Martha's Vineyard Pollinator Pathways:

Assessing and Supporting Pollinators on Martha's Vineyard Farms

A Project of the Betsy and Jesse Fink Family Foundation

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This report presents the highlights of a study of pollinators on farms on the island of Martha's Vineyard, Massachusetts. The project was developed and funded by the Betsy and Jesse Fink Family Foundation (BJFFF) in collaboration with eight Vineyard farms. Fieldwork was conducted across three growing seasons — 2022, 2023, and 2024 — by BiodversityWorks (BWorks), a conservation nonprofit based in Vineyard Haven, Massachusetts. Matt Pelikan, director of the Martha's Vineyard Atlas of Life project at BWorks, coordinated the scientific component of the project, including data collection and analysis, and was the primary author of this report as well as of year-end reports from the 2022 and 2023 field seasons. The BJFFF, in cooperation with participating farms, was responsible for the horticultural side of the project, including project plot preparation, sourcing plant material, and plant installation and maintenance.

BWorks and the BJFFF extend their warmest thanks to the eight farms that partnered with us on this three-year pilot project: Beetlebung Farm, North Tabor Farm, Mermaid Farm, Whippoorwill Farm, Thimble Farm (Island Grown Initiative), Morning Glory Farm, Slough Farm, and The Farm Institute (The Trustees of Reservations). The project could not have been conducted without the cooperation of our partner farms. But more than that, we found all of the participating farms to be endlessly rewarding places to visit and explore. Each farm has its own distinct character, with unique crop choices, cultivation methods, and management of non-producing areas, and those factors translated into distinctive ecological conditions and mixes of species. One thing shared by all the farms, though, was a remarkable degree of biological productivity, and studying that diversity was both interesting and fun.

Figure 1: Locations of the eight farms participating in this project

While the focus of this project was squarely on farm pollinators, and all fieldwork was performed on farms, many of our observations and conclusions are more broadly applicable. We would expect, for example, that the flowers we tested in the project's experimental plots on participating farms would perform in a similar way in residential settings on Martha's Vineyard. So we encourage readers of all kinds to make use of whatever inspiration and ideas they find here. At the same time, it is important to acknowledge the geographical and ecological specificity of this project. The Vineyard is an unusual place, with distinctive underlying geology, land use history, climate, and ecology. And farms are distinctive environments, characterized by high levels of management, intense cycling of nutrients, and a history of introductions (both deliberate and accidental) of non-native species. Other regions and other types of habitat, then, will be characterized by different species composition and, therefore, different ecological interactions. Many of our conclusions, we believe, will still be applicable across Martha's Vineyard and indeed most of the northeastern United States (for example, the important role we see goldenrods playing in the support of late-season, pollen-specialist bees). But extrapolation of our results to other regions and other habitats should be done with caution, the level of caution increasing with distance and dissimilarity from our geographical focus.

ORIGINS, GOALS, AND METHODS

This project began to take shape during the spring of 2021, emerging from an ongoing discussion among the BJFFF and several Vineyard farms of agricultural sustainability on Martha's Vineyard. At that point, methods that reduce the impacts of farming were already being broadly employed: organic farming methods, integrated pest management, low-till or no-till field maintenance, mulches for water moisture retention and weed suppression, and soil regeneration techniques were being used, in various combinations, by all the farms we were in contact with. Likewise, several of the farms were planting "pollinator rows" to encourage ecosystem services provided by the natural environment surrounding farms (on other farms, naturally occurring wildflowers in unmanaged areas served a similar function). But during an interesting and free-ranging discussion with Island Grown Initiative staff at Thimble Farm, a new twist emerged: beyond minimizing negative impacts and encouraging natural pollination and pest control, what if farms actively worked to support wildlife *purely as a contribution to the overall ecological health of Martha's Vineyard*?

The idea isn't really a surprising one in light of the many and varied ways in which Island farms already support the local community. And birders and butterfly-watchers, among others, would certainly agree that farms frequently offer valuable habitat for wildlife. But thinking of biodiversity as yet another "crop" farms can produce represented an intriguing new direction for the discussion of sustainability, raising a host of questions and possibilities. With ongoing input from local farmers, a BJFFF task force consisting of Matt Pelikan, Warren Adams, and Claire Callagy began identifying knowledge gaps, opportunities, and possible approaches to studying and promoting biodiversity on farms. Numerous other people contributed their ideas: in particular, Molly Jacobson, a pollinator ecologist and BJFFF Fellow at the School of Environmental Science and Forestry at the State University of New York (Syracuse), Sarah Bushman, an independent bee expert in Maine, and Kelly Gill of the Xerces Society offered indispensable suggestions.

The early planning stages involved some difficult decisions about the scope and goals of the project, necessary to accommodate the level of resources available. Given likely levels of staffing, the desire for a relatively short time frame for producing results, and the difficulties we anticipated in conducting any kind of rigorously controlled, manipulative experiment in open settings on working farms, we settled on a primarily observational approach for the project.

What emerged was the three-year study that is summarized in the following pages. Although many types of wildlife make use of farms as habitat, we chose to focus specifically on pollinators. (More accurately, we focused on arthropods and other animals visiting flowers for any reason, whether or not they were actually performing pollination. But we use “pollinator” as an imprecise but practical shorthand for flower visitors throughout this report.) This decision reflected the overall ecological importance of pollinators both on farms and in the general environment. Within the general class of pollinators, we settled on a particular emphasis on bees, a group that has especially close ecological relationships with flowers, and even more specifically on oligolectic bees — that is, bees that are conspicuously specialized in their foraging habits, having evolved to collect most or all of their food from a short list of plant genera or species. Such bees tend to be uncommon to start with, and in the context of climate change, habitat loss, and habitat fragmentation, can safely be presumed to be especially vulnerable because of their dependence on specific resources.

One question this study sought to address, then, was whether or how farms could feasibly contribute to the conservation of specialist bees on Martha’s Vineyard (and, by extension, elsewhere as well). The issue of feasibility was one we took seriously throughout the project. Vineyard farms, whether organized as for-profit or non-profit entities, need to be financially sustainable operations, and the amount of work required to run a successful farm is essentially infinite. We felt that any methods we ended up proposing to increase pollinator support had to be effective while adding very little to the workload of farm staff.

But as the project took shape, an information gap became evident: very little was known about the relationship between farm habitat and pollinators on Martha’s Vineyard. How many species visit flowers on farms, how can that suite of species be characterized, and what flowers do they visit? To address these unknowns required including a broad observational element in the project. Moreover, we recognized that our limited resources for the project and the difficulty of controlling the many variables that govern insect behavior in an open system made a rigorously quantitative approach impossible. We came to think of the study as a pilot project rather than an experiment; we would perform some simple habitat manipulations, apply a skilled naturalist’s eye across multiple field seasons, and see what the behavior of arthropods and the responses of plants could teach us. This observational approach limited our ability to draw quantitative conclusions. But by freeing our observers up to find where insects were concentrated, it allowed us to produce a detailed picture of what floral resources insects were actually using.

The project that emerged from this discussion had the following elements:

I. In an effort to find ways in which farms could encourage pollinators, particularly specialist bees, we decided to install test plots containing flower species selected to appeal to different groups of pollinators. We decided to limit ourselves to herbaceous plant species for our test plots; given the expected short duration of the project, we were not sure that woody plants would reliably reach maturity during the study, and we wanted our plots to be easily convertible to other uses once the project was complete (which might be complicated by the presence of well-established shrubs or trees). We also decided to test primarily perennial plants, on the assumption that yearly replanting with annuals would be too labor-intensive either for this project or for farms in general. Finally, we wanted to select a species mix that included both general pollinator plants, attractive to a wide range of insects, as well as species known to be used by pollen-specialist bees.

In the case of some of the participating farms, some of the species installed in our project plots would represent species newly added to the site, allowing a qualitative comparison between flower visitation within the project plots and flower visitation in adjacent areas of the farms. In other cases, our test species (or very close analogs) already existed on the farms; in these cases, we would still get qualitative information on what pollinators were visiting what flowers. Reflecting a mix of project goals and plant availability on the commercial market, we settled on a list of nine species for our project plots:

1. *Euthamia graminifolia* (flat-topped goldenrod): a common and broadly distributed species in the wild on Martha's Vineyard, *E. graminifolia* is a goldenrod species that begins blooming relatively early in the season and has a prolonged bloom period. Previous observation on Martha's Vineyard and consultation with pollinator experts suggested that this species would be popular with many generalist pollinators as well as with specialist bees associated with late-season native composite flowers.

2. *Solidago nemoralis* (field goldenrod): also native to the Vineyard, though relatively uncommon here, this species was selected over several other *Solidago* species because plugs were readily available on the commercial market. We made the untested but hopefully reasonable assumption that while the many *Solidago* species found on the Vineyard no doubt perform slightly differently as pollinator plants, members of this large and important genus are probably more similar than different in their ecological functions. As with *Euthamia*, our hypothesis was that this species would attract at least small numbers of specialist bees while also being attractive to many generalists.

3. *Symphyotrichum laeve* (smooth aster): yet another uncommon Vineyard native species, this aster produces fairly large flowers with blue rays and yellow centers. Again, our decision to use it stemmed partly from its easy availability in adequate quantities. While we originally hoped to complement this species with a white-rayed aster such as *S. pilosum*, we were unable to source such a plant. The inclusion of *Symphyotrichum*, as with the two goldenrod species, was partly aimed at attracting late-season specialized bees. We were curious about whether or how the species mix visiting *Symphyotrichum* differed from that visiting the goldenrods.

4. *Asclepias tuberosa* (butterfly weed): a widespread and abundant native species on Martha's Vineyard, butterfly weed is readily available from commercial suppliers and is famously attractive to pollinators of all kinds. We knew this species would already be present on some of the participating farms, either growing wild or included in pollinator rows, and we included it primarily for its ability to attract a wide range of generalist pollinators.

5. *Helianthus annuus* (sunflower): the only annual species included in our project plots, we chose to test sunflower in part because of its association with several specialist bees in the genus *Melissodes*.

6. *Trifolium repens* (white clover): a non-native plant that is widespread on farms and broadly naturalized in yards, old fields, and even some natural areas on Martha's Vineyard, *T. repens* is well known as a plant that attracts a mix of generalist pollinators and is also popular with several species of bumble bees (the genus *Bombus*). We were hopeful that one or both of the clover species would attract one of the *Bombus* species that are rarely observed or known only historically on Martha's Vineyard, e.g, *B. affinis*, *B. fervidus*, *B. terricola*, or the nest parasite *B. citrinus*. (None of these species was detected during the project, but clovers may figure in an

apparent association between the locally uncommon *B. vagans* and agricultural habitat on the Vineyard; see our "Results" section below for details.)

7. *Trifolium pratense* (purple clover): another non-native species that is both adventive and deliberately cultivated on farms, this plant was also chosen in the hope that it would attract some of the less common bumble bee species. Like *T. repens*, this species also attracts a wide range of generalist pollinators.

8. *Monarda punctata* (spotted horsemint): one of two species we tested with long, tubular flowers, this plant was included in our test plots mainly to see whether it attracted long-tongued members of the genus *Bombus*.

9. *Monarda didyma* (scarlet beebalm): also included primarily to see if it would attract long-tongued bees, this is another "near native" species that we selected in part because we expected it would flourish in Vineyard agricultural settings. Its flowers are more elongated and also more brightly colored than those of *M. punctata*, and we wondered if these two related species would function in similar or different ways.

Test plots were nominally planned to comprise 225 square feet in 5-foot X 45-foot patches, with 25-square-foot (5' X 5'), single-species plots of each test species. Space constraints and other considerations altered this model at some of the farms; plots varied somewhat in size and shape, and in some cases, species were interplanted (e.g., sunflowers growing in clover patches or the two *Monarda* species interplanted in the same plot). Our assumption, untested, was that larger, unbroken plots of our test plants would produce more pronounced visual and chemical signatures than more scattered plantings, increasing their detectability or attractiveness to pollinators.

Monarda punctata, *M. didyma*, *Symphyotrichum laeve*, and *Euthamia graminifolia* in bloom in the project plot at Whippoorwill Farm in 2022.

All test plots were prepared by tilling, with labor and equipment contributed by participating farms. Provision was made for irrigation of the plots at least during the first year, while the plants were becoming established. And a layer of wood chip mulch was applied to all project plots to suppress weeds while test plants were settling in. Test plants received a good deal of support in the first year of the project, with periodic weeding performed by Parker Fyfe-Kiernan and Elisabeth Sheldon. In years two and three of the project, somewhat less weeding and watering were performed, in part because we wanted to see how self-sufficient our test species would prove to be in an agricultural setting.

II. We settled on a three-year duration for the field component of the project. Two main considerations drove this decision. First, since we were installing our test plants as small, mostly one-year-old plugs, we wanted to ensure that these plants would have time to reach maturity during the project. Second, we were aware of how dramatically invertebrate populations can vary from year to year, and we felt that three years was the minimum duration that would allow the project to "even out" such variation and provide a realistic general picture of both plant growth and pollinator behavior.

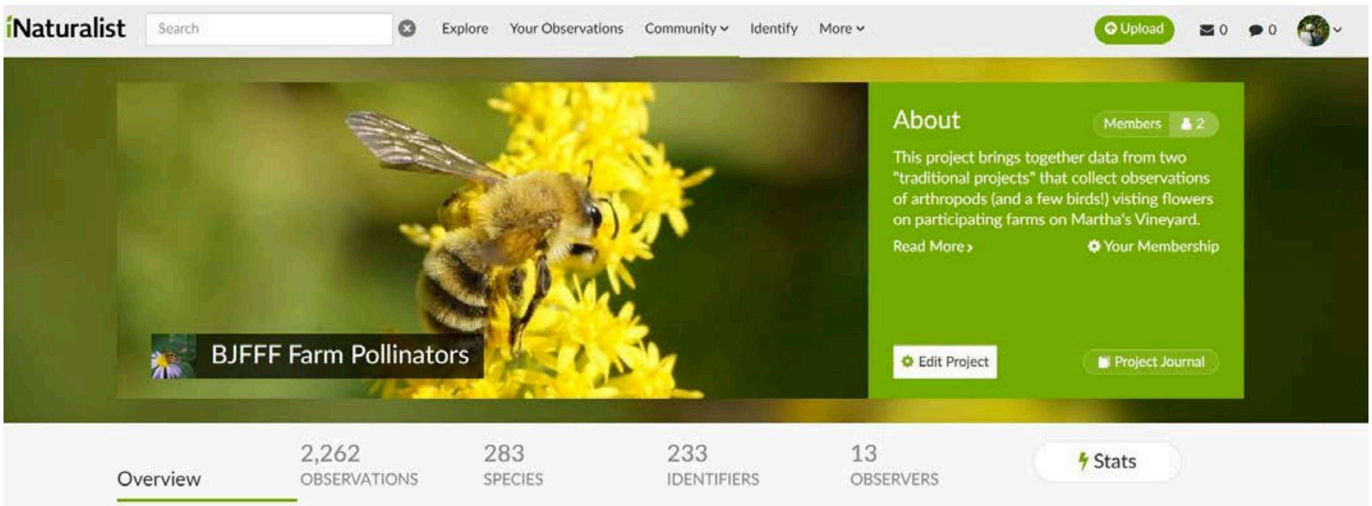
III. We concluded that the somewhat divergent goals of the project required multiple methods of data collection and aggregation. We settled on the iNaturalist ("iNat") community science platform as our main tool for managing data. This platform has many advantages: it is free to use, it offers identification help both from artificial intelligence and from human users, it allows for very easy data selection and sorting, and it enhances the utility of project data by making it available to naturalists and scientists around the world. The platform relies primarily on photographs to support observations, and our field staff used various kinds of digital or smartphone cameras in collecting data. Taking advantage of the analytical tools built into iNaturalist, we set up three iNat projects with an eye toward making it easy to select important subsets of data:

1. One project (https://www.inaturalist.org/projects/mv-pollinator-pathway-farm-pollinators) was established for observations on insects and other animals visiting flowers in areas outside our project plots (we called these "general" observations);

2. A second project (https://www.inaturalist.org/projects/mv-pollinator-pathway-project-plots) was established for observations made within the project's test plots, involving visits to the plants we had installed; and

3. An "umbrella project" was set up to automatically combine the observations from the first two projects: https://www.inaturalist.org/projects/bjfff-farm-pollinators. The first two projects required manual addition of qualifying observations, an extra step that could not be avoided given the nature of the data we were collecting. Requirements for inclusion in one of the projects were flower visitation by the subject and the inclusion of the name of the flower being visited in a special data field. Because the eight participating farms are well separated, iNat's map-based geographical filter makes it very easy to select the data from just one farm. So it is relatively easy to select general, project plot, or combined data from any of the farms, or compare general with project plot data across the entire project. Any data subset is also easy to search for any particular taxonomic group.

While iNaturalist proved to be a good choice for our purposes, it is important to note that species that are difficult to detect or photograph tend to be under-represented in iNaturalist data. And in the case of our project, very common species tended to be under-represented as well, since observers usually found it expedient to enter only a small number of "voucher" observations of plentiful species so that time was available to observe and document other species. It is important to remember that, due to the crowd-sourced nature of iNaturalist identifications, the project data set in iNaturalist will continue to evolve. Identifications may be added, refined, or corrected, and observations could be added or removed from the project. Numbers used in this report were accurate at the time relevant sections of the report were written but may have changed at any point in the future. We do, however, expect such changes to be relatively minor and unlikely to alter any of the generalizations or conclusions we draw.



