plantings have demonstrated the diversity of bees that use wetland plants like boneset, Joe-Pye weed (*Eutrochium* spp.), swamp vervain, flat-topped goldenrod, sneezeweed, swamp milkweed (*Asclepias incarnata*), buttonbush (*Cephalanthus occidentalis*), and great blue lobelia (*Lobelia siphilitica*) among others that are well-suited to these moist pockets and make for an extraordinary show of color and pollinator activity.

Expanding 'no-mow' wildflower areas and reducing lawn acreage in lieu of wild margins and seeded wildflower strips will help make use of otherwise overlooked corners. Any opportunity to replace exotic ornamental plants with natives that have similar attributes or are better suited to site conditions should be taken. Some existing landscaping features will undoubtedly be disturbed or eliminated due to future building renovations; it is imperative that these native plant communities be replicated or incorporated elsewhere to avoid the loss of unique host plants and seasonal resources for pollinators and wildlife. Alongside plantings, providing adequate access to open, uncompacted soil is vital for supporting solitary ground-nesting bees, which are often depauperate in urban settings due to lack of nesting substrates (Matteson et al, 2008). Reducing the use of mulch, stones, and landscaping fabric will improve nesting habitat availability for wild bees. If weed suppression is needed, consider alternatives such as leaf litter, pine needles, untreated wood chips, or denser plantings.

At the same time, there are still opportunities to continue expanding our species palette on the ESF campus. Numerous faculty, students, and student organizations have expressed a desire to see examples of unique and unusual habitats installed on campus, from salt marsh to pine barrens. Not only do these microhabitat patches have educational and research value, but they further serve to support more pollinator species if done effectively, including those that are rare and habitat-restricted in the northeast. We highly encourage collaboration between our Grounds and Landscape Architecture departments to develop planting designs to bring these ideas to fruition. On a per-species basis, we would recommend the addition of ericaceous plants, e.g., lowbush blueberry (*Vaccinium angustifolium*), great rhododendron (*Rhododendron maximum*), mountain or sheep laurel (*Kalmia latifolia*, *K. angustifolia*) – these require acidic and/or sandy soils which could be amended with the purpose of showcasing a unique natural community (such as alongside pitch pine and scrub oak) or individually; note though at least small colonies of the plants, and visible, open patches of sandy soil, are usually necessary for their associated pollinators.

*Figure 13. Two woodland-associated specialist mining bees that could be supported on campus if populations of their host plants are established. a) Spring-beauty mining bee (*Andrena erigeniae*), which specializes on spring-beauty (*Claytonia*). b) Cranesbill mining bee (*Andrena distans*), which specializes on wild geranium (*Geranium maculatum*). Ample space exists on campus that would meet the growing conditions of these plants.*

Other examples of high-value pollinator plants and specialist host plants that may more easily be added to campus include native sunflowers (e.g., *Helianthus divericatus*), native thistles (e.g., *Cirsium discolor*), wild geranium (*Geranium maculatum*), bellflowers (*Campanula* spp.), brambles (e.g., *Rubus occidentalis*), meadowsweet (*Spiraea alba*), ground-cherries (*Physalis* spp.), and more specimen canopy trees like red oak (*Quercus rubra*), sugar maple (*Acer saccharum*), black cherry (*Prunus serotina*), and tulip-tree (*Liriodendron tulipifera*). The addition of an ESF-grown American chestnut would be a poignant showcase that would support thousands of pollinators and potentially even attract the rare, at-risk chestnut mining bee, now that we know it occurs in Syracuse.

At its core, Bee Campus is about creating and restoring habitat. Bees are the umbrella taxon, but the principles behind their conservation are those which govern the conservation of all species. We strive to keep in mind the plants and habitat features that support other wildlife so closely intertwined with bees, like butterflies and moths, and songbirds. Lepidoptera require larval host plants like specialist bees, and not only do adults act as pollinators but they are a primary food source for songbird chicks (Narango et al. 2018). These songbirds, whether resident or migratory, forage for caterpillars and other insects, pluck berries and seeds, and find vital shelter from our trees, shrubs, and forbs on campus.

Alongside pollinator goals, we wish to provide ESF students valuable experiences and opportunities to grow and connect with the land around them. A secondary facet of our Bee Campus efforts has been to support food forest and edible landscape initiatives popular with students, choosing pollinator favorites that also produce human-edible fruits and nuts that students can forage. Serviceberries (*Amelanchier* spp.), spicebush (*Lindera benzoin*), and pawpaws (*Asimina triloba*) are just some of the multi-purpose plants we have added (Fig. 14).

