A Survey of Queen Anne's Lace on Nantucket and an Assessment of its Effect on Native Pollination, Year Two.

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Abstract

Daucus carota (Queen Anne's Lace) is a non-native plant species that was introduced to North America from Europe, and its presence on Nantucket Island, Massachusetts has been documented since at least the nineteenth century. Research in other plant systems has investigated whether the presence of a non-native can affect native pollination, and the results have been mixed. A native may be negatively affected, may not be affected or may be positively affected by the presence of the non-native. In 2015 A population survey was performed on *D. carota*, and a pollinator observation study was performed on *D. carota* and a native species, *Sericocarpus asteroides* (Toothed White-top Aster). Pollinators were observed for three hours per day and five days each for the two species individually and both species cohabitating together. In 2016, additional populations were added to the *D. carota* population survey, and a removal treatment was performed on sites where both species cohabitate. On day one, the sites were observed as described, however, *D. carota* umbels were then removed from the site, and on the following day, pollinators were observed on *S. asteroides*. In addition, *S. asteroides* populations from a range of distances from *D. carota* were assayed for the presence and degree of heterospecific pollen. We had four hypotheses: 1) *D. carota* would be present across Nantucket Island; 2) The presence of *D. carota* would increase pollinator visitation rates and diversity indices on *S. asteroides*; 3) The removal of *D. carota* would restore pollinator visitation rates and diversity indices to those found on sites with only *S. asteroides*; 4) Higher levels of heterospecific pollination would be found in *S. asteroides* populations located close to *D. carota*. We found *D. carota* to be abundant across the island. While both plant species are generalist-pollinated, *D. carota* attracted 15 insect families and *S. asteroides* attracted only 8, with the majority being flies and bees. Each removal treatment received at least 50 % fewer pollinator visits after *D. carota* was removed, and the analysis on heterospecific pollination is currently on-going.

Introduction

Humans have been facilitating the movement of species past natural borders for millennia. For the majority of that time the effects on native species were little known. Within the last century though, researchers began documenting that species introduced to non-native habitats were having several effects on native flora and fauna. Most early research focused on the consequences of non-native animal introductions, such as rats, cane toads, fire ants and zebra mussels, into non-native environments. These species overpopulate their introduced environments, decimate native competing animals and prey on other, native species[1,2]. However, many non-native plants, often unobtrusive, are now considered to be highly invasive species in their own right[3–8]. Consequences of plant invasions may appear to be more subtle than animal invaders, which interact with their environment to a more noticeable degree than plants. Nevertheless, plants are keystone species in many environments so the effects of non-natives may cascade to affect entire ecosystems. Successful plant invaders often outcompete native plant species for limited resources such as water, nutrients, space or sunlight[3,4,8,9]. Well-known early examples include kudzu, common dandelion and Japanese honeysuckle[7,10].

In addition to outcompeting natives for resources, it has become increasingly recognized that non-native plants may compete with native plant species and communities at the ecological level[4,11,12]. Most intriguingly, evidence shows that non-native plant species effectively interact with native plant species for pollinator services. In some cases the effects of these interactions are positive. Non-natives with more attractive flowers than natives increase pollinator species richness and number of pollinator visits which together may provide enhanced pollination to native species[3,8,12]. In these systems it appears that non-native species attract more pollinators to the community than would normally be present, and those pollinators visit the natives, in turn. In species that are pollen- or pollinator-limited, an increase in pollinator visits would increase seed set of the native, yet if the species experiences neither limitation, there would no increase in seed set. For example, in *Raphanus sativus*, seed set increased with increasing pollinator diversity, but at the highest species richness investigated, there was a slight reduction in seed set[13]. It is possible that at high pollinator visitation or diversity, a reduction of native pollen occurs, being effectively diluted by non-specific pollen on stigmas.

A meta-analysis of 40 studies obtained an overall significantly negative effect of non-native species on native species via pollination disruption[8]. Although increases in visits and

diversity may occur, non-native species may disrupt pollinator services and eventually, fecundity of native species. For instance, the presence of non-natives alters how pollinators behave towards natives. In a similar fashion to how non-natives may attract pollinators to a community, non-natives may alter pollinators' behavior, once present. A pollinator interacting with both species drawn to a community may follow two scenarios. It may initially visit the non-native before visiting the native, or it may visit the native but shift to a non-native before revisiting another native. In either case, the native's stigma will be "contaminated" with non-native pollen, called heterospecific pollination[6,14]. The non-native pollen may overload the stigma's capacity or simply dilute the native pollen that is present such that it negatively interferes with pollen germination and ultimately, fertilization. Subsequently, this shift in pollinator behavior has been shown to reduce seed set in native plant species[4,7,15].

Although the effects of non-natives on natives are variable, there is a consistent pattern to those effects. Native flowers that morphologically resemble a non-native will be affected more than a native that does not resemble the non-native[7,8]. If both species co-flower and are found in the same community, the effect on natives is more pronounced as pollinators will be able to directly interact with both species at spatial and temporal scales[9,11]. Likewise, when both species are generalist pollinated, they can compete for the same pollinators[4,8,11]. These effects are most prevalent when the non-natives are at high densities relative to the natives[5,9,12,14].

This project originally had two objectives and was performed in June and July 2015. The first objective was to map the distribution and density of a non-native, *Daucus carota* (Queen Anne's Lace) on the island. The second objective was to determine the effect of the presence of *D. carota* on the pollination of a native which is similar to *D. carota, S. asteroides* (Toothed Whitetop Aster). We hypothesized that *D. carota* was abundant on the island, and that *D. carota* has disrupted the pollination of *S. asteroides*. This native species was chosen based on its abundance, generalist pollination strategy and similar morphology, flowering time and habitat preference as *D. carota*[16]. Additional objectives were carried out during summer 2016. In addition to adding to the population and density maps for *D. carota,* we sought to increase the replicate sizes of the pollinator observation study treatments, in hopes that the statistical differences between treatments would become more pronounced. We also sought further evidence of the direct impact of *D. carota* on *S. asteroides* by performing a series of removal treatments. We hypothesized that when *D. carota* was removed from sites with *S. asteroides,* the

pollinator activity found on *S. asteroides* would return to the levels that are found in sites with only *S. asteroides* present. Finally, we investigated the possibility of heterospecific pollination on *S. asteroides* by collecting inflorescences from *S. asteroides* populations at various distances from *D. carota* and assaying those inflorescences for non-specific pollen.

Methods

Study Species

A common non-native species is Queen Anne's Lace, or wild carrot (*Daucus carota* ssp *carota*, L.). It is the wild relative of crop carrot (ssp *sativus*), a biennial member of the Apiaceae (Umbelliferae) family and considered a highly invasive plant species in numerous locations. The species is biennial, as it grows a rosette during the first year of growth and bolts (flowers) May – August in the second year before dying. The inflorescence of *D. carota* is a compound umbel composed of hundreds of white florets (Figure 1A). The species can reach between one and two meters tall[17]. It is generalist pollinated, with Diptera (flies) being the largest group of pollinators[18]. *D. carota* grows easily along roadsides and in disturbed landscapes and can produce several thousands of seeds per individual which facilitate its spread into new environments[17]. It was introduced to New England with the earliest settlers for medicinal purposes but quickly escaped into the wild[17,18]. It was described on Nantucket Island, Massachusetts in 1888 as being "Too common, a great pest; over-running entire fields"[19].