Recognizing our particular focus on bees and the challenges of species-level identification of bees from photographs, we collected bee specimens (as well as a few specimens of other taxa) during all three years of the project to facilitate identification and work toward a voucher collection for the project. As with our iNaturalist observations, species determination of our bee specimens will be an ongoing process; in particular, additional species may emerge from the many specimens that we have so far been unable to identify to species level.

Finally, for each site visit, the observer(s) created a narrative account summarizing conditions observed and memorializing, to the extent possible, all arthropods photographed for iNaturalist, all insects collected, and all arthropods observed on flowers but not documented by photographs or specimens. These site visit narratives, because they recorded the numbers of each species observed, are a helpful complement to iNaturalist data, though their text-based nature and their sheer volume can make them cumbersome to work with. In preparing this report, we have made considerable use of site visit narratives but have done so with a cautious awareness that they include observations unsupported by documentation and therefore unverifiable in retrospect.

ACTIVITY MEASURES AND 2024 SEASON SUMMARY

While the 2024 field season produced a lot of data and many interesting observations, it was not without its challenges. In general, little insect activity was observed during the early portion of the season, with activity starting to pick up around mid-July. Previous years showed a similar though less pronounced pattern, which we suspect results from some combination of actual insect diversity (low to start with and generally increasing as the season progresses) and plant phenology (especially in our project plots, the availability of flowers can be quite low early in the season). Results in 2024 may also have shown the effects of a severe drought during the summer of 2023, which may have reduced survivorship of the immature stages of many insects with annual life cycles, depressing populations in 2024. Much of the summer of 2024 featured warm, largely rain-free, but overcast weather, workable but not ideal for insect observation; these conditions may have reduced the total amount of activity we observed this year. Finally, mid- and late September featured a prolonged run of cool, overcast, and often wet weather. This coincided with the peak bloom period for goldenrods and asters, especially in our project plots, and the unfavorable conditions for fieldwork almost certainly reduced the number of observations of insects on goldenrod and aster that we were able to make.

Annual reports from previous seasons are available on the Martha's Vineyard Atlas of Life website:

> 2022: https://mval.biodiversityworksmv.org/wp-content/uploads/2024/08/2022-Report_MV-Pollinator-Pathways-2.pdf
>
> 2023: https://mval.biodiversityworksmv.org/wp-content/uploads/2024/08/2023-year-end-report.pdf

Project staff made a total of 82 site visits to participating farms in 2024, the first on April 26 and last on October 24. Across the three years of the project, we made a total of 261 site visits. Site visits were roughly evenly distributed among the eight participating farms. Observers included Parker Fyfe-Kiernan, the project field assistant in 2022 and 2024; Jennifer Sepanara, project field assistant in 2023; Matt Pelikan, project coordinator, who collected data all three years; and Molly Jacobson, a pollinator ecologist at the College of Environmental Science and Forestry at the State University of New York/Syracuse, who participated in some site visits in 2022 and 2024. Depending on conditions and the level of insect activity, site visits ranged in duration from about 30 minutes to almost two hours. Several other individuals added small numbers of observations to the project, and a few iNaturalist observations made independently of the project were included because they met project criteria.

On each site visit, the date, time, observer(s), temperature, sky conditions, and wind were recorded on a field data sheet designed for this project. Notes were made of the floral resources available at the time of the visit and of the condition and developmental state of plants in the project plots. On many visits, photographs were taken of project plots, further documenting their condition at the time of the visit. Observers visited both the project plots and adjacent areas of the farms, but observers were free to seek out insects wherever they occurred and no effort was made to control the amount of time or effort devoted to these two different areas. Three kinds of flower visitation data were collected: visual observations, noted on the field data sheet; iNaturalist observations, which include one or more photographs, basic metadata (date, time, location), and the flower species being visited; and specimens, which are retained in the BiodiversityWorks arthropod collection. All data sheets from the three years of fieldwork have been retained to facilitate reconciliation of any errors or ambiguities.

A total of 51 specimens were collected in 2024, ranging in date from April 26 to October 24. Across the three years of the project, we collected a total of 269 specimens representing 64 species, nearly all of them bees. All specimens have been pinned, labeled, and identified to the lowest taxonomic level we could achieve. Specimens are associated with metadata (date and location of collection, name of collector, etc.) and also with the names of the flowers they were collected from, identified to the lowest possible taxonomic level. Most specimen determinations were made by project coordinator Matt Pelikan, primarily using the identification keys found on the discoverlife.org website; Molly M. Jacobson assisted with or confirmed some identifications, and in some cases, identifications were obtained or confirmed by posting photographs of specimens as observations in iNaturalist. In December 2024, a few problematic but potentially significant bee specimens from this project were examined by Michael Veit, who generously assisted with species determination.

Project staff entered a total 797 iNaturalist observations in 2024, representing 171 species. Most of these were based on observations made in the field, but as noted above, a few were based on photographs taken of specimens. Overall, the project produced 2,264 iNaturalist observations representing 283 species. Of those observations, a total of 846 were of flower visitations in the project plots, and the remaining 1,418 were of flower visitations in other areas of the farms. With 14 bee species documented by specimens but not represented in iNaturalist, the project's total species count was at least 297. Gathered across many visits and multiple years from small project plots and relatively small surrounding areas, our photographs, specimens, and observations represent an unusually dense and detailed data set. And because eight sites distributed widely across the island were involved, project data make a considerable contribution to the general natural history information available for Martha's Vineyard.

RESULTS

It is difficult to assess our overall diversity results because there are no similar local studies for comparison. But with nearly 300 species meeting the quite restrictive spatial (in or near project plots) and behavioral (observed on flowers) criteria for inclusion in the project, it seems fair to say that our results show that Vineyard farms support a diverse and interesting flower-visiting fauna. This diversity extended to a high taxonomic level: five insect orders, for example — Coleoptera (beetles), Diptera (flies), Hemiptera (true bugs), Hymenoptera (bees, wasps, and ants), Lepidoptera (butterflies and moths) — were all commonly encountered. We observed small numbers of representatives of five other insect orders and one vertebrate class (Aves). The vast majority of the species we observed were native to North America; of the 283 species in our iNaturalist data set, only 24 are identified by iNaturalist as "introduced." The prevalence of introduced species, though, probably increases somewhat if you look at the number of observations: several non-native fly species, for example, were among the most commonly encountered Diptera.

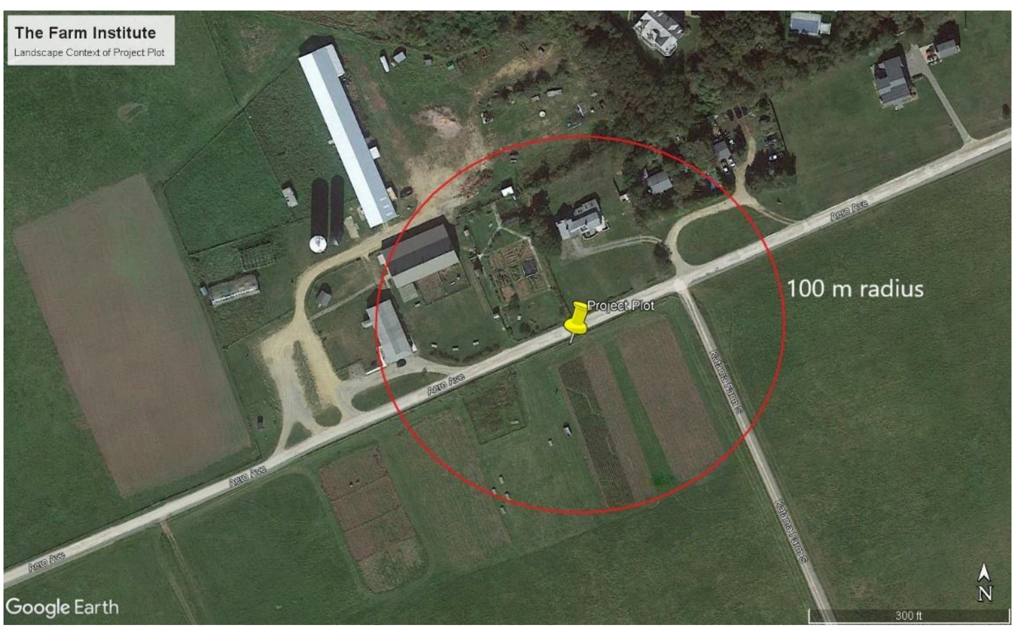
In addition to the diversity of arthropods we observed visiting flowers, the project generated an impressive list of flower species that were visited. Some plants that we would not have thought would be visited much by insects turned out to be fairly important pollinator plants, at least judged by the number of visits we observed (for example, members of the radish family, Brassicaceae, proved surprisingly popular). In retrospect, the project might usefully have collected more detail on plants. A systematic survey of plant species occurring on participating farms, for example, might have been helpful. And uneven precision in our plant identification, with some plants identified only to genus level and the same type of plant sometimes listed in project results under multiple names (e.g., scientific name, common name, or only genus), complicated analysis of our results. These shortcomings resulted from the project's ground-up focus on pollinators; flower-visiting insects, for example, were recorded in the form of discreet iNaturalist observations, while the flowers being visited were memorialized only in data fields associated within those observations, with this latter kind of data much harder to sort and analyze than full observations. It would be interesting to address these limitations in a subsequent study.

While each participating farm exhibited a lot of diversity and produced some interesting and significant discoveries, observed diversity varied somewhat from farm to farm. Some of this variation no doubt resulted from differences in the habitat and vegetation in the areas, adjacent to the project plots, that we surveyed. For example, at Thimble Farm, the project plot was sited at the edge of a fantastically varied and productive community garden, with a wide range of crops, ornamentals, and naturally occurring flowers almost always in bloom, making this site unusually productive. To some extent, our methodology has allowed us to incorporate our differences in our analysis as presented in this report. Another factor that we believe strongly influenced the results at individual farms is harder to get a handle on: the effects of landscape-scale conditions around the farms, extending out to whatever radius the farms were drawing insect visitors from. The most striking example of this was probably the relatively low productivity of the project plot at The Farm Institute, which was set in a purely agricultural context that was very poor in native flower populations, structural complexity, and important resources for nesting bees such as downed, decaying wood. Fully accounting for the interactions between landscape-scale context and arthropod diversity on farms would be very useful but would require much more involved methods, including some combination of exhaustive habitat sampling and remote habitat sensing, that would have made for a much more demanding project.

Figure 2: Farm-by-Farm Observed Diversity. Extracted from iNaturalist data. Obs. = observations; Sp. = species; Gen = general farm habitat. Plot = project plots. RG = "research grade" (i.e., confirmed)

Location	Total Obs.	Total Sp.	Gen. Obs.	Gen. Sp.	Plot Obs.	Plot Sp.	Total Obs. RG	Total sp. RG	Gen Obs. RG	Gen. Sp. RG	Plot Obs. RG	Plot Sp. RG	Bee Sp.
Beetlebung Farm	312	79	235	66	77	33	218	54	172	43	46	21	30
North Tabor Farm	329	102	207	71	122	55	189	70	118	46	71	38	31
Mermaid Farm	299	116	199	93	100	43	196	79	137	65	59	30	30
Whippoorwill Farm	329	105	173	69	156	60	227	71	124	47	103	39	27
Thimble Farm/IGI	393	115	287	96	107	48	272	83	220	69	53	30	35
Morning Glory Farm	237	81	130	57	107	49	169	58	104	48	65	26	26
Slough Farm	195	71	89	39	106	50	113	43	54	24	59	29	29
The Farm Institute	168	68	97	47	71	40	107	44	65	31	42	27	25

Figure 3: Effects of landscape context. While our methodology can't fully explain the effects, we believe that the condition of the landscape surrounding a farm strongly influences the level of diversity and the species mix that can be expected there. For example, the North Tabor Farm study area (70 "research grade" species, above) is surrounded by varied, structurally complex habitat, including native oak woodland and red maple swamp. Appreciably less diverse with just 44 "research grade" species, The Farm Institute study area (below) is embedded in a landscape dominated by farm fields, roads, structures, and lawn areas — much less promising habitat from a bee diversity perspective. It's hard to generalize about how far insects may travel in search of resources. But for many species (including many bees), 100 meters (the radius of the red circles in each image) probably represents a substantial journey.



Flower Assessments: Project Plot Test Species

1. *Euthamia graminifolia* (flat-topped goldenrod): This very common goldenrod species performed extremely well in our test plots, proving to be both durable and highly attractive to a wide range of insect visitors. Pre-existing populations of the same species also occurred on some of the participating farms, also attracting a wide range and large numbers of pollinators. Almost 11% of all project iNaturalist observations involved this single species. *Euthamia* lived up to our expectation that it would attract pollen-specialist bees. This plant produced all four of the project's records for *Andrena nubecula*, two of our specimen records for *A. simplex*, one of our three specimen records for *A. placata*, and our only record of *Colletes simulans* (a specimen). *E. graminofolia* also grew vigorously and bloomed well in all eight of our project plots, suggesting adaptability as well as the ability to persist with limited maintenance. Indeed, the ability of this species to spread aggressively by means of rhizomes amounted to a liability in some plots, where this species was interplanted with *Solidago nemoralis*; its vigor and early seasonality gave *E. graminifolia* a strong competitive edge over *S. nemoralis*, with the former almost completely replacing the latter in some plots by the project's end. Among the first goldenrods to bloom each year on Martha's Vineyard, *E. graminifolia* also has a very long bloom period, making this species an excellent choice for inclusion in any sort of pollinator planting.

2. *Solidago nemoralis* (field goldenrod): The genus *Solidago* in general emerged as a standout pollinator plant at all of our farms, and *S. nemoralis* performed very well. When interplanted with *Euthamia graminifolia*, *S. nemoralis* was soundly outcompeted, nearly disappearing from most co-planted plots by the end of the project. Where it had its own space, however, this species grew vigorously and bloomed copiously. *Solidago nemoralis* plants in the project plot at Whippoorwill Farm, for example, grew to nearly seven feet in height during the project's third year, producing correspondingly large flower heads that were extremely attractive to pollinators of all kinds.

Epic *Solidago nemoralis* in the Whippoorwill Farm project plot, October 1, 2024

3. *Symphyotrichum laeve* (smooth aster): This aster, native to Martha's Vineyard though not particularly common here, performed quite well in our project plots, growing vigorously in all the project plots and generally blooming copiously. Flowering was rather limited in the project's first season, suggesting that this species can be somewhat slow to mature. *S. laeve* did show vulnerability to damage from browsing by deer and possibly rabbits, though it also showed considerable ability to resprout and successfully flower after browsing. Flowers of this species also proved attractive to a wide range of pollinators, including many of the uncommon late-season composite flower specialist bees that were a particular focus of the project. We have no hesitation in recommending it for pollinator plantings, though many other aster species would likely perform about as well, and we think that pollinator plantings should ideally include white-flowered aster species in addition to blue-flowered ones like this plant.

4. *Asclepias tuberosa* (butterfly weed): Our success with this classic pollinator plant was limited: in 2022, the project's first year, nearly all of the butterfly weed we planted died before blooming, apparently due to an unknown pathogen. Ordinarily, this species grows vigorously and without apparent problems in any dry and open Vineyard habitat, so we surmise that the plugs were infected when they arrived. In order to interrupt the life cycle of whatever organism caused the high level of mortality, we did not replant this species in 2023. In 2024, another planting was successful to varying degrees at all eight of the project farms. But because they were planted as small plugs and didn't have time to fully mature, blooms were sparse and generally small. So *A. tuberosa* did not really get a fair trial in our project plots. Our other experience with this plant, though, still makes us recommend it strongly for Vineyard pollinator plantings. It is enormously attractive to a wide range of wasps, bees, and butterflies, and we believe it is among the very best choices for a durable, widely appealing, early-to-midsummer pollinator plant. This project's unfortunate experience with *A. tuberosa* aside, this is generally a long-lived, hardy, drought-resistant, and broadly adaptable plant, qualities that add to its value in pollinator plantings.

5. *Helianthus annuus* (sunflower): Sunflowers attracted their target in the project, bees in the genus *Melissodes*, at six of our eight participating farms. Both *M. trinodis* and M. agilis were confirmed during the project from specimens, but these species are closely related and very similar. Most of the individuals we encountered in the field, even ones we could photograph well, could only be identified as *Melissodes* sp. or, in some cases, as the subgenus *Eumelissodes*, and even some of our specimens have not been identified to species level. (Our impression is that *trinodis* is appreciably more common and flies somewhat earlier in the season, on average, than *agilis*). While the numbers of this species pair that we observed were generally modest, a count of two *trinodis* and 28 *Melissodes* sp. on sunflowers at Whippoorwill Farm on August 13, 2002, shows that these bees can be quite common on Martha's Vineyard. Of our 46 iNaturalist observations of *Mellisodes trinodis/agilis*, all except for six were of individuals on sunflowers, emphasizing the strength of the association between bee and flower. (The remaining six observations were all on other members of the composite family.)

Full "pollen pants" on a female *Melissodes trinodis/agilis*. She is collecting pollen from a sunflower (*Helianthus annuus*) in the project plot at Beetlebung Farm in late August 2022.