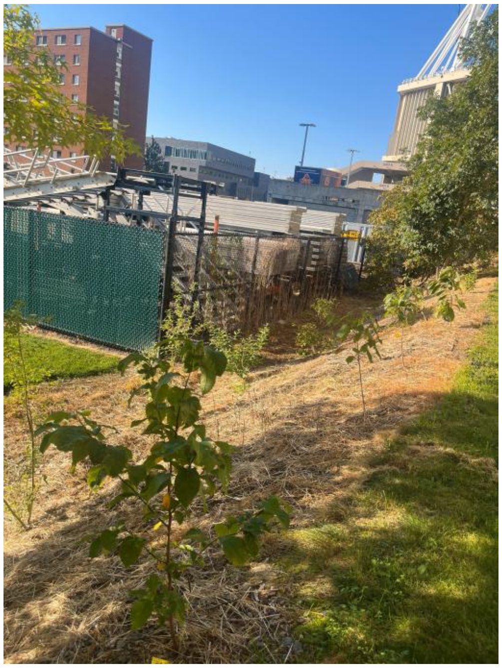

Figure 14. Enhanced Gateway hedgerow, partially cleared and replanted in July 2025. Pawpaws, beach plums, witch hazel, American hazelnut, pussy willow, and more have been added for pollinator, wildlife, and human value.

There is great overlap between the native plant species that most productively host bees, moths, songbirds, and more, while enriching human lives as well; it is not difficult to optimize native plant selection to create habitat for a wide swath of biodiversity under the guise of pollinator-friendly landscaping. This guiding principle marks the difference between ornamental flower plantings catered to common generalist bees and butterflies, and quality, functional habitat that contributes meaningfully to regional conservation. ESF must continue to innovate and seek the latter – not just on its main campus but its other campuses and properties as well – and the same can be said for the city of Syracuse itself.

Many, if not most, of the bee species we have documented on campus come to us from surrounding areas – corridors and habitat patches that already exist across neighborhoods and city-owned properties, granting bees passage to find our gardens. A commitment to using regionally native species in landscaping, to reduce or ideally eliminate pesticide use in our green spaces, and to follow ecological design principles instead of simply aesthetic or short-term financial ones, could transform this city – and any city – into a critical refuge for our native bees, birds, and butterflies, not just surviving but thriving alongside us. All of us can contribute to reconnecting the landscape, whether through a container garden, a sidewalk median mini-meadow, a farm field margin, or a community garden plot. We hope you will pledge to make this change with us, to build a better future for pollinators and humans alike.

Future Survey Efforts

Two full years of bee surveys, plus several years of iNaturalist observations, have produced what we deem to be a sufficient representation of our campus bee fauna. There are undoubtedly species we have missed, and we will continue to seek specific targets. Some plants with pollinator potential were not swept, such as winterberry holly (*Ilex verticillata*), Virginia rose (*Rosa virginiana*), and wild indigo (*Baptisia* spp.), thus we will attempt to fill these remaining gaps with intermittent effort in 2026. The iNaturalist project is self-sustaining and can continue indefinitely, and we will continue to promote student engagement. However, these surveys have served their vital purpose, and so, such intensive and comprehensive efforts are not needed in immediate following years. Instead, we recommend that followup surveys be undertaken once major campus plantings have had time to establish and mature, such as the Quad Meadow, Gateway hedgerow, and landscaping around newly-renovated Marshall Hall. The timeline for these future surveys may be five or ten years from present. The goal of followup monitoring would be to compare bee species richness and community composition to our current findings, ideally collecting necessary data to draw direct connections between increased bee diversity and increased quantity and quality of campus habitat. Plant species that have only recently been installed, such as pussy willow, mock-orange, American fringetree (*Chionanthus virginicus*), mountain maple (*Acer spicatum*), and many others, would be targets for sweep-netting, and specialist bees both documented and as-of-yet unrecorded should be focal taxa alongside bumblebees and at-risk species.

Surveys like those we have conducted are immensely valuable to our scientific understanding of species distributions, ecology, and conservation needs. Our campus is not supremely special; while we have gone out of our way to landscape ecologically – and this has almost certainly led to a richer bee community – we are still located in a moderately dense urban setting. Surprising species diversity can occur anywhere, and inventories will unfortunately never be performed for most places, making those that do occur all the more important. Other Bee Campus and Bee City chapters across the country are strongly encouraged to undertake their own survey efforts, to document the unique bee community in their patch of Earth, and to learn how their passionate efforts have benefited the small but resilient creatures they seek to protect.