Two native Nantucket Asteraceae (Compositae) species with morphologies and life histories similar to *D. carota* are *Sericocarpus asteroides* (L.), Toothed Whitetop Aster (*S. asteroides*), and *S. linifolius* (L.), Narrowleaf Whitetop Aster. These asters are putatively rhizomatous clonal, as is a related species that occurs in the Pacific Northwest, *S. rigidus*, although sexual reproduction does occur[20]. Like *D. carota*, they also produce a rosette of leaves during vegetative growth and an upright stem when bolting. The inflorescence is the head (composite), which in these species are themselves organized into a corymb-like structure, resembling a compound umbel (Figure 1B). The florets are white, which gives the inflorescences an overall morphology similar to *D. carota*. On Nantucket both species co-flower with *D. carota* and each other. Both species are smaller than *D. carota,* but *S. linifolius* is generally smaller still and has a more limited distribution than *S. asteroides*, creating fewer places on the island in which it co-occurs with *D. carota* (pers. obs.).

Queen Anne's Lace Population Survey

The presence of *D. carota* was investigated on properties owned and maintained by the Nantucket Conservation Foundation, Nantucket Islands Land Bank and the Linda Loring Nature Foundation, in addition to properties under public domain across Nantucket Island and on a small, neighboring island, Tuckernuck Island. Permission to perform research on private lands was provided by the respective conservation agencies, prior to performing research. When populations of *D. carota* were located, up to five density measurements (depending on the population's overall size) were taken randomly within the population with a PVC square meter. An average density for the population was later calculated by dividing the total number of individuals counted within each population by the number of density measurements recorded for that population (up to five). Latitude and longitude of each population were recorded using Smart Compass Pro (Smart Tools co., Daegu, Republic of Korea) installed on an Android smartphone. Distances from the population to the ocean were measured using the measure distance feature of Google Maps. A linear regression was performed on average density of the population by distance to the ocean in R (version 3.3.2). A population distribution map was generated by uploading the completed dataset to Google Fusion Tables[21] and using default settings. A density map was then generated by using the heat map feature of Google Fusion Tables, weighted by the average density of each population and a radius of 25. Although less thorough than the one for *D. carota*, a population survey was also performed for *S. asteroides*. Briefly, populations of *S. asteroides* were located and recorded using Smart Compass Pro, and the density of one square meter was recorded.

Pollination Observation Study

For 2015 a random site was observed between 8:00 and 11:00 am each morning, selected from one of three treatments: 1) a community containing *D. carota* but no *S. asteroides* (*D. carota (-S. asteroides)*), 2) a community with both species present (≤ 2 m apart) (*D. carota (+S. asteroides)* and *S. asteroides (+D. carota)*) and 3) a community containing *S. asteroides* but no *D. carota* (*S. asteroides (-D. carota)*). Peak pollinator activity for *D. carota* is reported as 10:00 – 11:00 am [18,22] and *Sericocarpus* is known to release pollen in the morning and be absent by days end[23]. In communities with only one of the species present pollinator activity was observed within one square meter. In all communities where both species were present, the species were never found within one meter of one another, therefore 2-one square meters were observed, one square meter that contained *D. carota* and one square meter that contained *S. asteroides*. Time of

pollinator visits was recorded, and pollinators were identified to the lowest possible taxon, adapted from Ahmad and Aslam[18] and Brown *et al.*[14]. Some pollinators were identified to the genus and/or species levels based on morphological characteristics in the field [24], but statistics were performed with all pollinators maintained at the family level since not all pollinator visitors were identified to a lower taxonomic level.

To equalize replicate size of the treatments that were performed in 2015 to six per treatment, one treatment of each species without the other species (treatments *D. carota (-S. asteroides)* and *S. asteroides (-D. carota)*) was again performed in 2016. Additionally, a series of removal treatments was performed. Sites were located that contained both species and observed over the course of two days. On the first day, these sites were observed as they were in 2015. After this observation, all visible umbels of *D. carota* were removed from the site and surrounding area, and pollinators were again observed the following morning on *S. asteroides*.

Although beetles and ants are frequent pollinators of many plant species, they appeared to be poor outcrossing pollinators of *D. carota* and *S. asteroides*, as neither was seen to leave the inflorescences over the observation time period (pers. obs.). Very few insects on *S. asteroides* were beetles or ants, and Ahmad and Aslam[18] found beetles infrequently on *D. carota*, as did we. As such, families of beetles and ants were omitted from the statistical analyses. Twenty communities were observed for the initial observation study for a total of 20 one-square meter treatment plots, six each of *D. carota (-S. asteroides)*, *D. carota (+S. asteroides)*, *S. asteroides (+D. carota)* and *S. asteroides (-D. carota)*. Additionally, twelve removal treatments were observed over the course of twelve days (six Pre- and six Post-). Pre-removal treatments were observed as described above for the treatment *S. asteroides (+D. carota)* on day one, then the umbels of *D. carota* were removed from the site and *S. asteroides* was observed the following morning.

The number of pollinator visits was standardized to the number of inflorescences per treatment, similar to Kandori *et al.*[7], and normalized using log transformation when necessary. ANOVAs were performed on the normalized, standardized number of visits (st.visits) to each treatment and the species richness (S) to each treatment. The Shannon (H') and Simpson diversity (D) indices and pollinator evenness (E) were calculated for each treatment in Microsoft Excel (2013), following Donaldson *et al.*[25] and Fang and Huang[26] and ANOVAs were

performed. A separate t-test was performed on the normalized, standardized visits and diversity indices for the removal treatments. All ANOVAs and t-tests were performed in JMP pro 12.0.1.

Heterospecific Pollination Assay

To assess the possibility of heterospecific pollination on *S. asteroides*, inflorescences were collected at random *S. asteroides* populations across the island. GPS locations were recorded. Once a population of *S. asteroides* was located, 15 inflorescences were collected and stored in 70 % ethanol on ice in the field and during transfer to the University of Memphis, before being stored at – 20°C in the lab. Inflorescences were dissected and stigmas were mounted on slides. Distances to the nearest *D. carota* population will be measured in Google Maps using the measure distance feature and the populations' GPS coordinates. The slides are currently being observed under light microscopy, and pollen grains are being identified to either morphospecies or species known to be in flower during collection (including *S. asteroides* and *D. carota*) and counted. Total pollen counts will be recorded and the percent of heterospecific pollination for each population will be calculated and the average percent heterospecific pollination will be plotted against distance to the nearest *D. carota* population in a linear regression framework (further details to be decided).

All statistics were initially run for data collected in 2015, but they were then re-run after collecting new data in 2016, including the linear regression for the *D. carota* population survey and the ANOVAs for the pollinator observation study. The following results include all data and are up-to-date.