In addition to the specialist *Melissodes*, sunflowers were highly attractive to many other bees. Two generalist, "workhorse" pollinators in farm environments, the ubiquitous *Bombus impatiens* and the small but industrious *Halictus ligatus*, were very common in sunflowers, with multiple individuals of one or even both of these species often observed visiting an individual sunflower head simultaneously.

While our evidence is mostly anecdotal, captured in our site visit narratives, we are confident that sunflowers vary dramatically in how effectively they attract pollinators. Varieties with dark rays ("mahogany" vs. yellow) tended to be less attractive, as did globe-shaped, highly doubled flower types. And pollen-free varieties, commonly grown for the cut-flower market, were often visited by nectar-seeking generalist bees but were of little interest to *Melissodes*. Our recommendation for use in pollinator plantings would be more traditional, pollen-producing varieties with yellow rays and medium to large disk size.

The only real drawback we see to including sunflowers in pollinator plantings is that the species to which "sunflowers" belong, *Helianthus annuus*, is an annual species that must be replanted every season. But for growers for whom this is not a deal-breaker, we strongly recommend sunflowers both for their popularity with generalist pollinators and their association with specialized *Melissodes*.

6. *Trifolium repens* (white clover): Both of the clover species we used in our project plots showed somewhat mixed results, appearing slow to get established during the project's first year, languishing badly in the prolonged drought of the project's second season, and then rebounding with vigorous growth and flower production in the final year. They did, however, live up to their reputations as pollinator plants, attracting good numbers and a wide variety of insects.

Perhaps the most significant observation to be made about *Trifolium* is the strong attraction it had for certain bumble bees, notably the *Bombus vagans/sandersoni* species pair.

7. *Trifolium pratense* (purple clover): Our comments on *T. repens* also apply to this species. Our observers sometimes noted distinct differences in insect preferences for clovers: for instance, on June 27, 2024, at Thimble Farm, Molly Jacobson noticed "that in a large field under a mixed clover cover crop, *B. bimaculatus* stuck quite consistently to *T. repens* while *B. impatiens* used *T. pratense*." So as with flowers generally, the presence of multiple clover species probably offers

more benefits than just a single species, catering to the preferences of more insects and perhaps allowing “resource partitioning” to reduce conflict among species that might otherwise compete against each other.

Despite their attractiveness to insects, we have minor reservations about including clovers in pollinator plots. This is simply because clovers occur widely on farms, frequently being used in cover crop mixes and growing wild on field edges and in unmanaged areas. So it may make sense to devote space in pollinator plots to other plants while trusting that ample clover will still be available. Moreover, the low stature of clovers can put them at a competitive disadvantage in pollinator plants including taller plants such as goldenrod or sunflowers.

8. *Monarda punctata* (spotted horsemint): This species grew vigorously in all our project plots, proving drought-resistant and free-flowering with a long bloom period. It did, however, prove vulnerable to competition from its taller and more aggressive relative, *M. didyma*. Our results also suggest that M. punctata may be relatively short-lived in the settings we were working in, losing some vigor by the project’s third year even where interspecific competition was not an issue. *M. punctata* proved especially attractive to the larger wasps, e.g., the genera *Sphex*, *Ammophila*, and *Eremnophila* (Sphecidae), *Polistes*, *Monobia*, and *Dolichovespula* (Vespidae), and *Tachypompilus* (Pompilidae). In addition to their role as pollinators, these wasps are ecologically important (and we would say generally beneficial, especially in an agricultural context) as predators of other arthropods. The large bees *Xylocopa virginica* (eastern carpenter bee) and *Bombus impatiens* (common eastern bumble bee), both in the family Apidae, were also frequently observed visiting the flowers of this species. These are abundant species that probably function very well as generalist pollinators. So all in all, we believe *M. punctata* is a very useful plant to include in pollinator plantings. But its life history may mean that populations of this plant require periodic augmentation in order to persist over the long term.

The wasp *Scolia bicincta*, apparently the first Martha’s Vineyard record, foraging on *Monarda punctata* in the Mermaid Farm project plot in late August 2024.

9. *Monarda didyma* (scarlet beebalm): This is the only species that we tested that we would recommend *not* including in pollinator plantings on Martha's Vineyard. Relatively few insects were observed visiting this species, perhaps because the very long, tubular shape of the flowers makes it difficult to reach nectar or pollen. (Some small bees in the tribe Augochlorini were seen solving this problem by walking entirely inside the flowers!) And as a tall plant that spreads aggressively via rhizomes, we believe this species is likely to cause management problems that outweigh its ecological benefits.

Performance of Project Plots

In general, our project plots were quite successful, their plants exhibiting vigorous growth and fairly good year-to-year survival and their flowers attracting large numbers of an impressive diversity of insects. But results also highlighted the predictable truth that pollinator patches face the same challenges as any other type of horticultural endeavor. Various combinations of drought, disease, damage from leaf-eating insects, browse damage or root disturbance caused by foraging mammals, insufficient light, or other perils can and did impair the effectiveness of some of our project plots. For example, an August 22, 2024 visit to one farm prompted this dejected summary of the project plot, which has been plagued by shade, animal browse, and interspecific competition: "The southern end of the project plot was in shade, and I wonder if limited light is one factor in why this plot looks so bad: The *Euthamia* is doing very well, just starting to bloom, but there were no sunflowers, no clover, no *Asclepias*, only a few *Symphyotrichum*, and only a few *Monarda didym*a with no *M. punctata* at all." One conclusion drawn from the project, then, is that a truly maintenance-free, self-sustaining pollinator resource is not possible. Prudent plant choice and careful installation will, in general, result in some measure of success. But anyone installing a pollinator patch should expect the need for at least a little ongoing maintenance, including weed suppression, occasional replacement of plants that have died or lost vigor, irrigation during periods of drought if that is possible, and protection from animals.

As noted above, one particular focus of the project was pollen-specialist bees and the question of whether appropriately designed artificial pollinator plots could contribute to bee conservation by offering new resources that such bees could find and utilize. We believe that we achieved successful "proof of concept" for that objective. But the ways in which our project plots functioned turned out to be surprisingly variable, complex, and interesting.

At some of the participating farms, the effects of our project plots appeared to be at least partially obscured by existing vegetation around the plots. At Mermaid Farm and North Tabor Farm, for example, enough goldenrod was already present so that the goldenrod in our project plot represented a fairly small addition to the amount of this resource that was available. With a few important exceptions, the pattern of visitation for plants in the project plots generally appeared, as one might expect, to be about the same as the pattern of visitation for the same or closely related species outside the plots, with the frequency of observation seemed to be roughly proportional to the amount of aster and goldenrod present in the two different settings. (This conclusion is based on a rough assessment of observations, not on any rigorous statistical analysis.) We found some of our target late-season oligolects on aster and goldenrod within our project plots — but we also sometimes found them outside the plots if suitable vegetation occurred there. Certain bees in the genera *Andrena* and *Colletes*, discussed below, may constitute the most important exception to this pattern. But in general, where project plots simply added to existing floral resources, those plots may not have had as much beneficial effect as they did at sites lacking goldenrod.

At some other farms, the effect of our project plots appears to have been muted for other reasons. At The Farm Institute, for instance, no goldenrod was present in the area surveyed except for the *Euthamia* and *Solidago* in the project plot. Most of the land around the project plot is being used in ways — lawns, crop fields, pasture — that would not be expected to support high bee diversity, or any of the late-season, composite-flower oligolects that were among our main interests. The project plot here, and indeed the entire area we surveyed, unsurprisingly yielded very little in the way of specialized bees; we found some *Melissodes* on sunflower in the project plot, but the native composite specialists in the genera *Colletes* and *Andrena* went totally unrecorded at this location, despite the presence of suitable resources in the project plot. We think the explanation is that, because of the dearth of pre-existing asters or goldenrod, no populations of composite specialist bees existed close enough to the project plots for the bees to discover the resources we added within the time frame of the project (at least not at a frequency that our methodology was able to detect). In other words, landscape context can limit the effectiveness of pollinator plantings, at least in terms of attracting certain specialist species, if existing resources are too sparse locally to support pre-existing populations of those specialists.

There is no doubt some very interesting biology going on here that project results alone can't untangle, involving interplay among factors such as the average and maximum dispersal distances of bees, the amount of a floral resource necessary to support successful reproduction, and the fact that suitable nesting habitat is as essential as the availability of food resources for bee populations to persist. Over a long enough time, the widest-ranging members of a bee population might discover a pollinator planting even if the closest source population for the bee is a long distance away. And if suitable nesting substrate exists close to the pollinator planting, such events could result in formation of new populations. But this type of outcome was not observed in the course of this project and can be expected to be relatively rare. In general and practical terms, then, we think that our strategy of adding host flowers for oligolectic bees is probably best thought of as a strategy to support the size and resilience of existing populations, rather than as a way to start new populations in areas currently devoid of those bee species.

All that said, it is intriguing to imagine a reasonably dense network of suitably designed pollinator patches being established across the entire island, involving not just farms but schools, landscaped areas around municipal buildings, in private yards, along roadsides, on traffic islands, and so on. As the density of added resources increased, there would be a greater chance of any particular pollinator plot being close enough to an existing specialized bee population so that specialized bees could discover the patch and exploit it. At some point, the average distance between patches of floral resources would approximate a reasonable dispersal distance for the target bee species as they explore for food. Existing bee populations would then usually be within "discovery range" of newly added resources, and bee populations that formed around those new resources would then be in a position to discover still more newly created resource patches. In theory, an existing pattern of a few relatively isolated populations of specialized bees could be stitched together in this manner into an island-wide, connected, resilient, metapopulation. Such a scheme is purely speculative at this point, and would be challenging (though, we think, not impossible) to bring to fruition. But it's an appealing dream.

Given current conditions, then, we believe that in some cases our project plots added little value because pre-existing resources were already plentiful, and in other cases our project plots added little value because pre-existing resources were too scarce. Even when the plants in the project plots were not utilized by specialist bees, though, those plots still attracted a wide range and large numbers of more generalist flower pollinators. And we did find considerable evidence of a "sweet spot" between these two extremes, where the floral resources in our project plots achieved their goal of attracting and presumably supporting bee species that would not otherwise have found suitable resources in the immediate area.

For example, the goldenrod specialist bee *Andrena nubecula* was recorded twice in 2024 on *Euthamia graminifolia* in the project plot at Morning Glory Farm, a site with either no or very limited quantities of goldenrod (depending on the year) in the area we surveyed. *A. nubecula* was also found on *Euthamia* in the Whippoorwill Farm project plot in 2024 (again, a farm at which our site visit narratives reflect a dearth of wild goldenrods). In neither case can we pinpoint the origin of the bees. But goldenrod is plentiful at Sweetened Water Preserve, just about a quarter-mile from the Morning Glory Farm project plot. And the Whippoorwill Farm project plot is only about one-third of a mile from large quantities of goldenrod in a fire break along the northern edge of Manuel F. Correllus State Forest. (In both cases, of course, there might be goldenrod that we are not aware of even closer to the project plots.) Based on our considerable experience with *A. nubecula* on Martha's Vineyard, we believe the association of this bee with goldenrod is a very close one (22 "research grade" observations of this bee in iNaturalist, including one observation based on photos of a specimen, are all of this species visiting goldenrod, and we can't recall seeing it on any other type of flower). So in the absence of our project plots, we would be very surprised to find this bee in the areas we surveyed, which lacked goldenrod, on these two farms.

Further examples come from *Andrena simplex* (apparently uncommon on Martha's Vineyard) and the closely related *A. placata* (which we believe to be locally common but very patchily distributed on the island and tending to fly a bit earlier in the season than *simplex*). We collected *A. simplex* from *Euthamia* in the project plot at goldenrod-poor Slough Farm and from *Solidago* in the project plot at goldenrod-poor Morning Glory Farm (as well as from *Solidago* in the project plots at goldenrod-rich Thimble Farm and North Tabor Farm). We collected *A. placata* from *Euthamia* in the project plot at goldenrod-poor Slough Farm in both 2022 and 2023, from *Euthamia graminifolia* in the project plot at goldenrod-poor Whippoorwill Farm, and from *Solidago nemoralis* in the project plot at goldenrod-poor Beetlebung Farm. While we found these bees only a few times, all occurrences were on goldenrod, specifically within project plots. Again, the pattern suggests that the project plantings achieved their goal, perhaps being visited in preference to less concentrated, pre-existing floral resources.

A generally similar pattern is evident for our small number of *Colletes* records (discussed below in our section on bees). We could adduce more examples but believe the point is made: our project plots, in a modest but possibly significant way, appeared to enhance bee diversity in surveyed areas at least at some of the participating farms. Where pre-existing host flowers were lacking, project plot plantings sometimes attracted specialist bees that would not otherwise have been expected. And where appropriate host flowers were already available, additional flowers in the project plots were regularly discovered and used by specialized bees and therefore represented an increase in floral resources.

Other Pollinator Plants

As we hinted above, this could be a very long list, and we wish we could justify the space and time that it would take to discuss all the plant species we saw being visited during this project! Instead, this section looks at a somewhat idiosyncratic selection of flowers that produced interesting results. In general, we don't consider the species treated in this section to be priorities for inclusion in pollinator plantings; in most cases, they were visited mainly by generalists, a functional group that by its very nature tends to be a low priority for conservation action. But the plants discussed in this section all appeared to play interesting roles, and in some cases these plants appeared to be particularly important to some subset of the insects we observed.

Chicory (*Cichorium intybus*): This non-native member of the aster family is a familiar flower of roadsides, field edges, and waste areas. Possessed of a deep tap root, which helps make it drought-resistant, and a broad, ground-hugging basal rosette of leaves, which helps it resprout readily after mowing or grazing, chicory is a tough, adaptable perennial that we found to be common and widespread on project farms. Its blue flowers were very attractive to insects, accounting for 52 iNaturalist observations during the course of this project. While a wide range of insects visited chicory, it seemed especially attractive to small bees in the family Halictidae, which we recorded 19 times visiting his flower. Most of those observations were of the genus *Lasioglossum*.

Queen Anne's lace (*Daucus carota*): Like chicory, this is a widely adaptable naturalized exotic that occurs commonly on Martha's Vineyard, including on project farms. Its umbel-shaped flower heads are composed of numerous tiny, white flowers, and it is presumably the flower size and configuration that makes this plant so attractive to smaller generalist insect species. Smaller flies and wasps, most of which we were unable to identify with any precision, were commonly observed on *Daucus carota*. Of particular interest are the tiny bees in the genus *Hylaeus*: of 19 total iNaturalist project observations of this genus, nine (just under half) were of individuals visiting *Daucus carota*. In many cases, multiple *Hylaeus* individuals were observed on single flower heads (a fact that is more evident in our site visit narratives than in our iNaturalist records, which tend to compress common species down to a small number of voucher observations): for example, on August 14, 2022, we noted at least 10 *Hylaeus* on Queen Anne's lace at Mermaid Farm (one was identified to species, as *H. modestus*, in iNaturalist).

Squash (*Cucurbita pepo*): While this crop species only figured in 11 of our iNaturalist observations, it is worth mentioning because of its association with the squash bee, *Peponapis pruinosa*. We found this highly specialized bee at five of the eight participating farms, with records ranging from early July to early September but concentrated mainly in the month of August. All of our observations of *Peponapis* were of individuals, mostly males, associated with large squash blossoms (e.g., pumpkin or winter squash). Our highest single-day, single-location count was of 10 individuals, at Thimble Farm on July 20, 2022. This bee can probably be found in any significant squash patch on Martha's Vineyard, if you look at the right time and in the right way: females are active mostly early in the day, when blossoms are fully open, and males can often be found roosting (sometimes in small groups) inside blossoms that have not yet closed. It seems likely that farms support most of the *Peponapis pruinosa* on the Vineyard, and anyone growing this popular crop in quantity can take some satisfaction in knowing that they are probably helping support an interesting, highly specialized insect.

Zinnia: A popular, adaptable, and highly variable ornamental, *Zinnia elegans* turned up frequently on project farms in pollinator patches, in cut-flower gardens, and as an ornamental. It was visited quite frequently by insects, generating 64 iNaturalist observations during this project along with many more visits recorded in our site visit narratives. But a very clear pattern emerges from our data of visitation only by certain taxa. We created 23 iNaturalist observations of Hymenoptera visiting Zinnia flowers, but all except for two of those involved members of the family Apidae: four visits by western honey bees (*Apis mellifera*) were recorded, and the remaining Apid visitors were all bumble bees (the genus *Bombus*). (The outlying Hymenoptera observations involved the generalist Halictid *Augochlora pura* and a presumed generalist member of the genus *Lasioglossum*.) Lepidoptera, almost exclusively butterflies, accounted for 40 of the visits to Zinnia that we recorded. (*Helicoverpa zea*, figuring in a single observation, was the only non-butterfly Lepidopteran entered into iNaturalist as a visitor to Zinnia.) While five butterfly families figured in our iNaturalist observations, Nymphalids (e.g., monarchs, American and painted ladies, and pearl crescents) turned up on Zinnia most frequently. The only visitor to Zinnia outside of those two orders was a single damselfly (Odonata) in the genus *Enallagma*, observed perch-hunting from a flower. This very strong pattern of usage suggests to us that Zinnia, while effective in a narrow sense, is highly overrated as an overall pollinator plant. It successfully attracts butterflies of all kinds and large generalist bees in the family Apidae, but it appears to be used by almost nothing outside those two groups. We suspect that the highly doubled form of the most popular Zinnia varieties accounts at least in part for this situation, with the complicated structure of those flowers posing a serious problem for most insects trying to access pollen or nectar. There is certainly nothing harmful in planting Zinnia as part of a pollinator patch, especially if your goal is to support butterflies or generalist bees. But from the perspective of broad pollinator support, or support of specialized species, Zinnia appears to be almost useless, and in our view the finite space in a pollinator patch could be more usefully devoted to some of our more strongly recommended plant species.