We hope that the fascinating and encouraging results from our surveys inspire other universities, municipalities, and homeowners to create native habitat. While our results are preliminary, we demonstrate that developed and disturbed landscapes can support diverse pollinator communities. Even small patches of habitat make a tangible difference, especially when designed thoughtfully and intentionally to meet the specific needs of native bees – bloom turnover, varied colors, shapes, and lineages of plants, nesting sites, and specialist host plants. What might start as a single small habitat pocket can easily grow into large, connected corridors capable of supporting immense biodiversity, when communities come together and commit to positive change. Here at ESF we are proud to be a part of these efforts, upholding the founding principles of our great College and planting seeds of hope for the future.

Acknowledgements

Photo credits: Figs 2–9 and 11–13 by Molly Jacobson. Fig 14 by Luella Johnson. Cover photo of male *Augochloropsis viridula* by Molly Jacobson.

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Further Information

ESF Bee Campus website: https://www.esf.edu/sustainability/initiatives/facilities-operations/campus-grounds/bee-campus-usa/index.php

ESF Bee Campus plant resources website: https://www.esf.edu/sustainability/initiatives/facilities-operations/campus-grounds/bee-campus-usa/plant-recommendations/index.php

Bee City USA & Bee Campus USA national website: https://beecityusa.org/

ESF Pollinators iNaturalist Project: https://www.inaturalist.org/projects/esf-pollinators

Restoration Science Center/ESF Bee Lab website: https://www.esf.edu/research/restorationscience/pollinator-ecology.php

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Table 1. Bee species recorded on the SUNY ESF main campus, through November 2025. This list combines data from specimen collection events and Research Grade observations on the ESF Pollinators iNaturalist project. Species observed by both survey methods are shaded gray, and the number of RG iNaturalist observations are given in parentheses in the abundance column. Those observed only on iNaturalist are denoted with * and thus abundance here refers to number of RG observations. † denotes non-native. Rankings when available taken from the 2022 Empire State Native Pollinator Survey.

Family	Bee Species	Common Name (if any)	Number Recorded	ESNPS Rank
Andrenidae	*Andrena arabis*	mustard mining bee	1	S2S3
	Andrena barbilabris	long-lipped mining bee	1	S2S4
	Andrena carlini	Carlin's mining bee	2	S3S5
	Andrena forbesii	Forbes's mining bee	3	S3S4
	Andrena crataegi	hawthorn mining bee	18	S3S5
	Andrena cressonii	Cresson's mining bee	1	S3S4
	Andrena dunningi	Dunning's mining bee	5	S3S4
	Andrena hippotes	orange-legged mining bee	4	S3S4
	Andrena hirticincta	hairy-banded mining bee	1(3)	S3S4
	Andrena imitatrix	imitator mining bee	19	S3S4
	Andrena integra	bare dogwood mining bee	1	S2S3
	Andrena mandibularis	toothed mining bee	4	S3S4
	*Andrena milwaukeensis**	Milwaukee mining bee	1	S3S4
	Andrena miserabilis	miserable mining bee	14	S3S4
	Andrena nasonii	Nason's mining bee	10	S3S4
	*Andrena nubecula**	cloudy-winged mining bee	2	S3S4
	Andrena perplexa	perplexing mining bee	1	S3S4
	Andrena placata	peaceful mining bee	1	S3?
	Andrena platyparia	plated mining bee	1	S3S4
	Andrena pruni	cherry mining bee	6	S3S4
	Andrena rufosignata	brown-fovea mining bee	1	S3S4
	Andrena simplex	simple mining bee	1	S3?
	Andrena vicina	neighborly mining bee	26	S3S5
	Andrena wilkella†	Wilkes's mining bee	3	SNA
Apidae	*Anthophora terminalis*	orange-tipped wood-digger bee	1	NR