Results

Queen Anne's Lace Population Survey

A total of 209 *D. carota* populations were located on Nantucket, and a single population was discovered on Tuckernuck Island during 2015. In 2016, 22 further *D. carota* populations were recorded on Nantucket, bringing the total to 231 (Table 1). These were added due to certain areas of Nantucket not being surveyed in 2015, notably the Tom Nevers area, the Nantucket Airport property and from Wauwinet to Coatue Peninsula (Figure 2). The average population density was 12.26 plants/m^2 across the island (Table 1). The population density ranged from a low of 1 plant/m^2 to a high of 109.4 plants/m^2 on the seaside cliff of Baxter Rd in Sconset (Figure 2B). Many of the populations of *D. carota* on the island were found along roadsides and in highly disturbed areas. Although the relationship is not strong, there is a significant negative

relationship between population density and the distance to the ocean. Population number decreased with increasing distance from the ocean, and population density decreased with increasing distance from the ocean ($p = 0.026$, $R^2 = 0.0178$; Figure 3). Few populations were found within the island's numerous conservation properties.

Pollination Observation Study

Toothed Whitetop Aster was found to co-occur with *D. carota* in several locations on the island, however, the two species were often not found to be direct neighbors (< 1 m apart). They were typically at least 1 meter apart at all sites investigated. Both species were confirmed to be generalist pollinated, but clear differences were found between them. Queen Anne's Lace attracted 15 insect families (Andrenidae, Apidae, Calliphoridae, Crabronidae, Dolichopodidae, Empididae, Halictidae, Ichneumonidae, Lycaenidae, Muscidae, Nymphalidae, Sphecidae, Syrphidae, Tabaninae and Vespidae) during 2015 and 2016 (Figure 4), whereas *S. asteroides* attracted only eight families both years (Andrenidae, Apidae, Crabronidae, Halictidae, Lycaenidae, Muscidae, Nymphalidae and Syrphidae), all of which are found on *D. carota* (Figure 5). The distribution of the number of pollinators was similar between species and years. The majority were sweat bees (Halictidae) followed by families of flies (Calliphoridae, Muscidae and Syrphidae).

During 2015 Toothed Whitetop Aster received a total of 149 pollinator visits and *D. carota* received a total of 477 visits, over 30 observation hours each. At the treatment level, *D. carota (-S. asteroides)* received 290 visits, *D. carota (+S. asteroides)* received 187 visits, *S. asteroides (-D. carota)* received 56 and *S. asteroides (+D. carota)* received 93 visits. During the additional species treatments in 2016, *D. carota* received 55 more pollinator visits and *S. asteroides* received 31 more pollinator visits, bringing the totals to 532 and 180 pollinator visitors (Table 3), respectively, while at the treatment level pollinator visits increased to 345 for *D. carota (-S. asteroides)* and 87 for *S. asteroides (-D. carota)* (Table 4). After standardizing by the number of inflorescences, *D. carota (+S. asteroides)* received the most average visits, 16.8 ± 8.93, followed by *D. carota (-S. asteroides)* with 14.1 ± 3.88, *S. asteroides (+D. carota)* with 2.4 ± 1.35 and *S. asteroides (-D. carota)* with the fewest average visits of the non-removal treatments, at 0.8 ± 0.27. For the removal treatments, Pre-removal had 178 total visits, while post-removal had 82 total visits. After standardizing by the number of inflorescences per site, pre-removal had 2.8 ± 0.49 visits and post-removal had 1.3 ± 0.31 visits (Figure 6).

Standardized visits, S, H', D and E were all significantly higher for *D. carota* than *S. asteroides* (st.visit = 15.4 and 1.58, p = 0.01; H' = 1.23 and 0.78, p = 0.03; D = 0.61 and 0.42, p = 0.0497; E = 0.78 and 0.54, p = 0.045; Table 3). At the non-removal treatment level only the st.visits are significantly different between *D. carota (-S. asteroides)* and *S. asteroides (-D. carota)* (1.06 and 0.21, p = 0.0082), *D. carota (+S. asteroides)* and *S. asteroides (-D. carota)* (0.94 and 0.21, p = 0.0247) and *D. carota (-S. asteroides)* and *S. asteroides (+D. carota)* (1.06 and 0.39, p = 0.427) (Figure 6). At the removal treatment level, st.visits is significantly higher for pre-removal than post-removal (2.8 and 1.3, p = 0.0224) (Figure 6), but S, H', D and E are not significantly different between treatments, although they are each higher for the pre-removal treatment (Table 4).

Fifteen heads were collected from each of 23 *S. asteroides* populations and are currently being assayed for heterospecific pollination. All heads have been dissected and slide-mounted, yielding 345 slides to be observed. To-date, approximately 20 % have been assayed. These data should be fully gathered by spring 2017.

Discussion

Daucus carota is a tenacious, non-native plant that can easily be found across Nantucket Island. There are localities where it tends to be found most often, including areas close to the ocean and along roadsides. Furthermore, it is generally found in the highest densities close to the ocean, with both a decrease in the number and densities of populations with an increasing distance to the ocean (Figures 2 & 3), and interestingly, *D. carota* is also reported to be abundant along the coastline in the British Isles[17]. On Nantucket, *D. carota* was historically found in a more widespread distribution, rather than being confined to currently disturbed landscapes[19]. It is highly probable that land use strategies on the island have changed over time which decreased the prevalence of *D. carota* on protected properties and farther inland from the ocean. Historic sheepherding on the island would have permitted consistent disturbance which facilitated *D. carota*'s incursion on the landscape, but as sheepherding has diminished and much of the island is now protected property, that disturbance has subsided within the last century[16]. Unfortunately, *D. carota* produces thousands of seeds which are easily dispersed by two common island mammal species, rabbit and deer. Its seed can also have a long dormancy[27], so the possibility that *D. carota* is hidden in the seed bank cannot be overlooked, even on currently undisturbed conservation properties.

Daucus carota is currently listed as non-native in Massachusetts, but elsewhere in the United States and across the world it is classified as an invasive or as a noxious weed, posing serious risks to native plants and communities[28,29]. The species is found across Nantucket, even though the island encompasses many diverse landscapes which allows it to be home to several hundred species of plants, many of which are threatened or endangered[16]. The distribution of *D. carota* on the island places it near many of these species, and *D. carota*'s high density growth pattern may put these species at risk of being displaced or forced into a competition for resources. In particular, our results show that *S. asteroides* does overlap in distribution with *D. carota*, although we found them no closer than one meter apart. Its Pacific Northwest relative, *S. rigidus*, is known to grow very slowly around competitors[30]. If this is also the case for *S. asteroides*, this may partially help explain why *S. asteroides* is not found closer to *D. carota*. Another possible explanation is in the difference in habitat preferences between the species. *Sericocarpus asteroides* tends to prefer stable, undisturbed grasslands whereas *D. carota* was found to inhabit mostly disturbed landscapes. This dichotomy still allows the two species to co-occur in the same communities, because several grasslands on the island are disturbed, notably roadways. The more dissected a habitat is by roads, the greater the chance of interspecific interactions occurring between these two species.