Fennel: This one surprised us with its popularity: while it was not widely grown across the eight project farms, *Foeniculum vulgare* generated 35 iNaturalist observations during the course of the project. The majority of these, 29 observations, involved Hymenoptera, but very few of the Hymenopteran visitors to this flower were bees. Instead, fennel turned out to be very popular with wasps, notably the family Vespidae (19 observations). The rather limited taxonomic range of visitors to fennel indicates that this plant is not a high priority for inclusion in pollinator plantings. But like *Monarda punctata*, trialed in our project plots, fennel might be worth including in plantings on farms because of its attractiveness to wasps, which as we note elsewhere in this report, can play beneficial roles on farms as predators or parasites of other arthropods.

The radish family: Brassicaceae, represented both by crop plants such as kale that had been allowed to bolt and flower and “weeds” growing on field edges and in unmanaged areas of farms, turned out to be surprisingly popular with pollinators during this project. Members of genera including *Brassica* and *Raphanus* were visited almost exclusively by generalists, primarily Apid bees and Syrphid flies, but a very wide taxonomic range of insects turned up on members of this large plant family at least occasionally. One interesting feature of many plants in this family is cold hardiness: radish family plants bloom throughout the growing season on Martha’s Vineyard and can even be found flowering in sheltered spots in early or late winter. (Whether support for pollinators at these extremes of the season, when only outliers of insect populations are active, matters much ecologically is an interesting question, albeit one we are not equipped to answer.) Given their association with generalist insects, which we regard as a relatively low priority for support, and their ability to fend for themselves successfully in unmanaged parts of farms, radish relatives are certainly not a high priority for use in pollinator patches. Also, while we did not systematically distinguish between bees taking nectar and bees collecting pollen, we believe that flowers of the radish family furnish bees primarily with nectar, which doesn’t help meet the nest-provisioning needs that are crucial for successful reproduction. But in the overall picture of pollinator ecology on Martha’s Vineyard, and particularly in agricultural settings, these (mostly non-native) plants may play a significant and complex role.

Rudbeckia: while not a very commonly observed genus on our project farms, two species of this genus appeared to be quite useful pollinator plants. While sometimes treated at the genus level in our observations, in retrospect we expect that all of our *Rudbeckia* observations were referable either to *R. hirta* (black-eyed susan) or *R. laciniata*. Overall, the genus figured in 48 of the project’s iNaturalist observations: 27 for *hirta*, 18 for *laciniata*, with the species not specified for the remainder. Six Hymenoptera families were photographed visiting this genus, and *R. hirta* accounted for one of our very few observations of the bee genus *Melissodes* that did not involve sunflower. *R. hirta* accounted for one of the project's most notable bee discoveries, the first Vineyard record for *Megachile inimica*. Smaller bees in the family Halictidae were among the frequent visitors we observed on *Rudbeckia*, and members of the fly family Syrphidae also showed considerable interest in this genus. *Rudbeckia* certainly did not show the nearly universal appeal to pollinators that we noticed among the goldenrods, and neither did it attract many of the pollen specialist bees that were a particular focus of the project. But *Rudbeckia* plants appeared adaptable and self-sufficient, and they consistently attracted a broad and what we would consider an interesting mix of insect visitors. The genus is definitely worth considering for inclusion in pollinator plantings, complementing other members of the composite family.

Cilantro: While *Coriandrum sativum* did not figure all that prominently in our observations, involved in just 23 of our iNaturalist observations, the pattern of visitation we observed on this commonly grown herb was interesting. While Syrphid and Calliphorid flies, a couple of Halictid bees, and even one Andrenid (*Andrena crataegi*) were photographed on cilantro flowers, most visits that we observed to this plant were by wasps, especially members of the families Vespidae and Crabronidae. We recorded single visits by three members of the "potter wasp" (Eumeninae) genus *Ancistrocerus* (the locally common *A. campestris*, the non-native *A. gazella*, and the infrequently observed *A. unifasciatus*). And cilantro also produced eight observations of the wasp family Crabronidae, with four of those visitors identified only to family, two belonging to the locally common *Philanthus gibbosus*, and two more in the less common genus *Ectemnius*. Cilantro, then, along with fennel as discussed above, represents yet another small-flowered plant that supports an interesting and probably beneficial variety of wasps, as well as flies and smaller bees. Roughly similar patterns of usage were observed across a wide variety of herbs, which we found growing on project farms both as pollinator plantings and as small-scale crops for sale. Most of these were in either umbellifers (the family Apiaceae, e.g., dill) or mints (the family Lamiaceae, e.g., *Agastache*, lavender, oregano, *Nepeta*, various types of mint, and thyme). We don't have room to discuss all these plants individually. But it is fair to say that while they make little contribution to supporting specialized insects, whether planted specifically for pollinator support or as crop plants that are allowed to bloom, herbs of many kinds appear to be very useful for helping support general pollinator populations in our region.

Dandelion: We include *Taraxacum* here mainly because the familiar, non-native dandelion has recently received a lot of popular and media attention for its supposed merits as an early spring pollinator plant. It is certainly a flower that insects visit regularly, including early in the growing season when relatively little is in bloom: we entered 24 observations of visits to *Taraxacum* into iNaturalist. The ecological value of dandelions is less clear, at least from the perspective of supporting species of conservation concern or native pollinator assemblages. Of our 24 iNaturalist observations, the visiting insects include an undesirable beetle (the spotted cucumber beetle, *Diabrotica undecimpuncata*), the non-native blowfly genus *Bellardia*, the non-native Syrphid fly *Merodon equestris*, the common, widespread Scathophagid fly *Scathophaga furcata*, and the exotic, human-subsidized Apid bee *Apis mellifera* (the most frequent visitor to dandelion in this project, discussed in detail elsewhere in this report). It is true that dandelions also figured in a few observations of generalist native bees, e.g., the ubiquitous *Bombus impatiens* as well as *Augochlora pura* and *Lasioglossum*. But results of this project suggest that at least on Martha's Vineyard farms, dandelions do little to support native pollinators and arguably have a net detrimental ecological effect by supporting non-native or undesirable species. We don't see much point in trying to reduce or eliminate dandelions on Martha's Vineyard; that train left the station a couple of hundred years ago. But at least from the perspective of native pollinator ecology, dandelions are not a plant to encourage.

Hymenoptera: Bees

A particular focus for this project, bees figured prominently in our observations. We recorded 66 bee species overall. The actual number of species we encountered is likely somewhat higher: many photographed bees could only be identified to genus level, and even some of our specimens in the more difficult genera like *Nomada*, *Lasioglossum*, and *Hylaeus* have not yet been identified to species level. It is likely that additions to the project checklist lie in wait among those unidentified bees. Some of the species observed were exceedingly common: we created 200 iNaturalist observations for *Bombus impatiens*, 163 for the western honey bee, *Apis mellifera*, and 80 for the tiny but highly adaptable *Halictus ligatus*. At the other extreme, a number of species were only recorded once or twice. Overall, we created 1,063 bee observations in iNaturalist, or about 47% of the total observations for the project, with 50 species represented. Five of those species — *Apis mellifera*, *Lasioglossum leucozonium*, *Anthidium manicatum*, *Megachile sculpturalis*, and *Andrena wilkella* — are non-native in our region. Six bee species were recorded at least once at all eight of our participating farms: *Lasioglossum fucipenne*, *L. leucozonium*, *Xylocopa virginica*, *Bombus griseocollis*, *B. impatiens*, and *Apis mellifera*.

While the vast majority of the bee species we observed had been documented previously on Martha's Vineyard, the project produced three first records for Martha's Vineyard and Dukes County: *Megachile inimica* (a single individual collected from black-eyed Susan, *Rudbeckia hirta*, at Thimble Farm on September 22, 2023); *Andrena bisalicis* (multiple individuals probably observed and one specimen collected from field pennycress, *Thlaspi arvense*, at Whippoorwill Farm on May 21, 2024); and *Protandrena compositarum* (two individuals on *Symphyotrichum pilosum* photographed for iNaturalist at Thimble Farm on October 22, 2024, and one individual collected from the same plant species the next day). Bees have been studied more thoroughly than most other insect groups on Martha's Vineyard, so new county records are not common; the documentation of these three bee species, then, represents a significant contribution made by this project.

Colletes: In this interesting genus represented by nine species on Martha's Vineyard, pollen specialization is the rule, not the exception. Five of our *Colletes* species are associated with late-season composite flowers, mainly goldenrods and asters; two spring species are associated with blueberry; one late spring/early summer species associates very strongly with *Lyonia ligustrina*, a member of the same family as blueberry; and only one of our *Colletes*, the early-season species *C. inaequalis*, can really be thought of as a pollen generalist. We were not surprised to end the project with no records for *C. inaequalis*, which is among the earliest bee species on the Vineyard and tends to visit flowers on woody plants including willow, blueberry, and Andromeda (*Pieris japonica*), or of *C. productus*, the *Lyonia* specialist, which is invariably found close to its preferred host plant, found on wetland edges. A little more surprising was the absence of any observations of the blueberry specialists *C. thoracicus* and *C. validus*; in particular, we had high hopes for a very large blueberry patch near the project plot at North Tabor Farm and a row of gigantic highbush blueberry bushes along the access road at Mermaid Farm. But these two bee species appear to be quite local on the Vineyard, with just a few known nest aggregations of either species. In all probability, there were simply no members of these two species around to find those blueberry resources.

We were hopeful that our aster and goldenrod plants would prove attractive to the late-season *Colletes* species. While we did document members of this genus using farms and, in particular, visiting flowers in our project plots, we were disappointed in the relative paucity of *Colletes* observations. Our observations of this genus, which included specimens, photographs entered into iNaturalist, and a purely visual observation of a distinctive species, are few enough so that we can list and discuss them all. One male *Colletes compactus* was collected off of *Symphyotrichum laeve* in the Mermaid Farm project plot on September 29, 2022; one female *C. simulans* was collected off of *Euthamia graminifolia* in the Slough Farm project plot on September 8, 2022; *C. solidaginis* was observed twice at Whippoorwill Farm, with one individual of this distinctive species seen (but not otherwise documented) on *Euthamia graminfolia* in the project plot on August 9, 2023, and one individual very well photographed on fleabane *(Erigeron* sp.) and entered into iNaturalist on July 15, 2024. One *Colletes*, currently identified only to genus level but probably *C. compactus*, was photographed on *Euthamia graminifolia* in the project plot at Thimble Farm on August 24, 2023.

Figure 4: Distibution of 58 iNaturalist observations (not just project data) of five late-season composite pollen specialists in the genus *Colletes*: *C. americanus*, *C. compactus*, *C. simulans*, *C. solidaginis*, and *C. speculiferus*. With just one exception, observations from the interior of the island (11 observations) all reflect C. *solidaginis*. Project specimen data is not reflected here.

It would be a mistake to try to lean too hard on only five records. But it is still worth noting that all five of these observations involved composite flowers (native species in four cases and a species of unknown origin in the fifth), four involved native composites within project plots, and three involved the pollinator magnet *Euthamia graminifolia*. It's a pattern that is consistent with the idea that carefully planned pollinator plantings can help support uncommon, specialized bees. It is interesting that four of our five *Colletes* observations were on plants in our project plots, despite some situations where the same or closely related flowers were available nearby in general farm habitat. It would be a mistake to press too hard on such a small sample size. But the preponderance of project plot observations certainly raises the possibility of the plots being especially attractive to *Colletes*, perhaps because the aster and goldenrod in the plot represented densely concentrated resources compared to the generally more thinly scattered, naturally occurring flowers nearby.

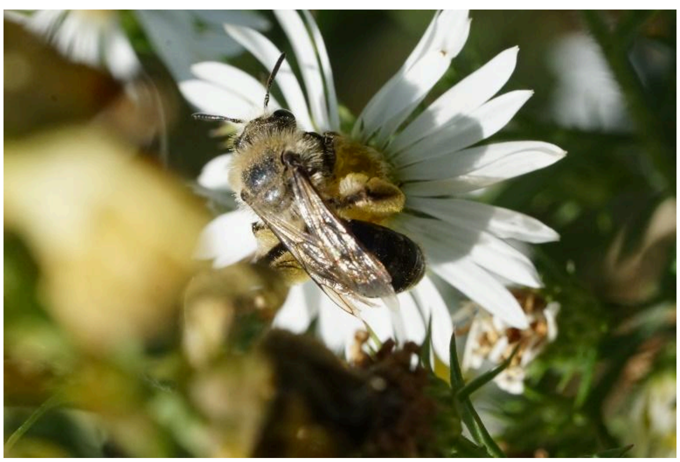
We are not entirely certain why *Colletes* figured so sparingly in our bee observations. But iNaturalist observations for this genus suggest that bees in this genus tend not to be very common on Martha's Vineyard (except, sometimes, very locally); that their distribution tends to be patchy, meaning that some of our project plots may not have been close enough to an existing *Colletes* population to be discovered by any members of that genus; and that the distribution of the late-season members of this genus tends to be coastal (Figure 4, above), perhaps reflecting an association (possibly a true preference, possibly just the result of overlapping seasonality) for *Solidago sempervirens*, seaside goldenrod, a late-blooming goldenrod that sometimes occurs in large quantity in back dune habitat on Martha's Vineyard.

In any case, we believe that encouraging *Colletes* is a worthwhile goal on Martha's Vineyard, and that suitable pollinator plantings can help that effort. Encouraging existing goldenrod populations, including native goldenrod and aster species in pollinator plantings, and growing multiple goldenrod species, perhaps including ones this project did not experiment with such as the above-mentioned *Solidago sempervirens*, might all be useful steps to take.

Colletes solidaginis foraging (atypically for this species, which strongly prefers goldenrod) on fleabane (*Erigeron* sp.) in mid-July 2024, at Whippoorwill Farm. At that point in the season, the earliest goldenrod species are just beginning to bloom, probably accounting for the unorthodox floral choice of this early bee.

Andrena: In contrast to *Colletes*, the large and important genus *Andrena* (the "mining bees") figured prominently in our results. Our iNaturalist data includes 77 observations of this genus, with 13 species represented. Adding in our specimen data, we documented 19 species of this genus during this project — just under half of the 40 *Andrena* species known from the island. One *Andrena* species we found, *A. wilkella*, is non-native. Of the native species we observed, some, such as *A. carlini* and *A. crataegi*, are common on Martha's Vineyard. But many of the species we found are known here from only a small number of records (which, it is important to remember, may reflect either true rarity or simply a tendency not to be found by human observers). Approximately six of our *Andrena* species can be considered oligolects, or pollen specialists (a category that has a clear definition but no precisely defined boundaries). Several of these bees are discussed briefly above, in our discussion of project plot flower results; two commonly observed oligolectic *Andrena* species are discussed in more detail below.

Andrena asteris: Going into this project, we believed that *Andrena asteris* was probably a rare species on Martha's Vineyard: we were aware of only a scant handful of records, and collecting a specimen of this species at Thimble Farm in early October 2021 offered an early, enticing hint that farms might offer workable habitat for rare, specialized bees. Subsequently, though, we've found *A. asteris* to be locally common and quite broadly distributed on Martha's Vineyard — but, as its species name suggests, it is almost invariably found in association with native asters. This project produced 14 iNaturalist observations of this species; many more individuals are memorialized in site visit narratives, unsupported by evidence but (we believe) probably correctly identified in most cases. Two iNaturalist observations were from *Symphyotrichum laeve* in project plots; one was from *S. undulatum* in general farm habitat; and the remaining 11 were from *S. pilosum*, again in general farm habitat. The species was found at half of the participating farms, with the majority of records coming from the plentiful *S. pilosum* growing wild in the community garden, next to our project plot, at Thimble Farm. Its relatively broad distribution on Martha's Vineyard and its clear affinity for small-flowered, white-rayed asters make *A. asteris* a good candidate for support by farms. Plantings of suitable aster species, or expansions of existing wild aster populations, are quite likely to be discovered and exploited by this widespread aster pollen specialist.



Andrena asteris, female, on her favorite pollen source, *Symphyotrichum pilosum*. Thimble Farm, 2024

Andrena hirticincta: A distinctive species by the standards of this difficult genus, *Andrena hirticincta* shows a preference for goldenrods but can turn up on a wide range of composite flowers. We recorded it at seven of the eight farms participating in this project, consistent with our general impression that *A. hirticincta* is widespread on Martha's Vineyard. Project records included some within our project plots (six observations) and others in general habitat (10 observations). Flowers that *A. hirticincta* was observed visiting were *Euthamia graminifolia* (one observation), *Solidago nemoralis* (three observations), *S. rugosa* (five observations), *Solidago* sp. (one observation), *Symphyotrichum laeve* (one observation), and *S. pilosum* (five observations). Like *A. asteris*, this is a species that we think is widespread enough so that it can benefit virtually anywhere on Martha's Vineyard from planting or encouraging native composite flowers.

Andrena hirticincta, male, taking nectar from *Euthamia graminifolia*.