	Apis mellifera†	western honeybee	60(47)	NR
	Bombus auricomus	black-and-gold bumblebee	5(8)	S2
	Bombus bimaculatus	two-spotted bumblebee	15(2)	S4S5
	Bombus cf. *vagans*	(likely) half-black bumblebee	1(1)	S5
	Bombus citrinus	lemon cuckoo bumblebee	1(3)	S2S3
	Bombus griseocollis	brown-belted bumblebee	35(25)	S4S5
	Bombus impatiens	common eastern bumblebee	5(61)	S5
	*Bombus perplexus**	confusing bumblebee	1	S3
	*Bombus terricola**	yellow-banded bumblebee	1	S3
	Ceratina calcarata	spurred small carpenter bee	88(5)	NR
	Epeolus scutellaris	notch-backed cellophane-cuckoo bee	1	NR
	Melissodes agilis	agile longhorned bee	2	S2S3
	Melissodes desponsus	thistle longhorned bee	2	S3S4
	*Melissodes druriellus**	Drury's longhorned bee	1	S3S4
	Nomada bidentate grp sp.		1	n/a
	Nomada pygmaea grp sp.		1	n/a
	Xylocopa virginica	eastern carpenter bee	7(34)	NR
Colletidae	*Colletes inaequalis*	unequal cellophane bee	39(10)	NR
	Colletes simulans ssp. *armatus*	eastern spine-shouldered cellophane bee	3	NR
	Hylaeus affinis		4	NR
	Hylaeus cf. *illinoisensis*		7	NR
	Hylaeus hyalinatus†	hairy masked bee	37	NR
	Hylaeus leptocephalus†	slender-faced masked bee	137	NR
	Hylaeus mesillae	Cresson's masked bee	29	NR
	Hylaeus modestus	modest masked bee	8	NR
	Hylaeus pictipes†	little masked bee	19	NR
	Hylaeus modestus grp sp.		21	n/a
Halictidae	*Agapostemon sericeus*	silky striped sweat bee	7	NR
	*Agapostemon virescens**	bicolored striped sweat bee	3	NR
	Augochlora pura	pure green sweat bee	16(2)	NR
	Augochlorella aurata	golden sweat bee	63	NR
	*Augochloropsis viridula**	northeastern epauletted sweat bee	1	NR

	Halictus confusus	confusing furrow bee	22(2)	NR
	Halictus ligatus	ligated furrow bee	43(6)	NR
	Halictus rubicundus	orange-legged furrow bee	12	NR
	Lasioglossum admirandum	admirable sweat bee	1	NR
	Lasioglossum cinctipes		4(1)	NR
	Lasioglossum coeruleum	deep blue sweat bee	1	NR
	Lasioglossum coriaceum	leathery sweat bee	1(1)	NR
	Lasioglossum cressonii	Cresson's sweat bee	1	NR
	Lasioglossum ephialtum	nightmare sweat bee	36	NR
	Lasioglossum foxii	Fox's sweat bee	1	NR
	Lasioglossum gotham	Gotham sweat bee	3	NR
	Lasioglossum heterognathus	wide-mouthed sweat bee	5	NR
	Lasioglossum hitchensi	Hitchens's sweat bee	8	NR
	Lasioglossum imitatum	bristle sweat bee	14(1)	NR
	Lasioglossum laevissimum	very smooth sweat bee	16	NR
	Lasioglossum leucozonium†	white-banded sweat bee	2	NR
	Lasioglossum lineatulum	lineated metallic sweat bee	40	NR
	Lasioglossum nigroviride	black-and-green metallic sweat bee	2	NR
	Lasioglossum oblongum	oblong sweat bee	2	NR
	Lasioglossum platyparium		3	NR
	Lasioglossum subviridatum		1	NR
	Lasioglossum tegulare	epaulette metallic sweat bee	3	NR
	Lasioglossum zonulus†*	bull-headed sweat bee	1	NR
	Lasioglossum (*Dialictus*) sp.		51	n/a
Megachilidae	*Anthidium manicatum*†*	European wool-carder bee	1	NR
	Anthidium oblongatum†	oblong wool-carder bee	9(4)	NR
	Chelostoma philadelphi	mock-orange scissor bee	1	NR
	Coelioxys modestus	modest cuckoo leafcutter bee	1	NR
	Coelioxys octodentatus	eight-toothed cuckoo leafcutter bee	3	NR
	Heriades carinata	carinate armored-resin bee	14	NR
	Heriades leavitti	Leavitt's armored-resin bee	1	NR
	Hoplitis pilosifrons	hairy-fronted small-mason bee	1	NR

Hoplitis producta	produced small-mason bee	5	NR
Megachile centuncularis†	patchwork leafcutter bee	3	S3S4
Megachile frigida	frigid leafcutter bee	1	S3S4
Megachile latimanus	broad-handed leafcutter bee	1	S3S4
Megachile pugnata	pugnacious leafcutter bee	6	S3S5
Megachile relativa	golden-tailed leafcutter bee	1	S3S4
Megachile rotundata†	alfalfa leafcutter bee	35	SNA
Megachile sculpturalis†*	sculptured resin bee	1	SNA
Megachile texana	Texas leafcutter bee	4	S3S4
Osmia cornifrons†	horn-faced mason bee	28(5)	SNA
Osmia georgica	Georgia mason bee	2	S2S3
Osmia lignaria	blue orchard mason bee	1	S3
Osmia pumila	dwarf mason bee	1	S3S5
Osmia taurus†	Taurus mason bee	1	SNA
Pseudoanthidium nanum†	European small-woolcarder bee	2(1)	NR
Stelis coarctatus	compressed dark bee	1	NR
Stelis louisae	Louisiana painted-dark bee	1	NR