In addition, the pollination ecology of both species poses a potential risk to the native *S. asteroides*. Here, we have confirmed that both plant species are generalist pollinated. We found that the majority of pollinator visits to each species are non-specialist pollinators, i.e. flies and bees. By far the largest pollinator family found on both species is the sweat bees, Halictidae, followed by three families of flies, Muscidae, Calliphoridae and Syrphidae, although the Calliphoridae were not found on *S. asteroides*. *Sericocarpus asteroides* has the smaller, less attractive inflorescence of the two species (Figure 1), and it generally receives fewer pollinator visits and has a less diverse pollinator community. On its own, *S. asteroides* does not appear to attract many pollinators, at least over the observation time frame. It is possible that *S. asteroides* has a pollinator visitation peak outside of the observation time frame, but nonetheless, in communities where both species were within a few meters of one another, *S. asteroides* received more visits from a more diverse pollinator community than when *D. carota* was not found nearby (Table 4).

It might be expected that the presence of an attractive non-native, like *D. carota*, would increase the number of visits and the diversity of the visitors to *S. asteroides*[8], as was found to be the case at low densities of the invasive *Taraxacum officinale* on two natives[12] and on natives in the presence of the invasive *Carpobrotus affine acinaciformis*[3]. Here, we show that the presence of *D. carota* does increase the number of visits and the diversity of the visitors to *S. asteroides*. Yet within each treatment there is a large amount of variation which further reduces statistical power. Even so, we report p values that are significant for S, H', D, E and st.visits between species. Moreover, although between treatment p values are non-significant, all four diversity indices increase for *S. asteroides* when *D. carota* is present compared to when it is absent and it receives two to three times the number of visitors when *D. carota* is present (Figure 6). Other, unaccounted site-specific factors, such as variations in weather, microclimates, composition of the local insect community and the presence of human activity may account for some of the variation within treatments and may help to explain why significance was not found for all diversity measurements. Whereas the *S. asteroides (+D. carota)* and *S. asteroides (-D. carota)* treatments were each entirely different sites from one another, the removal treatments have the added benefit of helping to standardize those potential effects as the pre- and post- removal treatments are the same site. Ideally, only the removal of *D. carota* umbels changed from one morning to the next. Indeed, st.visits is significantly different between the treatments ($p = 0.0224$), and the diversity indices approach significance between the treatments (H', $p = 0.10$; D, $p = 0.11$; S, $p = 0.08$; E, $p = 0.18$; Table 4). Additionally, since we did not collect pollinators for identification beyond the family level, we are likely underrepresenting the true pollinator diversity present. If an effort was made to identify pollinators to the species level, then larger differences than we report here may become evident.

Nonetheless, there is an association between the presence of *D. carota* near *S. asteroides* and higher pollinator visitation rates and pollinator diversity. Future studies should be carried out to investigate the fitness consequences of the presence of *D. carota* on *S. asteroides*, such as changes in seed set when *D. carota* is present in communities with *S. asteroides*, as has been reported for *Stachys palustris* in the presence of *Impatiens glandulifera*[31]. The final goal of this study with *D. carota* is investigating whether heterospecific pollination is occurring on *S. asteroides*, even at distances from *D. carota*. Pollinators are known to travel several kilometers to forage on *D. carota*[17,27], which produce thousands of pollen grains per anther[32], and move

between natives and non-natives with ease[5,14,33], so the possibility of non-native pollen being located on *S. asteroides* is valid. Heterospecific pollination can reduce seed set[34,35] so there is clear precedent to address this in *S. asteroides*. It would be revealing to discover if heterospecific pollination is occurring on *S. asteroides* and whether there is a correlation between heterospecific pollination and the distance to *D. carota*.

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Table 1. Populations and average densities of *Daucus carota* on Nantucket Island and their distance to the ocean.

Location Number	Location Site	Latitude	Longitude	Ocean Distance	$D_{Average}$
1	Eel Point, LLF Property, Roadside.1	41.2932110	-70.1669590	98.15	6.2
2	Nantucket Field Station, Driveway	41.2950780	-70.0404140	115.76	21.2
3	Nantucket Field Station, field	41.2960030	-70.0400360	34.69	11.2
4	Nantucket Field Station, Sea Bluff	41.2967560	-70.0389810	6.77	8
5	M6 Condo, Backyard.1	41.2733780	-70.1012720	944.09	10
6	M6 Condo, Backyard.2	41.2730500	-70.1018060	1001	3
7	Eel Point, LLF Property, Roadside.2	41.2914060	-70.1761000	265.77	63.8
8	Eel Point, LLF Property, Roadside.3	41.2919690	-70.1748360	217.2	13.4
9	Eel Point, LLF Property, Roadside.4	41.2921060	-70.1742750	204.55	28.4
10	118 Bellevue, Eel Point Rd	41.2924690	-70.1722030	181.45	30.2
11	5 Little Neck Rd	41.2794970	-70.1931250	273.86	18.6
12	Entrance Rd, Little Neck	41.2793000	-70.1935720	250.08	17.6
13	Little Neck Parking Lot, Beachside	41.2797390	-70.1941250	6.57	53.5
14	10 Blue Heron Way	41.2816690	-70.1904830	111.26	8.4
15	NILB Parking Lot	41.2807920	-70.1919640	192.9	1.333333333
16	NILB, Pine Tree	41.2812810	-70.1920360	80.57	1
17	NCF, Sanford Farm Overlook	41.2828670	-70.1373640	1190	8.2
18	NCF, Sanford Farm, Tile Silo	41.2811580	-70.1381860	1381	7
19	Waste Options, Madaket Bike Path	41.2822930	-70.1654490	1294	4.8
20	D.P.W. Office Entrance	41.2832110	-70.1675390	1209	3
21	East of DPW Entrance	41.2822150	-70.1639630	1291	3.666666667
22	Madaket, 3 Brick Stone, Roadside	41.2818400	-70.1552360	1288	17.6
23	Madaket Rd @ Worth Rd	41.2819370	-70.1581760	1297	13.6
24	NCF, Madaket Rd, West of Worth Rd	41.2819700	-70.1594810	1291	16.4
25	Madaket Rd, Bridge	41.2820310	-70.1609540	1289	7.2
26	Miacomet Rd, Loop.1	41.2455100	-70.1117830	360.52	12.8
27	Miacomet Rd, Loop.2	41.2448130	-70.1114810	276.07	27
28	Miacomet Beach Parking Lot	41.2433910	-70.1109580	107.43	13.4
29	Miacomet Rock Walking Trail	41.2470510	-70.1139980	466.27	42.4
30	Starbuck Rd, South Loop	41.2694220	-70.1978960	73.07	4.8
31	Starbuck Rd, SE Loop	41.2691900	-70.1968550	68.15	14.8
32	Proprietor Rd, Madaket Beach Parking Lot	41.2630890	-70.1805810	75.7	3
33	48 Proprietors Rd	41.2703490	-70.1939430	176.02	8
34	Pinetops, 54 Proprietors Rd	41.2713430	-70.1936440	285.84	12
35	Arkansas Ave @ S. Cambridge St.	41.2767500	-70.1869140	519	6.4