Bombus

Bombus impatiens: We are awed by the abundance, hardiness, and versatility of this familiar insect. This species is represented by 505 out of 50,615 observations iNaturalist observations from Martha's Vineyard, just about exactly one percent. While that may not sound impressive, iNaturalist includes observations of 4,574 Martha's Vineyard species, making it notable for a single species to represent anywhere near one percent of the total. *B. impatiens* has a very long season on Martha's Vineyard, having been recorded here as late as November 22 (2021), and overwintered queens of this species have been found as early as April 1 (on a daffodil blossom in 2022). Overall, Vineyard iNaturalist records for this and many other flower-visiting species are of course influenced in part by the large volume of observations made in the course of this project, where, again, *Bombus impatiens* stands out for its abundance and versatility. The 201 iNaturalist observations we made of this bee substantially outnumber those of *Apis mellifera* (163), the second most frequently observed species for this project. *B. impatiens* was already active at the times of our earliest surveys (e.g., one individual observed on a dandelion at North Tabor Farm on April 26, 2024, our first day of fieldwork for the year). And the species was still going strong all three years when we ended our fieldwork in the second half of October.

Single-day, single-location counts of *Bombus impatiens*, typically recorded in our site visit narratives rather than in iNaturalist, don't approach the maximum numbers of honey bees we observed (sometimes on the order of 200 individuals). But the human-subsidized life history of *Apis mellifera* and the vast population size evident at some multi-hive colonies give honey bees a significant advantage. Double-digit counts of *B. impatiens* were still routine, and the the highest count appears to have occurred on August 29, 2022, when we counted a total of 112 at Beetlebung Farm (32 in the project plot and the remaining 80 in general habitat around the farm, including many observed in the cut-flower garden that is always one of the most intriguing and productive features at this location). This date is probably about when one would expect peak numbers of this species, with colonies about at their maximum size and both males and mature gynes augmenting worker numbers.

Bombus impatiens queen foraging on a dandelion (*Taraxacum* sp.) at North Tabor farm in late April 2024.

The generalist habits of *B. impatiens* are as notable as its abundance and long season: our iNaturalist observations for this bee include visits to the flowers of at least 46 species of plants. This bee was frequently observed on flowers in our project plots (74 iNaturalist observations), as well as on the same or closely related species (e.g., goldenrods, *Monarda*, asters, and sunflowers) in general farm habitat. But the flower-visiting tastes of this versatile bee extend to an amazing range of herbs, ornamental flowers, agricultural weeds, and even crop plants (*B. impatiens*, for example, showed a fondness for roosting inside large squash blossoms, sometimes co-occurring there with true squash bees, *Peponapis pruinosa*).

We did not typically distinguish between male and female bees, or between bees taking pollen or just nectar from flowers. Nor were we able to determine if and when bees successfully carried out pollination, transporting pollen from one flower and depositing it on other flowers of the same species. But given what we do know about *Bombus impatiens* both in general and in the specific context of this project, we are confident that this bee is of enormous ecological importance on Martha's Vineyard, on farms and indeed in virtually all habitat types. *Bombus impatiens* is a true workhorse, and we suspect it is responsible for a high percentage of the pollination services carried out on farms on Martha's Vineyard.

We know very little about the rest of this bee's life cycle. Its general distribution around Martha's Vineyard suggests that it must not be terribly fussy about nest sites and habitat conditions around nests. As a result, we can't offer much specific advice on how to promote *Bombus impatiens* populations or encourage visitation by this species, beyond the general rule (applicable to supporting pollinators generally) of providing a diverse and season-long mix of flowers that are known to attract insects. We can report that Caitlin Jones, at Mermaid Farm, showed us a couple of *Bombus impatiens* nests underneath or in the lower levels of partially decayed hay bales, and this may point to a useful resource that could be provided for this and perhaps other bumble bee species.

Bombus vagans/sandersoni: *Bombus vagans* and the closely related *B. sandersoni*, both of which are known to occur on Martha's Vineyard, are difficult to distinguish from photos, and even when working from specimens, we are not confident of our ability to distinguish these species reliably. Given the difficulty of separating the two, we will use "*Bombus vagans*" (with quotation marks) as shorthand for "*the Bombus vagans/Bombus sandersoni species pair*" in this report. References without that punctuation are to *B. vagans* in the strict sense. We suspect (though can't be sure) that *B. vagans* is handily the more common member of this species pair on Martha's Vineyard, accounting for most or perhaps all of our project records. In any event, one of the more interesting outcomes of this project was what our results suggest about the status of this species pair on Martha's Vineyard.

Bombus vagans/sandersonii photographed in a vial after being temporarily captured while foraging on a kale blossom. Late May 2022 in the "Friendship Garden" at The Farm Institute.

In brief, project results suggest that "*Bombus vagans*" has a very strong association with agricultural settings on Martha's Vineyard. The "*B. vagans*" species pair falls in the middle range of its genus in terms of how often we observed it (less often than *B. impatiens*, with 201 iNaturalist observations, or *B. griseocollis*, with 42, but more often than *B. bimaculatus*, which we entered into iNaturalist 20 times, or *B. perplexus*, with just 12 iNaturalist observations). We observed "*B. vagans*" at five of the eight farms participating in this project. Of our 23 observations of "*Bombus vagans*," 15 have achieved "research grade" status as *B. vagans* in the strict sense (we know little about the basis on which identifications were confirmed but tip our figurative hat to bee experts who feel confident distinguishing *vagans* from *sandersoni* from photographs!). None of the specimens or iNaturalist observations from this project have been identified as *B. sandersoni*, though it is certainly possible that we encountered this species.

Remarkably, all Martha's Vineyard iNaturalist observations of "*B. vagans*" are from this project! This report's author, who has energetically studied bees on the Vineyard over the last few years (e.g., 2,034 Vineyard bee observations in iNaturalist, about 650 bee specimens from the island, and many thousands of bees observed and tentatively identified in the field), cannot recall encountering "B. *vagans*" on Martha's Vineyard anywhere other than on a farm. We think it unlikely that "*B. vagans*" is truly restricted solely to farm habitat on the island (indeed, we know that some records exist from habitats other than farms, thanks to a magisterial bee survey coordinated by Paul Goldstein and John Ascher in 2010–2011). But given that Martha's Vineyard sightings of members of the genus *Bombus* have been entered 790 times into iNaturalist, and all 23 observations of "*B. vagans*" have come from farms, one could be forgiven for arriving at that conclusion.

We have no definitive explanation for this peculiar state of affairs (assuming it is real and not somehow a relic of how observer effort is distributed). Part of the explanation might lie in the availability of floral resources: 13 of our 23 "*B. vagans*" observations (56%) involved clover, with purple clover (*Trifolium pratense*, 10 observations) appearing to be preferred over white clover (*T. repens*, 3 observations). Clovers of these two species and indeed several others are common on farms, used as cover crops or simply growing wild in unmanaged areas, and "*B. vagans*" may find that attractive. (Clearly a generalist species group, "*B. vagans*" was also observed on *Centaurea*, *Brassica*, common pea, *Monarda fistulosa*, vetch, and *Zinnia elegans* flowers.) Nest site preferences can also exert a strong effect on bee distribution, so perhaps some aspect of farm management results in a high density of possible nest sites for this species pair (see, for instance, our comments on decaying hay bales in our discussion of *Bombus impatiens*, above). In any case, it is hard to avoid concluding that for some reason, farms play a very important role in supporting "*B. vagans*" on Martha's Vineyard.

*A**pis mellifera*** **(western honey bee)**: This non-native species is commonly encountered on Martha's Vineyard, occurring virtually anywhere flowers can be found. While honey bees sometimes establish feral colonies, these seem to be infrequent on the Vineyard, and short-lived if and when they do occur. But many farms and individuals keep honey bee hives, presumably to promote pollination and produce honey, and these bees, essentially being managed as a livestock species, range far and wide in search of floral resources. While we do not know how many participating farms keep honey bees, or how many hives in total are involved, *Apis mellifera* figured prominently in our results. We entered 163 observations of this species into iNaturalist, and our site visit narratives captured sightings of thousands of individuals of this species, with high single-day, single-location counts ranging upward to well into the hundreds (e.g., 290 in general habitat at Thimble Farm on October 3, 2024). Honey bee numbers were surprisingly variable both among different sites and across time individual sites. The former disparity no doubt stems in part from the fact that some farms have hives while others don't; the temporal variation in numbers doesn't seem to admit a simple explanation, but there is undoubtedly some interesting honey bee biology behind those variations.

A western honey bee, *Apis mellifera*, sharing a *Euthamia graminifolia* flower head with a bumble bee in the project plot at Whippoorwill Farm in late September 2022.

As we have noted in previous reports on this project, a steadily growing body of research raises concerns about the impacts that introduced honey bee populations may have on native bee populations. The highly social behavior of honey bees and the well-known ability of this species to coordinate the foraging efforts of the entire worker force of a hive makes *Apis mellifera* a formidable competitor for nectar and pollen, which are finite resources. And the relatively large size of *A. mellifera* (by bee standards) gives it social dominance over many native bee species, allowing honey bees to displace smaller native bees from flowers. Effects on reproductive success or population sizes of native bees are very difficult to demonstrate under field conditions, and obviously real-world ecological interactions among insect species can be incredibly complex. But during the course of this project, we tried to learn what we could about interactions between honey bees and native species.

On the one hand, we sometimes noted that honey bees were consistently displacing other species from flowers. For example, on an October 22, 2024, visit to Thimble Farm, we counted 143 *Apis mellifera* visiting *Symphyotrichum pilosum* and noted "many instances of this species displacing other species off of flowers." But these displacements were generally momentary, with the dislodged bee generally just moving to another flower a few inches away. Such competitive interactions are surely not helpful from the perspective of the native bees, representing lost foraging time and additional energy expenditure on short flights that would otherwise be unnecessary. But given the behavior we observed, with short relocations and rapid resumption of pollen-collecting behavior, these impacts were probably minor, and we certainly have no evidence at all that they resulted in reduced reproductive success.

On other occasions, various factors appeared to keep *Apis mellifera* from having any impact at all on native bee species, sometimes even at farms known to have multiple honey bee hives. Sometimes honey bees were simply absent from the flowers we surveyed, either foraging someplace else or perhaps tending to business within the hives that prevented them from foraging at all. On a few other occasions, we observed what we termed “resource partitioning,” with bees of different species apparently sorting themselves out to forage on different flower species. For instance, on May 21, 2022, we observed *Apis mellifera* and *Bombus griseocollis* neatly dividing their efforts in a field section under a blooming cover crop mix of vetch and crimson clover; the honey bees (“present by the hundreds”) were mostly visiting the clover, while the much less plentiful *B. griseocollis* were confining their efforts entirely to the vetch flowers. We did not witness any interactions between the two species. Similarly, on October 27, 2022, honey bees were plentiful (we estimated 260) on a row of kale that had bolted and flowered; these bees appeared to be taking only nectar, not pollen, exhibiting empty corbicula and “both inserting their faces and presumably their tongues from the front of the flowers, and also approaching the bases of the flowers from the sides, apparently working their tongues in through the sepals and base of the petals.” Not far away, on the season’s last *Solidago nemoralis* flowers in the project plot, we observed about 10 *Lasioglossum* individuals and a single *Bombus impatiens* collecting pollen — but no honey bees at all. Again, this appeared to be an instance in which non-native honey bees and native bees were self-segregating onto different preferred resources, preventing any sort of competition or other interaction.

It is important to note the limitations of our methodology for assessing honey bee impact. For one thing, we have no idea what native bee populations looked like before the introduction of honey bees on Martha’s Vineyard. Nor do we know what native bee populations would look today if the honey bee had never arrived here. So it is entirely possible that the native bee populations we observed had already been substantially affected by competition from honey bees. We also focused entirely on agricultural land, where floral resources were generally abundant, and therefore our conclusions cannot be extrapolated to other settings. Since our methodology focused only on flower visitation and did not allow any meaningful assessments of reproductive success or population changes over time, our view on the ecological impacts of honey bees during the project are necessarily speculative. Again, we do not see how the presence of human-subsidized populations of an aggressive, highly social, non-native bee species could ever be beneficial from the perspective of native bee conservation. But based on what we were able to observe, we believe that as long as floral resources are plentiful and diverse, negative impacts of *Apis mellifera* on native bee species range from nonexistent to minor in the agricultural settings we were studying.

Halictidae: Between specimens and iNaturalist observations, we recorded 19 species in this incredibly diverse bee genus. The actual number of species we encountered is probably appreciably higher: while some Halictids are distinctive and easily recognized, this family is fraught with identification difficulties, and many of Halictids we observed are only identified to the genus level. (Among photographically documented individuals entered into iNaturalist, a depressing number remain identified only to *family*.) Halictids generally, and certain species in particular, were abundant during this project. We entered 290 Halictid observations into iNaturalist, and *Halictus ligatus*, the member of the family that we encountered most often, was recorded throughout the season at all eight participating farms and produced 80 iNaturalist records. In several genera in this family, the abundance of individual species varied hugely. To go with those 80 iNaturalist observations of *H. ligatus*, for example, we created only nine observations of *H. confusus*, four of *H. parallelus*, and two of *H. rubicundus*. The genus *Agapostemon* was similarly uneven in abundance: we entered *A. virescens* into iNaturalist 28 times (and we suspect that most of our 26 genus-level iNaturalist observations were also referable to this species), while we produced only two observations of *A. splendens* and one each of *A. sericeus* and *A. subtilior* (formerly known as *A. texanus*).

The common and highly adaptable "sweat bee" *Halictus ligatus* collecting pollen from a sunflower in the Morning Glory Farm project plot in early August 2022.

While it does contain some pollen specialists, Halictidae is dominated by generalist species, a fact that is very evident from this project's results. For example, our 80 iNaturalist observations of *Halictus ligatus* involved visits to the flowers of at least 25 plant species. As you'd expect from a taxonomic group dominated by generalists, no clear patterns of plant visitation emerge from our data beyond, perhaps, the same fondness for sunflowers, goldenrod, and asters that we observed quite widely across the pollinators we encountered. But given their diversity, their abundance, and their broad foraging habits, members of this family can safely be described as an ecologically important component of the insect fauna on our participating farms. That works both ways: Halictids are, we are confident, important pollinators on Vineyard farms, and these bees rely extensively on floral resources available on those farms.

Figure 5: Bee Occurrence at Participating Farms

Compiled from all available project data (specimens, iNaturalist observations, and visual identifications of species that be identified with confidence under field conditions), this table summarizes the occurrence of bee species across the eight Martha's Vineyard farms that participated in this project.

FAMILY	GENUS	FARM -> SPECIES	Beetlebung	Mermaid	Morning Glory	North Tabor	Slough Farm	The Farm Institute	Thimble Farm	Whippoorwill Farm
Colletidae	Hylaeus	affinis								x
	Hylaeus	mesillae					x			
	Hylaeus	modestus		x		x				
	Hylaeus	sp.		x		x	x		x	x
	Colletes	compactus		x						
	Colletes	simulans					x			
	Colletes	solidaginis								x
Halictidae	Augochlora	pura		x	x	x				
	Augochlorella	aurata				x			x	
	Augochloropsis	viridula		x						
	Augochlorini	sp.	x	x		x	x		x	x
	Agapostemon	sericeus		x						
	Agapostemon	splendens	x							
	Agapostemon	texanus			x		x			
	Agapostemon	virescens	x	x		x	x	x	x	x
	Agapostemon	sp.	x	x		x	x	x	x	x
	Lasioglossum	coriaceum	x			x				
	Lasioglossum	cressonii		x						
	Lasioglossum	fuscipenne	x	x	x	x	x	x	x	x
	Lasioglossum	leucomomus			x	x				
	Lasioglossum	leucozonium	x	x	x	x	x	x	x	x
	Lasioglossum	pilosum			x					
	Lasioglossum	complex L. pilosum	x							
	Lasioglossum	vierecki			x					

	Lasioglossum	sp. (Lasioglossum)	x	x	x	x	x	x	x	
	Lasioglossum	sp. (Dialictus)	x	x	x	x	x	x	x	x
	Halictus	confusus		x		x			x	
	Halictus	ligatus	x	x	x	x	x	x	x	x
	Halictus	parallelus	x					x		
	Halictus	rubicundus	x				x		x	x
	Halictus	sp.		x		x	x	x	x	
	Sphecodes	coronus				x				
	Specodes	johnsonii					x			
	Sphecodes	sp.							x	
	Andrena	asteris	x		x	x			x	
	Andrena	bisalicis								x
	Andrena	braccata		x				x		
	Andrena	carlini				x		x	x	x
	Andrena	crataegi	x				x	x		x
	Andrena	cressonii	x		x				x	
	Andrena	hippotes					x	x		
	Andrena	hirticincta	x	x		x	x	x	x	x
	Andrena	imitatrix			x			x		
	Andrena	melanochroa							x	x
	Andrena	miserabilis	x	x	x	x		x	x	
Andrenidae	Andrena	nasonii	x	x	x		x			
	Andrena	nubecula		x	x					x
	Andrena	nuda							x	
	Andrena	placata	x				x			x
	Andrena	rufosignata				x				
	Andrena	simplex		x	x	x	x		x	
	Andrena	spiraeana				x				
	Andrena	tridens				x				
	Andrena	wilkella	x				x	x	x	x
	Andrena	sp.	x			x	x	x	x	x
	Calliopsis	andreniformis							x	
	Protandrena	compositarum							x	

	Megachile	addenda	x							
	Megachile	brevis							x	
	Megachile	inimica							x	
	Megachile	latimanus					x			
Megachilidae	Megachile	sculpturalis	x							
	Megachile	sp.	x	x	x		x	x	x	
	Anthidium	manicatum	x	x	x				x	x
	Osmia	taurus	x							
	Osmia	sp.	x			x		x		
	Nomada	depressa				x				
	Nomada	sp.	x	x		x				x
	Ceratina	sp.	x	x	x	x	x	x	x	x
	Xylocopa	virginica	x	x	x	x	x	x	x	x
	Melissodes	agilis			x		x		x	
	Melissodes	trinodis	x		x	x	x		x	x
	Melissodes	sp.	x		x	x	x	x	x	x
Apidae	Peponapis	pruinosa	x			x	x	x	x	
	Bombus	bimaculatus	x		x	x	x		x	x
	Bombus	griseocollis	x	x	x	x	x	x	x	x
	Bombus	impatiens	x	x	x	x	x	x	x	x
	Bombus	perplexus		x					x	
	Bombus	vagans	x			x	x	x		x
	Bombus	sp.		x		x		x	x	
	Apis	mellifera	x	x	x	x	x	x	x	x

Other Hymenoptera

Bees accounted for about 72% of our 1,477 Hymenoptera project observations in iNaturalist and around half of the diversity we documented within this order. Ants — the family Formicidae — were rather sparingly represented in our data set, with just 19 observations representing five species entered into iNaturalist. But wasps, an astonishingly diverse and important group of insects, figured prominently in project results; we entered 395 observations representing 61 species. Many wasps visit flowers as adults, taking nectar and pollen as food and often serving as pollinators (though as a group, wasps are less highly evolved for transporting pollen than bees are, and are presumably less effective pollinators as a result). The larval stages of many wasps live either as parasites on other arthropods or, effectively, as predators, feeding on arthropods captured by adult female wasps and placed into nests by those females along with her eggs. Other wasps, mostly the social species, feed their young on prey or scavenged carrion. As a group, then, wasps play an important role regulating arthropod populations, making this group ecologically very important and generally beneficial, especially in an agricultural setting. The abundance and diversity of wasps that we observed, then, suggests that extensive floral resources benefit farms by attracting these important insects, and that farms benefit the greater ecosystem by helping support wasps.