Table 2. Specialist bee host plants installed on the ESF campus through Bee Campus plantings since 2022, and associated specialist bees we have documented on campus. Information adapted from Fowler & Droege 2020; some specialists were excluded based on habitat restrictions, dubious presence in the region, or uncertainty as to the frequency some plant genera are used as secondary hosts. Plants arranged taxonomically by family and further grouped by common relationships to specialist bees.
Numbers with a "~" are estimates, as many specialist-host relationships are not well-understood. * denotes specialists where the listed plant is believed to be a secondary host rather than the main host. "G" means the genus, but not the species, was present prior to Bee Campus plantings.

Host Plant	Previously Present on Campus?	# of Possible Specialist Bee Species	# of Specialists Detected	Specialist(s) Detected
Rhus copallinum (winged sumac)	Y	~2	0	
Zizia aurea (golden-alexanders)	Y	1	0	
Coreopsis lanceolata (lance-leaved coreopsis)	Y	~6	1	*Megachile pugnata*
Coreopsis verticillata (whorled tickseed)	G	~6	1	*Megachile pugnata*
Rudbeckia fulgida (orange coneflower)	N	~12	3	*Megachile pugnata, Melissodes agilis*, Melissodes druriellus**
Eurybia macrophylla (large-leaved aster)	G	~21	6	*Andrena hirticincta*, Andrena nubecula*, Andrena placata*, Andrena simplex*, Melissodes druriellus*, Colletes simulans**
Eurybia spectabilis (showy aster)	G	~21	6	""
Symphyotrichum novae-angliae (New England aster)	Y	~21	6	""
Symphyotrichium oblongifolium (aromatic aster)	G	~21	6	""
Symphyotrichum oolentangiense (sky-blue aster)	G	~21	6	""
Symphyotrichum prenanthoides (crooked-stem aster)	G	~21	6	""
Symphyotrichum puniceum (swamp aster)	G	~21	6	""

Euthamia graminifolia (flat-topped goldenrod)	Y	~22	6	*Andrena hirticincta, Andrena nubecula, Andrena placata, Andrena simplex, Melissodes druriellus, Colletes simulans*
Oligoneuron rigidum (stiff goldenrod)	N	~22	6	""
Solidago flexicaulis (zigzag goldenrod)	G	~22	6	""
Solidago caesia (blue-stemmed goldenrod)	G	~22	6	""
Solidago gigantea (giant goldenrod)	G	~22	6	""
Solidago nemoralis (old field goldenrod)	G	~22	6	""
Solidago ohioensis (Ohio goldenrod)	G	~22	6	""
Solidago patula (rough-leaved goldenrod)	G	~22	6	""
Solidago puberula (downy goldenrod)	G	~22	6	""
Solidago rugosa (wrinkle-leaved goldenrod)	G	~22	6	""
Solidago sempervirens (seaside goldenrod)	Y	~22	6	""
Solidago speciosa (showy goldenrod)	Y	~22	6	""
Solidago uliginosa (bog goldenrod)	G	~22	6	""
Solidago ulmifolia (elm-leaved goldenrod)	G	~22	6	""
Hydrophyllum virginianum (Virginia waterleaf)	N	1	0	
Cardamine concatenata (cut-leaved toothwort)	G	1	1	*Andrena arabis*
Uvularia grandiflora (merrybells)	N	1	0	
Uvularia perfoliata (perfoliate bellwort)	N	1	0	

Cornus racemosa (gray dogwood)	Y	4	2	*Andrena integra, Andrena playparia*
Gaylussacia baccata (black huckleberry)	N	1	0	
Vaccinium corymbosum (highbush blueberry)	N	8	0	
Astragalus canadensis (Canada milkvetch)	N	1	0	
Philadelphus inodorus (scentless mock-orange)	N	1	1	*Chelostoma philadelphi*
Hibiscus moscheutos (swamp rose-mallow)	Y	1	0	
Claytonia virginica (Virginia spring-beauty)	N	1	0	
Penstemon digitalis (foxglove beardtongue)	N	1	0	
Penstemon hirsutus (hairy beardtongue)	Y	1	0	
Lysimachia ciliata (fringed loosestrife)	N	3	0	
Ceanothus americanus (New Jersey tea)	N	1	0	
Salix discolor (pussy willow)	G	10	0	
Viola pubescens (downy yellow violet)	G	1	0	