36	Head of Plains @ Red Barn Rd	41.2702190	-70.1845650	678.35	1.5
37	Red Barn Rd Near Head of Plains	41.2697860	-70.1840420	647.23	8.4
38	Red Barn Rd @ WNTX Driveway	41.2683900	-70.1827010	567.55	10.8
39	Long Pond Sanctuary, Parking Lot	41.2721420	-70.1848300	844.7	16
40	Massasoit Bridge Rd, Fork	41.2730840	-70.1728990	1342.56	8
41	36 Washington St.	41.2812490	-70.0957510	50.5	1
42	2 Fairgrounds Rd	41.2804390	-70.0944620	12.1	10
43	N Beach Rd @ Brant Pt Rd, field	41.2910750	-70.1029120	255.78	6.6
44	Bathing Beach @ Hulbert Ave.	41.2933330	-70.1050770	193.68	24.4
45	Jetties	41.2941020	-70.1049370	179.64	6.2
46	Cliffside Beach Club	41.2937860	-70.1075840	192.29	30.6
47	Brant Point Beach	41.2900410	-70.0914530	0	5
48	New Ln @ Franklin St.	41.2860680	-70.1086500	955.1	3.25
49	68-70 W. Chester St	41.2868590	-70.1119840	873.76	38.4
50	96-98 W. Chester St	41.2864200	-70.1160570	876.96	7.4
51	Crooked Ln @ Cliff Rd	41.2891460	-70.1208740	552.21	9.333333333
52	The Tupancy Links	41.2904550	-70.1280810	365.44	13.8
53	The Sound Bluff, The Tupancy Links	41.2935410	-70.1295460	12.49	2.5
54	The Tupancy Links, Trail.1	41.2917610	-70.1283260	214.25	5.25
55	The Tupancy Links, Trail.2	41.2904350	-70.1267740	364.9	11
56	Cliff Rd Bike Path	41.2889980	-70.1234230	507.51	3
57	186 Cliff Rd	41.2877810	-70.1281670	656.31	6
58	7 Washing Pond Rd	41.2889160	-70.1318370	546.41	9
59	27 Washing Pond Rd	41.2916060	-70.1357080	220.8	32.8
60	26 Washing Pond Rd	41.2921920	-70.1340300	160.11	6.5
61	39 Madaket Rd	41.2815610	-70.1153860	1416.8	11
62	Christian Science Society	41.2813930	-70.1095250	1166.66	1.666666667
63	Nantucket Cottage Hospital	41.2758060	-70.1014620	777.51	15.4
64	Nantucket Tackle Center	41.2719400	-70.0938710	628.41	17
65	Milestone Bike Path, 67 Milestone Rd	41.2698900	-70.0647750	1947.31	2.5
66	Larsen Acres, 4M	41.2630900	-69.9821220	1625.44	2.5
67	Milesone Overlook Trial, P.L. Entr.	41.2624970	-70.0127889	2558.86	37.5
68	Milesone Bog	41.2640060	-70.0072980	2574.95	17.33333333
69	220 Milestone Rd	41.2622760	-70.0086780	2430.11	14
70	Milesone Bog, North.	41.2742970	-70.0052660	2655.42	3
71	199 Polpis Rd, Polpis Bike Path	41.2902890	-70.0380900	702.49	6.8
72	180 Polpis Rd, Polpis Bike Path	41.2903690	-70.0402390	568.9	18.8
73	153 Polpis Rd, Polpis Bike Path	41.2900290	-70.0457080	465.56	2
74	Polpis Bike Path	41.2887120	-70.0501700	744.56	22.4
75	82 Polpis Rd, Polpis Bike Path	41.2829280	-70.0624170	785.45	9.6

76	55R Polpis Rd, Polpis Bike Path	41.2788090	-70.0679430	958.94	15.6
77	6 Fair St	41.2825430	-70.0996300	341.96	1.5
78	20 Vesper Lane	41.2744710	-70.1019970	902.47	2.5
79	Madaket Beach	41.2523820	-70.1527070	27.3	8.4
80	Madaket Beach Place	41.2535570	-70.1516570	183.21	3.333333333
81	Hummock Pond Rd @ Hellers Way	41.2569510	-70.1447480	734.42	1.25
82	14 Hellers Way	41.2557380	-70.1403880	680.44	39.33333333
83	Cisco Beach Bike Path	41.2580340	-70.1433310	880.01	7.5
84	199R Hummock Pond Rd	41.2601750	-70.1406370	1195.74	1
85	167 Hummock Pond Rd	41.2638770	-70.1346820	1705.9	34.4
86	Advice 5Â¢	41.2688400	-70.1247260	2462.3	5.6
87	8 Somerset Ln	41.2685730	-70.1230260	2478.39	4.8
88	18 Somerset Ln	41.2671520	-70.1221920	2349.64	2.2
89	Raceway Dr @ Bartlett Rd	41.2612140	-70.1181080	1866.84	1.5
90	Tuckernuck.1	41.3008770	-70.2485920	70.07	24
91	Madaket Harbor	41.2755810	-70.1955700	7.94	14.6
92	Burnt Swamp Ln	41.2756000	-70.1231000	2011.68	9
93	Milestone Rd @ New St	41.2621410	-69.9730050	860.89	16
94	Captain Cabin, Baxter Ave	41.2690390	-69.9625770	136.56	9.666666667
95	36 Baxter Ave	41.2703800	-69.9623020	117.21	11.5
96	Owl's Nest	41.2726090	-69.9621460	109.88	13.25
97	Baxter Field Cliff	41.2780210	-69.9623570	15.33	109.4
98	Sankaty Lighthouse	41.2829530	-69.9649260	31.07	7
99	Sankaty Rd @ Bayberry Sias Ln	41.2757680	-69.9640790	233.6	11.8
100	Sankaty Rd @ Isobel's Way	41.2739820	-69.9640680	262.26	29.2
101	Wells Guest Cottage	41.2743990	-69.9661460	423.23	53.6
102	Meetinghouse Ln @ Sankaty Rd	41.2711420	-69.9639140	245.79	25.6
103	20 Sconset Ave	41.2592700	-69.9651650	119.05	4.5
104	South Rd	41.2661380	-69.9656460	365.27	6.333333333
105	W Sankaty Rd @ Coffin St	41.2656980	-69.9668670	449.09	2.333333333
106	New St @ Shell St	41.2629880	-69.9641310	159.12	4
107	One Ocean Ave	41.2612640	-69.9644000	127.84	3.666666667
108	Ocean Ave @ Carew Ln	41.2589310	-69.9652730	119.51	7.8
109	19 Ocean Ave	41.2554110	-69.9686370	217.34	15
110	Low Beach Rd Beach, NILB	41.2535920	-69.9682880	121.22	5
111	Low Beach Rd	41.2511350	-69.9759930	364.75	6.6
112	Underhill Ln @ Morey Ln	41.2578560	-69.9670210	210.42	15.75
113	44 New St	41.2627670	-69.9711460	726.17	15.8
114	15 1/2 Burnell	41.2646950	-69.9691640	624.81	10
115	Blackfish @ Burnell St	41.2668360	-69.9691980	667.51	6