It is hard to tell whether a tiny wasp like this *Cleonymus* sp. is truly rare or just overlooked. In any case, this individual, this beautiful *Cleonymus*, photographed in late July 2024 after it visited a fleabane flower, apparently represented the first record for Martha’s Vineyard.

In addition to these “workhorse” wasps, observed widely and often in considerable numbers, this project also documented a number of wasp species that appear to be rare, or at least rarely encountered, in our region. For example, a colorful wasp nicely photographed on *Monarda punctata* at Beetlebung Farm on July 29, 2024, proved to represent the only Vineyard iNaturalist observation, and just the second observation for all of New England, of a wasp in the elegant parasitic genus *Cleonymus*. A tiny wasp, barely a millimeter long, collected from fleabane (*Erigeron* sp.) at North Tabor Farm on June 12, 2024, apparently represents the only Vineyard iNaturalist observation of the subfamily *Telemoninae* (in the poorly known family Scelionidae). A confirmed observation of the "potter wasp" (the subfamily Eumeninae) *Parancistrocerus leionotus*, photographed on an unidentified *Monarda* flower at Thimble Farm on July 20, 2022, is the first in iNaturalist for the Cape and Islands region. A confirmed iNaturalist observation of *Scolia bicincta* (Scoliidae) found on *Monarda punctata* at Mermaid Farm on August 27, 2024, was a first for the Vineyard and just the second observation for the Cape and Islands; this species, common in most of interior southern New England, appears to be inexplicably almost absent from the coastal plain and Cape and Islands region. We repeat our caution that a shortage of observations does not necessarily prove actual rarity. Nevertheless, project results make us confident that Vineyard farms support a diverse and interesting wasp fauna, and that the rich resource mix of a Vineyard farm can play an important role in supporting less common or more specialized members of this broad taxonomic group.

Hemiptera

A relatively small component of the flower-visiting insects observed during this project, Hemiptera (true bugs) accounted for some interesting observations. Overall, we entered 79 observations of this order into iNaturalist, representing 20 species. Due to the difficulty of identifying Hemiptera from photographs and, probably, the relative scarcity of serious students of this large and complicated order, only 25 of those observations representing nine species were confirmed to "research grade." But a few of those observations appear to be significant. *Poesilocapsus lineata* (four-lined plant bug), found on clover at Whippoorwill Farm in June 2024, was just the second iNaturalist observation from Martha's Vineyard and one of just a handful from the entire Cape and Islands region. The ominously named insidious flower bug, *Orius insidiosus*, found on annual fleabane at North Tabor Farm in early July 2024, represents the first and so far the only Vineyard observation of this species. And *Sehirus cinctus*, the white-margined burrower bug, found at North Tabor Farm in May 2022, represents one of just three Vineyard iNaturalist observations. Taking into account non-"research grade" observations that we feel are probably correct, the project also produced the only Vineyard observation to date of the genera *Plagiognathus* and *Taylorilygus* (probably the non-native *T. apicalis*).

A small milkweed bug, *Lygaeus kalmia*, on a dandelion (*Taraxacum* sp.) flower at Thimble Farm in early April 2023.

The true bugs we observed were visiting a wide range of flowers, including clovers, herbs, and mint family members including motherwort and both of the *Monarda* species grown in our project plots. But 45 of the observations — about 57% of our total observations of this order — involved native or exotic composite flowers, suggesting a particular attraction to this group. *Euthamia graminofolia* (16 Hemiptera observations, about 20% of the total) in particular was popular with the true bugs. Interestingly, while the aster-like genus *Erigeron* (fleabanes) was visited frequently by Hemiptera, no true bug observations were associated with native aster species (e.g., the *Symphyotrichum laeve* in our project plots or the *S. pilosum* that functioned so well as a naturally-occurring pollinator plant). We can think of no explanation for this apparent avoidance of species that other flower-visiting insects often favor.

In general, true bugs tend toward vegetarian diets, often feeding on seeds or the sap of plants and often with some level of specialization in terms of host plants. Members of this order generally have piercing/sucking mouthparts, and many species are implicated either directly as agricultural pests, or indirectly as vectors of disease that can harm crop plants. Some Hemipteran species put their mouthparts to predatory use, such as the ambush bugs (*Phymata* sp.) that we occasionally observed waiting on flowers for potential victims, and a surprising number of true bugs are known to be occasional predators or scavengers. Overall, the diversity of Hemiptera detected by this project may not seem like good news from a farmer's perspective (though it doesn't seem like many of the species we found are regarded as serious agricultural pests). Moreover, with just a few exceptions, the presence of true bugs on flowers was likely just coincidental, not a deliberate feeding strategy of the bugs. But the focus of this project was ultimately on biodiversity, and from that perspective, it seems fair to say that farms participating in the project play a significant, possibly important role in supporting Hemiptera diversity on Martha's Vineyard.

Diptera

We have noted in previous reports on this project that the fly fauna found on project farms has a conspicuous non-native component. The full data set for the project supports this assessment, but with some qualifications: while a relatively small number of non-native species do account for a high percentage of our total observations, the steady addition of new fly species over the course of the project gradually produced a picture of greater overall diversity and a less exotic-rich species mix.

Some species of non-native flies, like this *Eristalis arbustorum*, figured prominently in the Diptera fauna that we observed on participating farms.

Overall, across project plots and other areas of farms, we observed members of 19 fly families visiting flowers, which we think represents remarkable diversity at this taxonomic level. But a deeper dive into our results suggests that the family-level diversity we observed was somewhat misleading. Many families were represented by just a few observations or species: Anthomyiidae, Dolichopodidae, Lonchaeidae, Milichiidae, Platystomatidae, Scatopsidae, Tabanidae, Therevidae, and Ulidiidae were all represented just by single observations; Asilidae by two; Bibionidae, Polleniidae (surprisingly, given the prevalence of this family in most human-modified habitats on Martha's Vineyard), and Sepsidae by just three. We compiled 14 observations of the family Conopidae, but of these were all of a single species, the bee parasite *Physocephala tibialis*. While most of the flies we found on flowers were probably there to forage on nectar or pollen, we observed a few flies that are predatory as adults visiting flowers, such as the robber fly (Asilidae) *Efferia aestuans*. These flies were probably visiting flowers only incidentally, being interested instead in potential prey items visiting flowers. Calliphoridae (blow files), Tachinidae (bristle files, all with parasitic larval stages), and especially Syrphidae (hover flies or flower flies) were by far the most prevalent fly families in our observations.

In assessing the project's fly data, it is important to remember that many individual fly observations could be identified only to genus or sometimes even higher taxonomic levels. So limiting an analysis to "research grade" observations, which must be identified to species level, significantly alters the picture. For example, we made 26 observations of the genus *Lucilia*. While most, perhaps all of those observations are referable to the non-native *Lucilia sericata*, only nine of our *Lucilia* observations were identified to species, and of those, only four have been confirmed and hence achieved "research grade" status. Knowing the specific identity of the remaining observations could substantially alter our impression of the status of this genus on project farms, either revealing unexpected diversity or cementing *L. sericata* as a very common species on farms. Except as noted, we used all observations for the analysis in this section, not just "research grade" ones, because in almost all cases, we think it is the precision and not the accuracy of the identification that disqualifies the observation from "research grade." We may not know what species a fly is, but we are confident we got the genus (or family) right.

Overall, the project produced a total of 289 iNaturalist fly observations representing at least 49 species. Of these, 84 observations (29%) represent seven species (14%) classed as non-native by iNaturalist. Three species, all in the family Syrphidae, account for most of these observations of exotics: *Eristalis arbustorum* (39 observations, recorded at seven of the eight project farms), a fly that seems to associate strongly with farms on Martha's Vineyard; *Syritta pipiens* (17 observations, recorded at all eight project farms); and *Eristalis tenax* (16 observations, found at seven farms). Clearly, non-native fly species represent a significant component of the species mix visiting flowers on farms, and an even greater portion of observed individual flies. But the project also documented a rich native fly fauna active on the farms, and we detected a number of taxa that appear to represent significant finds: for example, as of mid-November 2024, this project had produced the only Vineyard iNaturalist observation of the tribe Diaphorini (a tribe within in the long-legged flies, family Dolichopodidae) and the only Vineyard observation of the genus *Leptometopa* (in the family Milichiidae, an unconfirmed ID but one we are confident of).

The family Syrphidae (hover flies or flower flies) dominated the fly fauna we found, with 160 observations accounting for about 55% of all our fly contributions to iNaturalist. Syrphidae is an interesting and ecologically important family, with high diversity, a penchant for flower visitation by adults, and predatory habits among the larvae of many species. While, as noted above, a short list of non-native species accounts for a good portion of our Syrphid observations, the full Syrphid list of 24 "research grade" species includes a number of interesting and possibly significant observations: the only Vineyard iNaturalist observations of *Epistrophella emarginata*, *Ceriana abbreviata*, *Mallota posticata*, and *Tropidia albistylum*, and one of just two Vineyard observations of *Paragus haemorrhous*. Other observations of these or other interesting species may be lurking among the many Vineyard fly observations identified only to higher taxonomic levels. It is the unfortunate case that flies, like many other insect groups, have never been the subject of a systematic survey on Martha's Vineyard, meaning that an absence of previous records doesn't necessarily mean that a species is rare, or even hard to detect. But still, this project's roster of infrequently reported fly species argues for both the importance of local farms for supporting fly diversity and the value of the data set this project produced.

Apparently representing a first record for Martha's Vineyard, this *Ceriana abbreviata*, foraging on the flowers of a parsley plant at Thimble Farm in late June 2024, was one of this project's notable finds. Parsley and other herbs proved to be surprisingly effective at attracting pollinators, especially small flies and wasps.

Of 40 observations of flies in the family Calliphoridae (the blow flies), few were identified to the species level. (Species-level ID in this and indeed most other fly families often depends on tiny anatomical details, sometimes internal ones, that are difficult or impossible to capture in photographs.) Exotic flies in the genus *Calliphora* were common, along with *Lucilia* as discussed previously. Laval blow flies are mostly detritivores, with many species preferring rotting meat as their larval substrate. Adults, our results suggest, our true generalists in their flower-visiting habitats. Our 27 observations of Tachinid flies included many observations of the genus *Archytas* and 13 of the distinctive species *Trichopoda pennipes*. This family is probably an important and generally beneficial one on farms. Adults of most species are enthusiastic visitors of flowers and probably function fairly well as pollinators of at least some plant species. Larvae of all Tachinids are parasites on other arthropods. In the case of *Archytas*, host species are generally Noctuid caterpillars, including cutworms generally regarded as agricultural pests; in the case of *Trichopoda*, hosts are generally true bugs, and the fondness of *T. pennipes* for squash bugs (*Anasa tristis*) in particular has led to this fly being used as a biocontrol agent for this widespread agricultural pest.

It is difficult to characterize the flower preferences for flies we recorded; flies were observed on an extraordinarily broad diversity of flowers, native and non-native species alike, and many species for which we have multiple observations were observed on multiple species of flowers. Overall, 95 (almost 33%) of our observations were of flies visiting native, late-season, composite flowers in the genera *Euthamia*, *Solidago*, and *Symphyotrichum*, highlighting once again the importance of these late-season composite flowers for supporting a diverse pollinator community. But flies were also observed visiting a wide range of non-native species, including both plants deliberately grown on farms (e.g., herbs such as fennel, coriander, oregano, clover) and weedy, adventive species found in unmanaged areas of farms (e.g., chicory, Queen Anne's lace, cat's ear, and members of the radish family such as *Raphanus* sp.). If a generalization emerges from all this, it is that flies tended to visit plants with small, shallow flowers — presumably a preference based on the relatively short mouthparts with which flies have to forage. But our data suggest that flies as a group, and most individual genera and species within that group, are flexible and adaptable in their use of plants. Finally, flies exhibit a very long season, with observations from both our earliest and latest site visits. Overall, results of this project indicate that farms play a significant role in supporting fly diversity on Martha's Vineyard, and that flies, in their ecological roles as pollinators, predators, detritivores, parasites, and prey species, are likely of considerable importance to farm ecosystems.

A first record for the Vineyard as far as we can tell, this *Epistrophella emarginata* was one of many pollinators we observed on fennel plants (*Foeniculum vulgarum*) at Mermaid Farm. Late August 2022.

Coleoptera

Legendary for their global diversity (an estimated 400,000 species!), beetles (the order Coleoptera) have evolved to take a bewildering variety of forms and occupy an astounding range of ecological niches. Many families or subfamilies of beetles associate more or less closely with flowers, and hence it is no surprise that the Coleoptera figured fairly prominently among the observations made during this project. In all, we compiled 103 observations representing 15 families and 29 species of beetles (we are confident that all or nearly all of our family-level IDs are correct). Looking at the more narrow selection of confirmed, "research-grade" observations, those figures shrink substantially to 75 observations and 21 species, reflecting the difficulty of identifying many beetle taxa from photographs.

Predictably, our beetle observations skew strongly toward taxa that are well known for associating with flowers: Cantharidae (soldier beetles), 14 observations; Cerambycidae (longhorn beetles, including the subfamily Lepturinae, or flower longhorn beetles), 25 observations; Mordelidae (tumbling flower beetles), nine observations; Phalacridae (shining flower beetles), one observation; and Ripiphoridae (wedge-shaped beetles, which frequent flowers because their larvae are parasites on bees), four observations.

Among the Cerambycidae, 17 observations were of the boldly marked locust borer, *Megacyllene robiniae*, adults of which are almost invariably observed on flowers even though this species is in the subfamily Cerambycinae rather than Lepturinae). Larvae of this beautiful insect bore into the wood of locust trees, but adults are inveterate flower-visitors with a strong preference for goldenrods: all of this project's observations of this species were on either *Euthamia* or *Solidago*, and it was found both within and outside our project plots. Lepturinae was represented by two species and a total of just five observations: *Typocerus velutinus*, known to be quite common on Martha's Vineyard, and the much more scarce *Brachyleptura vagans*. Our final longhorn beetle species was the red milkweed beetle, *Tetraopes tetrophthalmus*, which we found occasionally (three observations) on common milkweed (*Asclepias syriaca*), its usual host plant on Martha's Vineyard.

The longhorn beetle (Cerambycidae) *Megacyllene robiniae* was a common site on its preferred forage plant, goldenrod, during the course of this project.

Superficially resembling a flower longhorn beetle, the goldenrod soldier beetle (*Chauliognathus pensylvanicus*, in the family Cantharidae) was represented by 13 "research-grade" iNaturalist observations. A common species on Martha's Vineyard, this beetle lives up to its usual common name, goldenrod soldier beetle, in showing a strong preference for the flowers of *Solidago* and *Euthamia*. This project also documented it visiting *Allium*, sunflower, the native asters *Symphyotrichum pilosum* and *S. laeve* (the latter in the Morning Glory Farm project plot), and two species of *Monarda*. The project's most significant beetle observation may have been of the goldenrod soldier beetle's close relative, *Chauliognathus marginatus*, observed on a yarrow flower head at Thimble Farm in late June 2024. This is the only Vineyard observation to date for this species in iNaturalist, and just the second for the Cape and Islands region. It's too bad this species is so scarce: according to the species account on Bugguide.net, its larvae are predatory and known to feed on corn earworm and corn borer moth caterpillars, to moths that most farmers would be happy to see reduced in number.