116	Sconset Bike Path	41.2621700	-69.9796610	1391.15	3
117	Phillips Run Rd @ Milestone Rd	41.2625320	-69.9923940	2027.77	28.8
118	Milestone Rd @ Proprietors Way	41.2694400	-70.0615420	2027.77	11
119	69 Sparks Ave	41.2747740	-70.0975400	598.86	6
120	Ruddick Commons	41.2655020	-69.9764250	1245.87	4
121	Proprietors Way @ Hinsdale Rd	41.2645700	-70.0646400	2204.8	4
122	8 Pine Tree Rd	41.2630710	-70.0650340	2043.87	20.4
123	Pine Tree Rd @ Old South Rd	41.2612850	-70.0656750	1834.65	3.6
124	Old South Rd Bike Path	41.2616050	-70.0683280	1866.84	4.666666667
125	Consignment Shop	41.2617620	-70.0767130	1866.84	1
126	Eel Pt Rd @ Dionis Beach Rd	41.2893360	-70.1499290	464.01	4
127	Eel Pt Rd @ Primrose Ln	41.2874240	-70.1449310	686.29	3
128	7 Eel Pt Rd	41.2853730	-70.1416590	905.47	8.6
129	Surrey Ave @ Sandsbury Rd	41.2463320	-69.9923480	379.94	5.5
130	Surrey Ave @ Old Tom Nevers Rd	41.2451830	-69.9926830	254.72	13.4
131	Wanoma Way, Tom Nevers Beach	41.2430110	-69.9943970	63.45	9.6
132	Nichols Rd	41.2453970	-69.9948750	332.62	2.8
133	3 Bosworth Rd	41.2446660	-69.9973740	310.62	5.2
134	JFK Bomb Shelter	41.2408600	-70.0049280	71.79	1.5
135	7 New South Rd	41.2412810	-70.0165810	200.45	3
136	Forked Pond Valley	41.2416030	-70.0228180	125.33	1
137	Russells Way	41.2497150	-70.0358860	777.14	14
138	38 Wigwam Rd	41.2509220	-70.0336370	934.54	5
139	Wigwam Rd @ Russells Way	41.2528190	-70.0362690	1124.2	17.4
140	Milestone Bike Path, New South Rd	41.2676040	-70.0488720	2671.51	1
141	Surfside Beach Parking Lot, East	41.2442170	-70.0938150	118.78	79.2
142	Surfside Beach Parking Lot, West	41.2445410	-70.0947350	171.25	52.2
143	Farrell Beach, NILB	41.2438920	-70.0988950	284.09	17.4
144	27 Western Ave	41.2439470	-70.0973780	213.13	3.5
145	Uncatena St @ Nonantum Ave	41.2451410	-70.0879220	83.49	19.6
146	Pochick Ave @ Surside Rd	41.2494270	-70.0943630	678.53	7.5
147	Masaquett Ave @ Surside Rd	41.2509260	-70.0944300	837.33	4
148	124 Surfside Rd	41.2541860	-70.0938020	1190.77	6.333333333
149	South Shore Rd @ Surfside Rd	41.2585560	-70.0979400	1754.18	2.8
150	5 Wherowhero Ln	41.2576700	-70.1013550	1786.37	2.666666667
151	Zachary Way @ South Shore Rd	41.2505360	-70.1020150	1050.68	4
152	85-87 South Shore Rd	41.2455100	-70.1048390	480.81	5.4
153	34 W Miacomet Rd, Miacomet Beach	41.2438840	-70.1191130	62.65	6.4
154	28-34 W Miacomet Rd.1	41.2455130	-70.1179810	237.28	6.8
155	28-34 W Miacomet Rd.2	41.2490000	-70.1162560	649.56	1

156	28-34 W Miacomet Rd.3	41.2501470	-70.1156650	786.61	4
157	6-28 W Miacomet Rd	41.2534530	-70.1169910	1108.58	2.6
158	76 Millbrook Rd	41.2692160	-70.1302670	2365.74	6
159	Millbrook Rd, NILB Property	41.2767730	-70.1280030	1882.93	1
160	55 Millbrook Rd	41.2763360	-70.1264950	1947.31	8.6
161	19 Burnt Swamp Ln	41.2756460	-70.1226280	1995.59	1.333333333
162	Massasoit Bridge Rd	41.2747020	-70.1679300	1754.18	1
163	2 Massasoit Bridge Rd	41.2713660	-70.1787050	965.3	3.2
164	330 Madaket Rd	41.2712380	-70.2011040	123.93	13.6
165	Ames Ave	41.2733650	-70.2047280	106.34	2
166	Massachusetts Ave	41.2737200	-70.2093980	0	2
167	Rhode Island Ave	41.2734440	-70.2063850	118.94	10
168	Tennessee Ave	41.2761640	-70.1932950	103.55	11.8
169	Tennessee Ave @ N Cambridge St	41.2790190	-70.1875650	296.78	37.8
170	Vestal St @ Winn St	41.2887050	-70.1101210	714.18	30.4
171	74 Monomoy Rd	41.2813850	-70.0786900	96.64	4.6
172	Monomoy Harbor Path	41.2789410	-70.0832780	167.76	3
173	47 Monomoy Rd	41.2786650	-70.0821990	139.64	4.6
174	Eat Fire Spring Rd	41.3073590	-70.0068420	146.55	5.5
175	16 Eat Fire Spring Rd	41.3072060	-70.0016010	586.4	9.2
176	Wauwinet	41.3279320	-69.9966000	214.34	3.5
177	Squam Rd @ Wauwinet Rd	41.3256560	-69.9962050	316.9	12.4
178	Crow's Net Way @ Squam Rd	41.3256240	-69.9937860	132.31	30
179	Squam Rd.1	41.3234390	-69.9928110	170.16	39
180	Squam Rd.2	41.3183950	-69.9918720	336.63	36.2
181	Squam Rd.3	41.3068220	-69.9827280	190.87	21
182	Quidnet.1	41.3048150	-69.9798540	95.94	3
183	Sesachacha	41.3038950	-69.9793950	118.23	9.6
184	Windswept Cranberry Bog	41.2969980	-70.0058120	749.81	23.33333333
185	Almanack Pond Rd.1	41.2918320	-70.0078290	1156.53	3
186	Almanack Pond Rd.2	41.2970390	-70.0113130	559.64	6.666666667
187	Miacomet Golf Course, South	41.2555500	-70.1207230	1207.16	11
188	A Full House	41.2443260	-70.1205370	83.29	18.4
189	W Miacomet Rd.1	41.2462810	-70.1220660	228.96	2.8
190	W Miacomet Rd.2	41.2477250	-70.1229940	322.58	21.6
191	Proprietors Way @ Mioxes Pond Rd	41.2516190	-70.1279400	577.12	1.5
192	Proprietors Way	41.2494780	-70.1291740	316.32	7.6
193	Heller Way	41.2545940	-70.1300570	828.84	1
194	Bartlett Farm Rd	41.2537520	-70.1310500	717.13	10.4
195	Cisco Brewery.1	41.2629230	-70.1301240	1705.9	11.6

196	240 Polpis Rd	41.2905200	-70.0241600	444.06	5.8
197	9 Pocomo Rd	41.3147400	-70.0088330	599.64	7.5
198	Pocomo Rd.1	41.3152130	-70.0143830	328.23	3.666666667
199	43 Pocomo Rd	41.3147360	-70.0208300	181.32	3.5
200	79 Pocomo Rd	41.3146100	-70.0301340	115.77	4.5
201	Pocomo Head	41.3160470	-70.0323460	0	18.5
202	Polpis Harbor Rd	41.3022670	-70.0107010	35.54	1.5
203	Red Barn Rd.1	41.2644170	-70.1810130	158.45	25.2
204	Sheep Pond Rd	41.2646750	-70.1860610	65.3	3.333333333
205	Red Barn Rd.2	41.2626830	-70.1767690	241.86	9.75
206	Moors End.1	41.2793100	-70.0689670	874.03	8.666666667
207	Moors End.2	41.2778900	-70.0708730	831.93	40.6
208	Polpis Rd @ Sesachacha Pond	41.2901360	-69.9836180	1190.13	4
209	320 Polpis Rd	41.2974770	-69.9978600	1866.84	17.2
210	Rock Face	41.2931870	-70.0209490	164.99	24.2
211	Airport, gravel lot	41.2562610	-70.0662590	1333.75	22
212	Airport 1	41.2629430	-70.0560760	2140.43	22.2
213	Airport 2	41.2538350	-70.0530930	1121.01	12.6
214	Airport 3, Sand Bank	41.2645170	-70.0477730	2349.64	4.6
215	Airport 4, field	41.2633590	-70.0484990	2220.9	10.4
216	Airport 5	41.2610080	-70.0505150	1931.31	11.8
217	Airport 6, Bunker	41.2564100	-70.0547630	1395.06	14.25
218	Airport 7	41.2468510	-70.0698990	288.44	5.2
219	Airport 8, w/TWTA	41.2458980	-70.0705180	179.79	15.4
220	Airport 9, west fence	41.2503080	-70.0709310	669.07	16.2
221	Tom Nevers @ Norwood	41.2613330	-70.0135520	2478.39	8.8
222	Tom Nevers @ Kendrick	41.2596710	-70.0115950	2253.08	10.6
223	Tom Nevers @ Exeter	41.2566330	-70.0078590	1866.84	8
224	Tom Nevers @ Berkeley	41.2550520	-70.0059070	1641.53	11.6
225	Tom Nevers w/TWTA	41.2530440	-70.0034340	1353.05	15
226	Tom Nevers @ Marcus	41.2448370	-69.9976300	352.52	9.6
227	Tom Nevers field cliff	41.2403650	-70.0053130	48.32	37.2
228	16 Berkeley	41.2533260	-70.0069740	1503.37	10.8
229	22 Exeter	41.2542220	-70.0092270	1647.53	13
230	Wauwinet 1	41.3304300	-69.9972200	120.07	4.5
231	Wauwinet 2	41.3363340	-70.0010140	33.26	9

Table 2. Populations of *Sericocarpus asteroides* on Nantucket Island.

Location Number	Location Site	Latitude	Longitude
1	Linda Loring Foundation.1	41.289992	-70.171492
2	Linda Loring Foundation.2	41.289914	-70.172725
3	ACK Sparkle Clean	41.286922	-70.174961
4	Linda Loring Foundation.3	41.289061	-70.174649
5	Linda Loring Foundation.4	41.291503	-70.170817
6	LLF, Beach Trail, South end	41.287781	-70.177794
7	Sanford Farm	41.278289	-70.137069
8	North Head Hummock Pond, Sanford Farm	41.277894	-70.135561
9	Sanford Farm, W of deer exclosure	41.276303	-70.137775
10	NILB, Madaket Rd to Eel Pt property	41.283573	-70.156976
11	NILB, Worth Rd property	41.285976	-70.155407
12	Dionis	41.287827	-70.159307
13	Miacomet Rd	41.244914	-70.111420
14	Head of Prairies @ Red Barn Rd	41.270177	-70.184992
15	The Tupancy Links	41.290455	-70.128081
16	The Tupancy Links, West Entrance	41.288227	-70.131163
17	Milestone Trail	41.265514	-70.012435
18	The Tupancy Links.2	41.291761	-70.128326
19	Tuckernuck.1	41.300877	-70.248592
20	Middle Moors	41.265514	-70.012435
21	West Miacomet Rd	41.251299	-70.115314
22	Ram Pasture	41.260507	-70.155101
23	Ruddick Commons	41.265995	-69.976201
24	Starbuck Rd	41.270231	-70.194051
25	Linda Loring.1	41.290700	-70.170427
26	Linda Loring.2	41.290257	-70.171681
27	The Tupancy Links.1	41.290537	-70.128030
28	The Tupancy Links.2	41.290748	-70.128431
29	The Tupancy Links.3	41.292683	-70.129337
30	Red Barn @ Head of Plains	41.270166	-70.184936
31	Red Barn Rd	41.271229	-70.185237
32	225 Madaket Rd	41.277954	-70.182333
33	Madaket @ Worth	41.281781	-70.158223
34	Northern Loop @ Ram Pasture	41.279454	-70.138048
35	Ram Pasture Rd.1	41.275887	-70.140255
36	Ram Pasture Rd.2	41.273783	-70.140407
37	Ram Pasture @ Ocean Walk	41.260781	-70.154432
38	Ram Pasture Rd.3	41.260414	-70.155120

39	280 Miacomet Rd	41.244408	-70.110810
40	146 Miacomet Rd	41.248534	-70.114390
41	Middle Moors.1	41.265705	-70.012212
42	Middle Moors.2	41.264824	-70.013954
43	Milestone @ South Pasture	41.264464	-70.026957
44	Sconset Bike Path @ Phillips Run	41.262284	-69.990021
45	Milestone @ Skinners	41.263067	-69.977518
46	Wauwinet @ Fargo	41.317307	-70.006141
47	101 Polpis Rd	41.285003	-70.057695

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452

453 Table 3. Pollinator diversity by species. S, H', D and E are significantly different between
454 species (p = 0.0101, 0.0302, 0.0497, 0.0450, respectively). S = mean Species Richness; H =
455 mean Shannon index; D = mean Simpson index.