Chauliognathus marginatus exploring a common yarrow flower head (*Achillea millefolium*) at Thimble Farm in late June 2024. As far as we know, this is the first Martha's Vineyard record of this beetle.

A beetle family that in general is easy to defend as generally beneficial, Coccinellidae (the lady beetles) figured in a modest 13 observations across the three years of the project. All 13 have achieved "research grade, reflecting the relative ease of identifying the more common members of the family. Those observations captured considerable diversity (five species) and also a remarkable pattern of unspecialized flower visitation: our 13 lady beetles were observed on the flowers of 12 different plant species, with dandelion (*Taraxacum* sp.) being the only type of flower involved in more than one observation. A non-native species now found across the United States, the seven-spotted lady beetle, *Coccinella septempuncatata*, was our most frequently observed species in this family, with six observations spread across five of the project farms. *Coleomegilla maculata*, a native North American species, figured in three observations, two on dandelion and one on the similar flower of cat's ear (*Hypochaeris radicata*). And the non-native fourteen-spotted lady beetle, *Propylea quatuordecimpunctata*, accounted for just one observation. These beetles prey on aphids and a range of other insects, many of them considered harmful in agricultural settings; it is often the larval stage that is most active as a predator. Adults of many species visit flowers, feeding on pollen to supplement their diet of other arthropods. Two other species we detected on flowers during the project are less welcome. The Asian lady beetle, *Harmonia axyridis*, figured in two observations; an exotic species introduced to control aphids, this species turns out to be a potential crop pest as well as being implicated in the decline of native lady beetles, which *H. axyridis* sometimes preys on. *Epilachna varivestis*, for which we had just one observation, is another member of this family that is not beneficial on farms. It belongs to the small subfamily Epilachninae, the members of which feed on leaves rather than being predatory. The common name of this species, Mexican bean beetle, accurately identifies its preferred host plant. We observed many adults and larvae on bean plants during the course of the project, but just the one individual visiting a flower (common mugwort, *Artemesia vulgaris* — another unpopular species!)

Finally, it is worth mentioning our 10 observations of the family Scarabaeidae, the scarab beetles. The two species we observed in this family are both non-native: the Oriental beetle, *Exomala orientalis* (one observation, found on valerian flowers), and the Japanese beetle, *Popillia japonica* (nine observations, five of these on *Monarda didyma*). Both of these beetles, which feed on roots as larvae and, as adults, feed on a wide range of leaves (reportedly more than 350 species in the case of P. japonica!) are non-natives generally regarded as pests. Both species are known to feed on flowers as well as leaves, so their presence among this project's observations is not surprising.

Perhaps the biggest surprise emerging from our Coleoptera observations is that there weren't more of them. Given how prominently flowers figure as primary or alternate food sources for various groups within this order, one might have expected beetles to account for more than roughly 4.5% of the insects we observed on flowers. We have no explanation for this outcome, and indeed can't even say for sure whether it's truly surprising.

Lepidoptera

This order was well represented in our project results, in terms both of diversity and number of observations. We found representatives of 16 Lepidopteran families. Overall, this project compiled 283 iNaturalist observations of this order, representing 55 species. Selecting just "research grade" observations alters these figures to 231 and 44, respectively; the relatively high ratio of confirmed to unconfirmed observations reflects the fact that many Lepidoptera species (at least the adult forms, which were mostly what we observed) are fairly distinctive in appearance. Of the full set of observations, 187, representing 28 species, were of butterflies (the superfamily Papilionoidea); the rest were of moths. (The designation of six taxonomic families as "butterflies," and the remaining 83 Lepidopteran families as "moths," is arbitrary, but it is familiar enough and useful enough for us to follow it here.) A total of 82 species of butterflies have been documented on Martha's Vineyard, including a number of rare vagrants and several extirpated species; the fact that this project detected more than a third of those species (34%) is remarkable, given that we surveyed a very limited geographical area entirely dominated by fairly uniform anthropogenic habitat. One obvious conclusion to draw from our results is that the flower-rich habitat of Vineyard farms is attractive to a wide range of butterflies; another is that butterflies are mobile animals that are deft at locating rich concentrations of resources.

While the common ornamental plant *Zinnia elegans* was not very attractive to pollinators in general during this project, butterflies like this cloudless sulphur (*Phoebis sennae*) made frequent use of its flowers. We surmise that having a long proboscis feeding, like the one visible in this photograph, makes it easy for butterflies to feed on *Zinnia* flowers, which have often been selectively bred into globe-shaped, highly doubled forms.

A wide variety of flowers were visited by butterflies, including naturally occurring species, species in our project plots, species grown as cover crops, and species included in pollinator rows. Lepidoptera were unique among insect orders in making frequent use of Zinnia flowers (listed variously in our records as either "Zinnia" or "*Zinnia elegans*"): 39 of our Lepidoptera observations (more than 14% of our observations of this order) involved this common garden flower. Our observers frequently commented on how Zinnia, especially varieties with highly doubled, ball-shaped flowers, appeared to be underutilized by insects. We surmise that this type of flower structure makes nectaries or pollen difficult for most pollinators to reach; but a butterfly equipped with a long, siphon-like proboscis has no trouble feeding from such a flower. Lepidoptera also made frequent use of native composite species, with 36 observations on goldenrod (either *Euthamia* or *Solidago*) and an additional 24 on *Symphyotrichum* (combined, a total of about 21% of all our observations of this order). The fact that a group so well equipped for generalist foraging focused so much on these native composites highlights once again how broadly attractive these flowers are to almost every type of pollinator. As with other taxa, we found no evidence that the location of native composites (inside or outside our project plots) made any difference to Lepidoptera, which visited these species freely whether they were planted or naturally occurring.

An uncommon and local butterfly on Martha's Vineyard, this juniper hairstreak (*Callophrys gryneus*) was a nice surprise when it turned up *Euthamia graminifolia* in the Beetlebung Farm project plot in late July 2023.

Three butterflies that can be considered rare or uncommon on Martha's Vineyard were documented during this project: juniper hairstreak (*Callophrys gryneus*), generally scarce and rarely found away from its larval host plant, eastern red cedar (*Juniperus virginiana*); white-M hairstreak (*Parrhasius m-album*), an oak-feeding species that is infrequently reported on the Vineyard; and cloudless sulphur (*Phoebis sennae*), an immigrant from the south that appears here most years in variable numbers. The most frequently observed species in this order was the Huron sachem, *Atalopedes huron* (46 observations, more than 16% of our Lepidoptera observations!). Just 15 years ago, this butterfly (as *A. campestris*, prior to the recent split into the western *A. campestris* and the eastern *A. huron*) was considered rare on Martha's Vineyard and throughout southern New England, occurring solely as a rare immigrant from the south. But this species has extended its year-round range northward relentlessly in recent decades, probably taking advantage of milder winters associated with climate change, and it is now one of the most common butterflies on the Vineyard.

Moths, which as a group are much more likely to be nocturnal than butterflies, were accordingly encountered less often and in less diversity than butterflies (despite the Vineyard's considerable moth diversity). We recorded individuals in 11 moth families, though some of these families were represented by just a few observations. Standing out in terms of abundance was the diurnal moth *Atteva aurea* (the Ailanthus webworm moth, in the family Attevidae), which we recorded 17 times across five of the participating farms. This colorful moth is most closely associated with tree-of-heaven (*Ailanthus altissima*), which does not seem to be very common on Martha's Vineyard (there are just five observations from the island in iNaturalist). But Bugguide.net reports that it uses other larval hosts, including sumac, which would account for the moth's apparent abundance here. Adults, which take nectar from flowers, favored goldenrods, with 12 of our observations involving either *Solidago* or *Euthamia*.

Another moth we encountered fairly often was the Hawaiian beet webworm moth, *Spoladea recurvalis*, in the family Crambidae, which was recorded at four of the project farms. Our iNaturalist observations for this species involve the native composite flowers *Euthamia*, *Solidago*, *Symphyotrichum*, but also on *Monarda punctata* and once on flowering oregano. This is a species that appears to be far more common and versatile than iNaturalist records alone managed to capture; during its late summer flight period, our field staff often noted its abundance but were only able to generate a single "voucher" iNaturalist observation. To cite just one instance, on her September 12, 2023 visit to Morning Glory Farm project field assistant Jennifer Sepanara noted "...at least 15 (surely an undercount): at least 7 on asters in plot (photo at 10:03; in iNat), at least 4 on *Solidago* in plot, at least 1 on *Euthamia* in plot, at least 1 on oregano, at least 1 on anise hyssop, at least 1 on catmint." Using a number of crop plants including spinach and beet as larval host plants, this nearly cosmopolitan moth can be truly abundant where it occurs on the Vineyard.

Probably the most interesting moth observation from this project was *Spragueia leo* (Noctuidae), recorded on *Monarda punctata* at Morning Glory Farm on August 20, 2022. On the research-grade observation in iNaturalist, Massachusetts moth expert Steven Whitebread commented that "[Martha's Vineyard] seems to be its stronghold [in Massachusetts], but nevertheless, it is very rarely found (several records from the 1940s, but only one other recent record)." Otherwise, the project's moth records were generally of common species, including some considered agricultural pests. And as with other taxonomic groups, our Lepidoptera observations highlight the importance of asters and, especially, goldenrods, in supporting flower-visiting insects.

Results of this project indicate that farms on Martha's Vineyard play a significant role in supporting Lepidoptera populations. But it is important to keep in mind some important biological features of this insect order: a pervasive pattern of host specialization among larval stages; mobility, especially in adult life stages; and the ability, discussed above, of adults to feed successfully from a wide range of flowers. We found relatively little evidence of reproduction by Lepidoptera: no instances of oviposition and just a few observations of Lepidoptera larvae on flowers. To be sure, known or possible host plants for some Lepidoptera we observed were very much in evidence during our field work: e.g., sheep sorrel (*Rumex acetosella*), the usual host plant of American copper (*Lycaena hypophlaeas*), which we recorded visiting flowers 24 times); clouded and orange sulphurs, *Colias philodice* and *C. eurytheme*, which use the common pasture plant, hay plant, or cover crop alfalfa *(Medicago sativa*); or the corn earworm moth, *Helicoverpa zea*, a notable agricultural pest species with larvae that feed on corn. But for many other species, particularly ones that visit flowers as adults, we suspect that farms may provide adult food without meeting the full ecological needs of moths and butterflies by also providing suitable larval host plants.

Miscellaneous Species

Among the oddities we found on flowers were an earwig (*Forficula* sp., in the order Dermaptera), found on a cat's ear flower (*Hypochaeris radicata*); a Chinese mantis, *Tenodera sinensis* (in the order Mantodea), observed patrolling for prey on *Euthamia graminifolia* blossoms; several scorpionflies (*Panorpa* sp., in the order Mecoptera), perching for unknown reasons on goldenrods; and damselflies in the genus *Enallagma* perching on *Solidago* and *Zinnia elegans*, plus an eastern amberwing dragonfly, *Perithemis tenera*, on *Cosmos*, all in the order Odonata and all probably awaiting prey. We also observed several Orthoptera on flowers: the band-winged grasshopper (Oedipodinae) *Chortophaga viridifasciata* on *Euthamia*; a total of seven individuals in the grasshopper genus *Melanoplus* (Melanoplinae), visiting sunflower, *Symphyotrichum pilosum*, *Calendula*, *Euthamia graminifolia*, *Monarda didyma*, or teasel (*Dipsacus* sp.), with single individual *Melanoplus femurrubrum* and *Melanoplus differentialis* identified to the species level; and the katydids (Tettigoniidae) *Orchelimum minor* on *Euthamia graminifolia* and *Scudderia furcata* on sunflower and *Campanula*. Our observations of Orthoptera included both adults and nymphs (immature forms). In general, we have no idea what these grasshoppers and katydids were doing on flowers. But on one occasion, an adult *Melanoplus femurrubrum* was observed actively feeding on the petals of an aster flower, and it may be that flowers are an occasional or even regular food source for some Orthoptera.

An uncommon species on Martha's Vineyard, this lesser pine katydid (*Orchelimum minor*) came as a surprise when it was photographed on *Euthamia graminifolia* in the Morning Glory Farm project plot in September 2022. While Orthoptera were not commonly observed on flowers during project and are probably not effective pollinators, it is possible that flowers or pollen may be an occasional food source for katydids and grasshoppers.

Among non-insects, we recorded four spiders representing Thomisidae (crab spiders, three observations) and Salticidae (jumping spiders, one observation) — numbers that in retrospect seem surprisingly low. These spiders can safely be assumed to have been hunting for prey on the flowers they were observed on: *Solidago*, *Euthamia*, or *Monarda*. Finally, while we were unable to capture it in an iNaturalist observation, our field staff saw ruby-throated hummingbirds (*Archilochus colubris*) taking nectar from flowers on several occasions. These miscellaneous observations obviously represent a very small portion of our total data set. But they serve as a reminder that flowers have evolved precisely to be attractive resources for animals, and that an astonishing diversity of animal life will take advantage of floral resources at least occasionally.

Recommendations for Encouraging Pollinators

The wealth of observations we made of insects on flowers outside our project plots underscores the fact that even without taking special measures, farms on Martha's Vineyard offer floral resources that help support a wide range of animals. Our results also show that augmenting existing floral resources with appropriate plantings can enhance the value of farm habitat to pollinators, attracting and helping to support species, sometimes including uncommon and/or specialized ones, that would not otherwise occur at particular locations. We feel we were successful, then, in showing both the value of farms as pollinator habitat and the possibility of increasing that value with relatively simple manipulations. The key to any such effort is the selection of an appropriate mix of plant species, favoring species known to attract pollinators — pollen specialists, pollen generalists, or both. Beyond that, some general rules, based on project results, previous research, and common sense, should govern any plan for augmenting floral resources:

1. Variety is good: since most insects display at least some level of selectivity in the flowers they visit, including multiple species in a pollinator planting is likely to increase the number of species that are likely to visit.

2. Include a variety of flower shapes: many insects that visit flowers, including many flies, wasps, and beetles, have mouthparts that show little adaptation specifically for feeding on flowers; such insects may prefer to visit small or shallow flowers such as those of butterfly weed (*Asclepias tuberosa*). Other insects, such as some of the bumble bees (*Bombus* sp.), have mouthparts or foraging behavior adapted to taking nectar from longer, tubular flowers and will prefer to visit plants such as *Monarda*.

3. Take seasonality into account: any given plant species typically blooms for only part of the growing season. And insects, for the most part, exhibit similar seasonality, with adults active mostly or exclusively during a fairly short period (months or even just weeks). To be as successful as possible, a pollinator patch should offer a range of flower types at all points in the season.

Species selection

There is no single best mix of species to include in a pollinator plot; anyone contemplating the creation of such a feature will probably be influenced by availability, personal preferences for flowers, and the primary purpose of the plot (e.g., attracting beneficial predatory insects, or supporting specialized bees, or attracting a broad mix of pollinator species). Above sections of this report give considerable detail on how various plants performed over the course of the project.

Plant selection should also take into account the existing floral resources on the site. As one would expect, we detected little difference in performance between a particular species growing in one of our project plots and the same species growing wild. In planning a project plot, then, it makes sense to begin by assessing the floral resources that already exist in the area. There is not much point to using limited pollinator plot space for what amounts to a negligible increase, so if multiple *Solidago* species are common and widespread around the site, you might usefully select goldenrod species that are not already present (we encourage experimentation and would like to hear from anyone with results to report), so that you broaden species diversity. Or you could even not plant goldenrod at all, devote the available space and other resources toward planting other genera, and rely solely on the naturally occurring population to provide the benefits that this group of wildflowers provides.

All that said, we confidently make the following recommendations for plant selection for a basic pollinator resource on Martha's Vineyard, attractive to high diversity of both generalist and specialized pollinators:

Goldenrod: *If there is one point we feel is important to emphasize based on the results of this project, it is the importance of native goldenrods for supporting pollinators on Martha's Vineyard.* Goldenrods accounted for the lion's share of most of the oligolectic bee species we observed and also seemed to be preferred by many more generalist pollinators. Ideally, we believe a Martha's Vineyard pollinator resource should include both *Euthamia* and *Solidago*. The species we tested, ***E. graminifolia*** and ***S. nemoralis***, performed well and make a good species pair as long as they are not interplanted. But the island's other native *Euthamia* species, *E. caroliniana*, would probably also work well (though it seems to be on average shorter and less vigorous than *graminifolia* and perhaps a little more fussy about soil type and other conditions). Many other *Solidago* species would presumably work well, and we recommend adding additional ones if they are available and can be accommodated in the plot. ***S. odora***, ***S. rugosa***, and ***S. sempervirens*** are all goldenrods that grow well on the Vineyard and that we consider to be very effective pollinator plants, for both oligolects and generalists, based on our observations from around the island.

The beneficial fly *Trichopoda pennipes* visiting *Euthamia graminifolia* in the Thimble Farm project plot. Early September 2024.

Asters: We recommend that any pollinator patch include native asters, which we found to be second only to goldenrod in the numbers and "quality" of insects attracted. ***Symphyotrichum laeve***, tested in our project plots, generally performed very well, though it didn't bloom heavily during its first season and it appeared vulnerable to browsing damage. Other blue-flowered native aster species, such as New England aster, *S. novae-angliae*, would be worthy additions or replacements, if they are available. But another very clear conclusion from this project was the value of aster species with small, white flowers such as ***S. pilosum*** and ***S. ericoides***, which were strongly preferred by some of our late-season specialist bees and were also heavily used by generalist pollinators. Regrettably, these species seem to have been deemed “weedy” by the horticulture industry, presumably due to their smaller flowers and sprawling habit. But if they can be sourced commercially or grown from local seed sources, they would be a highly valuable addition to any pollinator resource on Martha’s Vineyard.

A female Huron sachem (*Atalopedes huron*) on smooth aster (*Symphyotrichum laeve*) in the Mermaid Farm project plot in early October 2024.

Monarda: ***Monarda punctata*** was a very successful component of our project plots, being especially attractive to large Apid bees (powerful pollinators including bumble bees, large carpenter bees, and honey bees) and larger wasps (valuable not just as pollinators but as predators or parasites that help regulate arthropod populations). As we noted, *M. punctata* was resoundingly outcompeted by the related but much less useful *M. didyma* where the two species were interplanted. We also suspect that even under the best conditions, *M. punctata* may be rather short-lived for a perennial, and so may need periodic replenishment in order to survive long-term in a pollinator patch. But the very good performance of this species in attracting beneficial insects makes us feel that it is worth a little effort to include in a pollinator resource. While we did not test it, ***M. fistulosa***, with pinkish flowers that are a bit shorter than the red ones of *M. didyma*, is a “near native” species that might perform well on Martha’s Vineyard and has the advantage of being quite widely available. We would love to hear from anyone who experiments with *M. fistulosa* in pollinator patches on the Vineyard.

Milkweed: While we had poor success growing butterfly weed (***Asclepias tuberosa***) in our project plots, we believe that was the result of an isolated problem associated with a particular supplier. A host of observations from across many years on Martha’s Vineyard persuade us that this plant makes a useful addition to any pollinator patch on Martha’s Vineyard. The bright orange flowers in its broad panicles seem to offer nearly inexhaustible supplies of pollen and nectar, attracting pollinators from many insect orders. Once established, this deeply tap-rooted plant is almost indestructible, and individual plants can persist for many years. Other members of the genus also attract pollinators; common milkweed, ***A. syriaca***, strikes us as about as effective as *A. tuberosa*, though *syriaca* is a sometimes excessively vigorous species that can spread aggressively via rhizomes. It would make a suitable replacement or complement for *A. tuberosa* in settings where its aggressive habits won't cause problems. Finally, swamp milkweed, *A. incarnata*, is a widely available species that is almost as good a pollinator plant as its two relatives we have mentioned. However, while it does not actually require swampy conditions, it is less vigorous and appreciably less drought-resistant than its relatives and should probably only be used in settings where competition can be managed and where soils are naturally damp or irrigation is available.

One of this project's less frequently observed bumble bees, *Bombus perplexus* visits common milkweed (*Asclepias syriaca*) in general farm habitat at Thimble Farm in late June 2024.

Sunflower: Suitable varieties of ***Helianthus annuus***, the common sunflower, are rugged and highly effective pollinator plants. As we note above, sunflowers in any significant quantity attract several species in the bee genus *Melissodes* quite reliably. They are also visited by a host of more generalist pollinators — most conspicuously, in this project, the generalist bees *Bombus impatiens* and *Halictus ligatus*. We recommend traditional (or at least traditional-looking) varieties of sunflower, with yellow rays and medium or large flower disks. "Pollen free" sunflowers appear to be a useful nectar resource for bumble bees and honey bees but were not successful at attracting *Melissodes*. Planting multiple varieties of sunflower is recommended, since doing so can extend the bloom period of this species and result in more varied flower characteristics, perhaps translating to a wider range of insect visitors. The drawbacks of sunflowers in pollinator plots are an annual life cycle, meaning they need to be planted anew each season, and susceptibility to deer browse where the plants can't be adequately protected. But if these limitations are manageable, *Helianthus annuus* is a valuable addition to a pollinator resource.

It is worth emphasizing once again that while some plants emerged as especially popular pollinator plants, virtually every species of plant we observed in bloom during this project attracted at least something, at least some of the time. Crop plants, cover crops that are allowed to bloom, ornamentals, and agricultural “weeds” all figured in the overall mix of pollinator resources offered by farms, some of them performing quite well indeed. And we are nowhere near sorting out all the all the flower-pollinator associations captured in our data, or identifying the preferred flower types of all the insects we observed. So while a carefully planned pollinator patch can be a useful addition to a farm (or yard), especially in providing resources for specialized insects, any action you take that promotes the presence of flowers probably makes a contribution to the overall pollinator resource on the site you’re managing. We encourage experimentation with species not discussed in this report, and we encourage leaving as much unmanaged land as possible alone through the growing season so that whatever flowers occur there can bloom. It’s impossible to predict what flower might meet the needs of some poorly known insect. From the pollinator’s perspective, more flowers and more floral diversity are almost always good things. And so developing an overall mindset of promoting flowers in general, however it can be done, may be as important as installing pollinator resources that meet our specific recommendations.

Site selection and preparation:

Site selection for a permanent pollinator plot should involve the same considerations given to any kind of perennial planting. Plots should be located in places unlikely to be required for any other use, so that plants have time to grow to maturity and so that the effort that goes into creating a plot is not wasted. Most of the plants we recommend do best in **full or nearly full sun**, so exposure to sunlight (including in the near- to medium-term future, as trees to the south of the plot continue to increase in height) should be considered. While **irrigation** isn’t an absolute requirement for a pollinator plot, periodic watering proved very helpful in getting plugs established or for maintaining good plant health during the summer droughts that appear to be getting longer and more frequent on Martha’s Vineyard. So siting a plot near existing water connections is desirable. Deer and possibly rabbit **browsing** damaged some of our plantings, with sunflowers and *Symphyotrichum laeve* appearing to be the most vulnerable among the species tested in our project plots. So siting pollinator patches within any fenced areas a farm may have is a good idea. Finally, on large farms, sites in the interior of the farm may be separated from native habitat and existing pollinator populations by a substantial swath of habitat that many insects will consider inhospitable; in such cases, siting pollinator plots near the edges of the farm may increase the chances that a good mix of pollinators will be able to discover the newly created resource.

While it is not an assumption this project tested, nor one that we’ve found much information on in the scientific literature, we suspect that plantings for pollinators may be most effective when arranged in single-species blocks (as opposed to mixed-species blocks or planting in long, narrow rows). We have noted that interplanting species can result in the decline or eventual loss of less competitive plants. So there is a horticultural reason for avoiding mixed-species plantings. We also hypothesize that planting in blocks may result in concentrated resources with strong chemical or visual signatures, making them easier for insects with a strong preference for a particular flower type to locate. And we surmise that block plantings make it easy for insects to forage efficiently once the flowers have been discovered. With narrow row plantings, only two specific directions will take an insect from one plant to another one of the same species. But with a two-dimensional plot, even insects on the outer edge of the plot will find additional resources in half the directions they can possibly move in, and this figure increases to all directions once an insect is in the interior of a plot.

While we think that any quantity of added resources for pollinators are likely to be useful and very unlikely to cause any harm, it is probably the case that more is better. Our nominal five-by-five foot, single-species plots, as we have discussed, were certainly capable of providing detectable benefits to flower-visiting arthropods, particularly when they included highly effective pollinator species that were absent or scarce in nearby habitat. Smaller flower patches might also be effective, but we suspect that the plot size we experimented with is probably close to the minimum size for plantings the effects of which are great enough to justify the expense and effort of creating a pollinator resource. Larger plots presumably work better, up to whatever size a farm finds to be affordable to install and manageable to maintain once established. And there is no reason not to include multiple pollinator plots on a single farm!

As with any effort to get new plants established, some measure to subdue existing vegetation (including potential vegetation in the form of seeds banked in the soil) is strongly recommended. At all of the sites involved in this project, we opted for tilling to discourage existing vegetation and also facilitate planting plugs of our chosen species. But using black plastic or landscape fabric to solarize the plot, killing existing vegetation, and then planting plus with minimum soil disturbance might also be a viable approach.

While it is no doubt possible to establish a pollinator resources solely from seeds planted directly into the plot (and direct seeding is the method we recommend for growing sunflowers), we opted to rely as much as possible on transplanted plugs, in order to avoid the risks of low germination and high mortality of seedlings, and to expedite the establishment of stands of mature plants. While the project allowed no comparison between plots grown from seed and ones established by planting plugs, we recommend the latter approach to the extent possible. Many excellent pollinator plants are available commercially; farms may also have the capacity to collect seed from local sources and grow their own plugs, which would substantially increase the variety of pollinator plants to choose from.

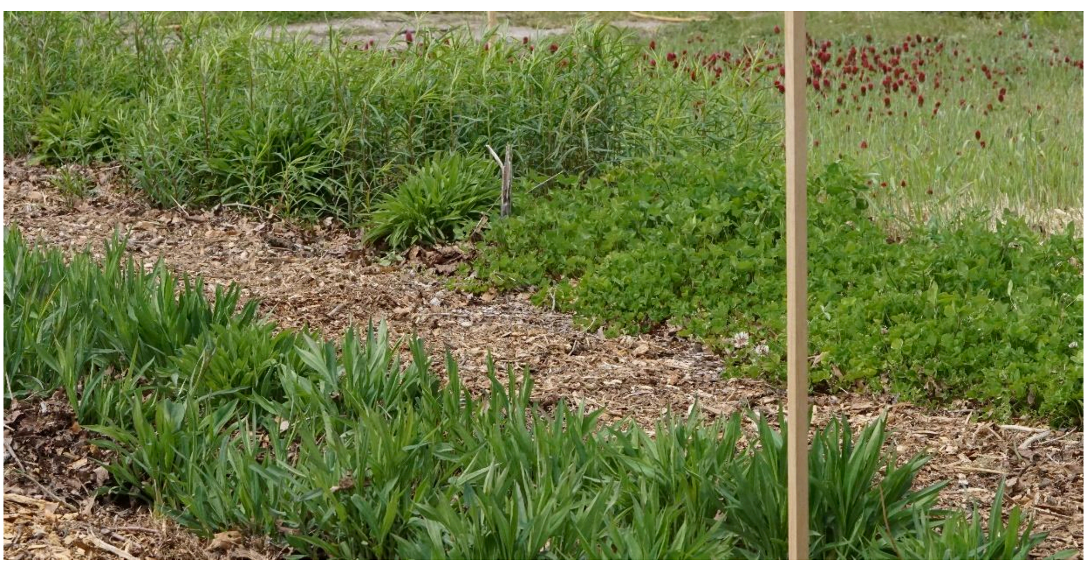
Planting rates should of course be appropriate for the size of the species you are planting. In general, we think that erring on the side of density makes sense. Plantings in agricultural settings can be expected to experience considerable pressure from weed seeds in the soil or arriving from nearby, and denser plantings may be more effective than sparser ones in crowding out such interlopers. And as with any horticultural project, some level of mortality among your transplants is likely, and it makes sense to anticipate that in planning planting density. We planted plugs of our smaller species, such as *Monarda punctata*, roughly on 12-inch centers, and larger plants, such as *Euthamia graminifolia*, slightly farther apart, with generally satisfactory results.

Plot management:

We wish that the simple experimental component of this project had led us to a pollinator plot design that, once established, would persist indefinitely, maintenance-free, while continuing to support both generalist and specialist pollinators. But anyone who has ever undertaken a horticultural project of any complexity will recognize how unrealistic that goal is. Plants die, for a host of reasons. Unwanted plants seize every opportunity to get established. And left untended, any kind of planting evolves, whether slowly or not so slowly, into something different from what was originally created.

Three years in duration, this project did not run long enough to fully assess the long-term development of our project plots. And being focused on plant-insect interactions at least as much as on the durability of our project plots, we continued to provide a measure of care — weeding, watering, fencing — in an effort to ensure a continued supply of flowers. That said, our project plots were not exactly coddled. And the enduring vigor of some of our plants in some of our plots suggest that even if left totally unattended, some of our plantings will continue to benefit pollinators for many years to come. *Euthamia graminifolia*, for example, which emerged as arguably our most effective pollinator plant, flourishes to the point of dominance in many places on Martha's Vineyard, with no human assistance at all. As noted earlier, we deliberately selected test species partly on the basis of expected ruggedness, with the intent of producing a plot design that required as little maintenance as possible in order to persist.

While we made no comparative tests, **we recommend the use of mulch** of some kind in project plots to help suppress weed growth. The wood chips we used were fairly effective, lasted a long time, and were affordable; other mulches or water-permeable fabrics would presumably also be effective.



Neatly mulched project plot at Beetlebung Farm, mid-May 2023. Smooth aster in the foreground, clover and goldenrod in the middle distance, and a flowering crimson clover cover crop (not part of the project plot) in the background. Bring on the pollinators!

With climate change, it appears that prolonged summer droughts may be increasing in frequency and severity on Martha's Vineyard. For this reason, **arranging for irrigation** is as desirable for project plots as it is for any other kind of outdoor horticulture. However, while the assumption was not tested, we hypothesize that irrigation can be overdone with the kind of pollinator plot we are recommending. Most of the priority plants we identified are quite drought-resistant (indeed, that is one quality we looked for in the species we elected to test). Drought resistance may translate to a competitive edge relative to many of the plants that could be expected to encroach into pollinator patches on a Vineyard farm. Watering when it is not truly needed may do more to encourage undesirable vegetation than it does to support the pollinator plants. In the absence of any real data, we suggest that irrigation only takes place when the pollinator plants themselves are beginning to show early signs of drought stress.

While the innate vigor of our recommended pollinator plants and the use of mulch of some kind are likely to offer considerable resistance to competition from undesired plant species (we dislike the judgmental tone of the word "weeds"!), it is inevitable that a pollinator plot will eventually see some encroachment by species that haven't been deliberately planted. How, and how aggressively, to respond is largely a subjective matter, depending on the resources that can be devoted to maintaining the pollinator patch and how you want it to look. But our recommendation is to **proceed cautiously with weeding**, which is labor-intensive and may not be all that important in the context of the type of plot we're recommending. For one thing, once established, most of our priority plant species can be expected to be quite competitive and unlikely to be harmed by modest levels of weeds. For another thing, the presence of some weeds in a pollinator plot may actually be beneficial, representing structural complexity that offers shelter to arthropods and, if the weeds bloom, possibly adding additional floral resources to the plot. (Keep in mind our discussion earlier in this report on the wide variety of plants that we observed hosting pollinators.) Again, given the relatively short duration of this project, we can't say with any real confidence how our recommended type of pollinator plot will evolve over a period of years. But in most cases, the purpose of a pollinator resource is to support pollinators, not to have a pristine look, and until the point where competition from unplanted species begins to weaken the deliberately established pollinator plant species, the presence of weeds is quite consistent with that goal.

Finally, to be successful over the long term, a pollinator resource needs periodic assessment and replacement or augmentation of plants that have died or grown weak. This can be done at any point during the season, and the more often a planting is inspected, the better. But in any case, examination in late August or September, as the growing season approaches its end, will give growers an opportunity to decide what is needed, make appropriate plans for the next season, and order any plant material that is needed well in advance of planting time the following spring.

Conclusion

Collected across 261 site visits over three field seasons, distributed across eight Martha's Vineyard farms, the data set produced by this project is daunting. We regret that considerations of space and available time meant that we couldn't find time to discuss all the species we encountered. And some types of analysis that the data set could support, such as characterizing the results from each particular farm and trying to identify ecological factors that accounted for the differences among farms, could not feasibly be accommodated in this document. But we hope this report has at least captured some of the most useful and important conclusions to be drawn from that huge volume of information. And, especially, we hope that this report contains observations and suggestions that will both inspire and usefully guide Vineyard farmers, and ideally many others, in taking action to support pollinator populations and diversity.

At the very least, we believe the project demonstrated beyond any doubt that Vineyard farms, even without the presence of dedicated pollinator resources, offer valuable habitat for flower-visiting insects. The sheer diversity that we recorded, and the number of species we documented that appear to be at least locally rare or uncommon, should be a source of pride to all eight participating farms, showing that their efforts to farm responsibly and sustainably are paying off in the form of healthy and productive habitat. We are also confident that project results show that even small-scale enhancement of pollinator resources, if they are appropriately designed, can offer benefits to uncommon and specialized species like the oligolectic bees we recorded. We hope that these outcomes will inspire participating farms, other farms on and beyond the Vineyard, and other constituencies such as municipalities and individual homeowners to make the modest efforts needed to augment resources for pollinators. If you look at the activities of both generalists and specialist species, the beneficial effects of even a single plot from this pilot project have not been trivial. If the methods we experimented with and recommend are widely adopted, the cumulative benefits could be substantial indeed. In an era of anthropogenic climate change, accelerating translocation of species beyond their native ranges, and steadily expanding, fragmenting impacts of human infrastructure, development, and economic activity, any measures that mitigate threats to native pollinators are worth considering.

Finally, we'd like to thank once again the eight farms that cooperated with this project — for assisting our exploration, but also for the many ways that they benefit the Vineyard community. Frequent opportunity to bug-watch on project farms was a fun and interesting privilege, one that we will miss in coming field seasons. We wish you all the very best in your agricultural efforts and hope that you find the results of this project interesting and inspiring.

The bee-mimic Syrphid fly *Mallota posticata* on golden alexander (*Smyrnium* sp.) at Mermaid Farm, late May 2022.