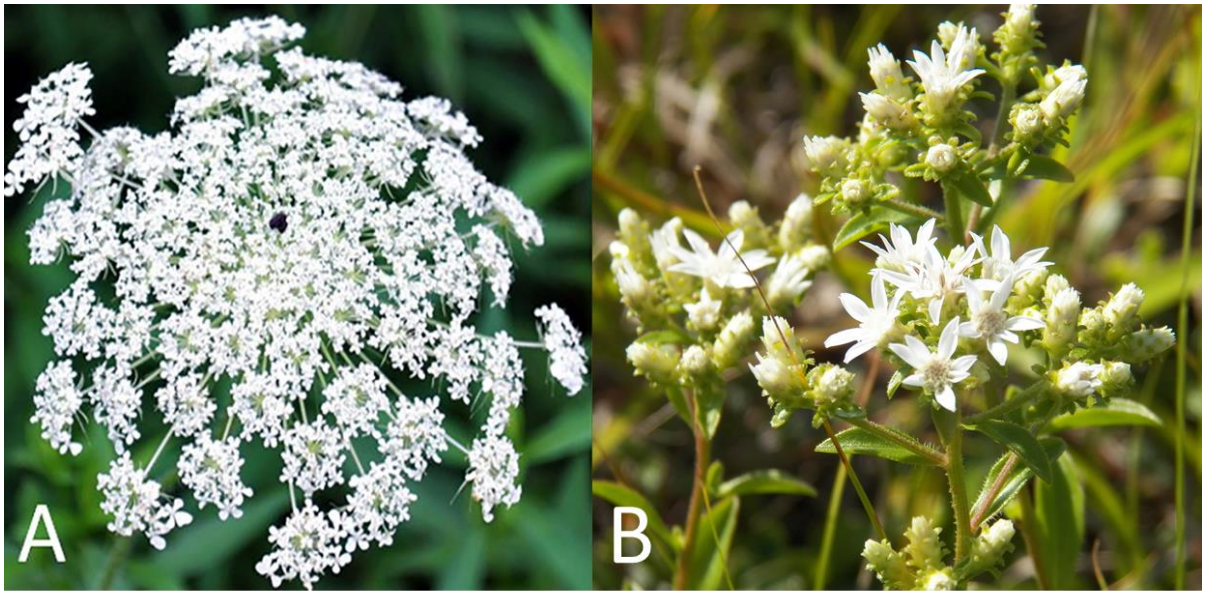
Species	Total Visits	S	H'	D	E
D. carota	532	5.5	1.23	0.61	0.78
S. asteroides	180	3.17	0.78	0.42	0.54

456

Table 4. Pollinator diversity indices by treatment. No diversity indices are significant; however, the removal treatments are near significantly different from one another (S, $p = 0.08$; H', $p = 0.10$; D, $p = 0.11$; E, $p = 0.18$). S = mean Species Richness; H = mean Shannon index; D = mean Simpson index.

Treatment	Total Visits	S	H'	D	E
D. carota (-S. asteroides)	345	6.17	1.21	0.56	0.68
D. carota (+S. asteroides)	187	4.63	1.25	0.66	0.67
S. asteroides (+D. carota)	93	3.17	0.8	0.42	0.56
S. asteroides (-D. carota)	87	3.17	0.76	0.41	0.53
Pre-removal	178	4.17	1.03	0.57	0.78
Post-removal	82	3	0.75	0.42	0.63

462 Figure 1. Morphological similarities between *Daucus carota* and *Sericocarpus asteroides*
463 inflorescences. A) *Daucus carota* with a compound umbel, B) *Sericocarpus asteroides* with a
464 corymb of composites. Note: not to scale relative to one another.



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Figure 2. *Daucus carota* populations across Nantucket. A) Dots indicate one population occurrence. B) Warm colors indicate high densities, whereas cool colors indicate low densities. Contour lines indicate approximate distance to the ocean.

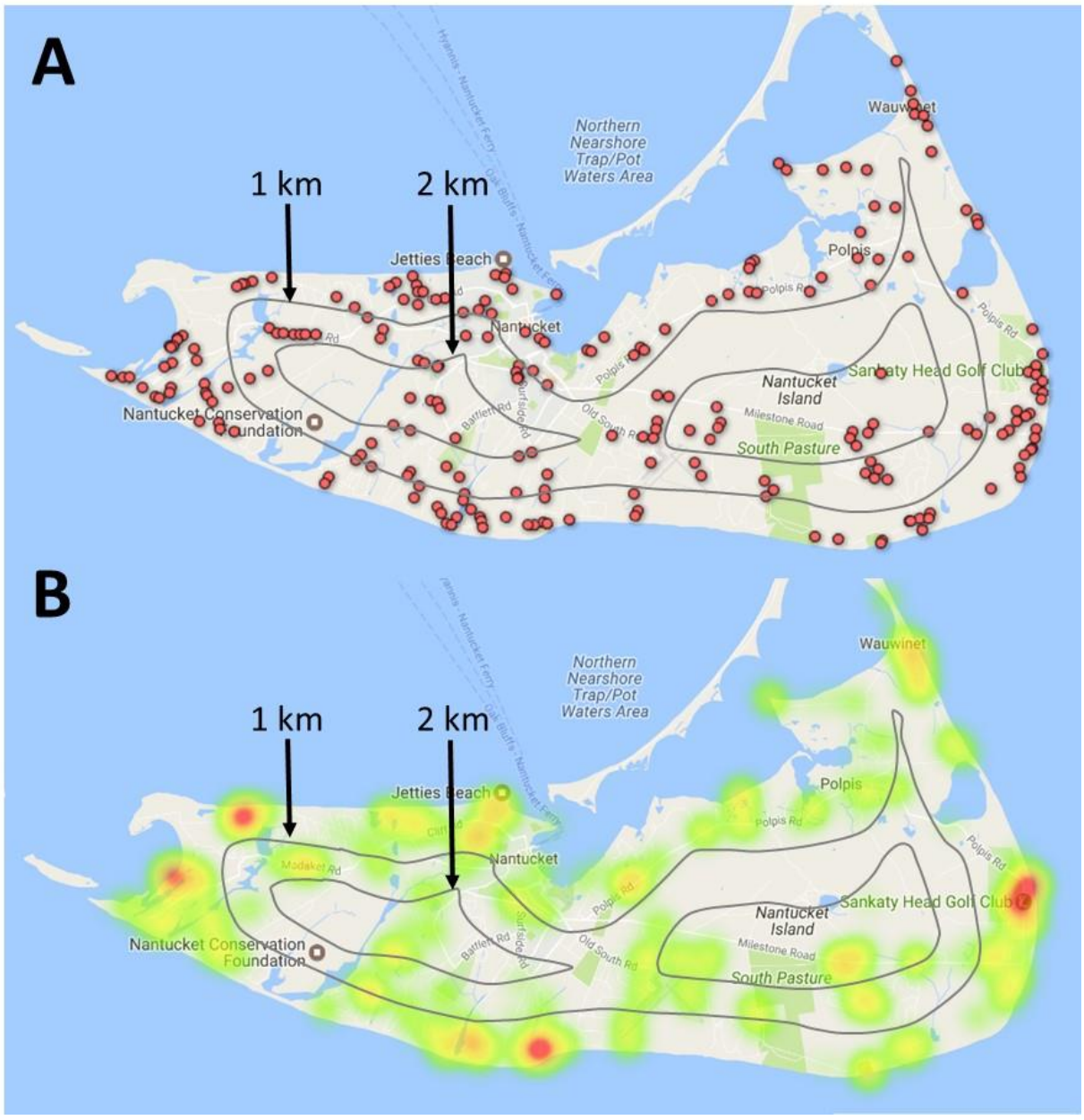


Figure 3. Linear regression of *Daucus carota* population density by the distance from the ocean. Line of best fit is a linear curve with a fit of $R^2 = 0.0178$ and $p = 0.023$.

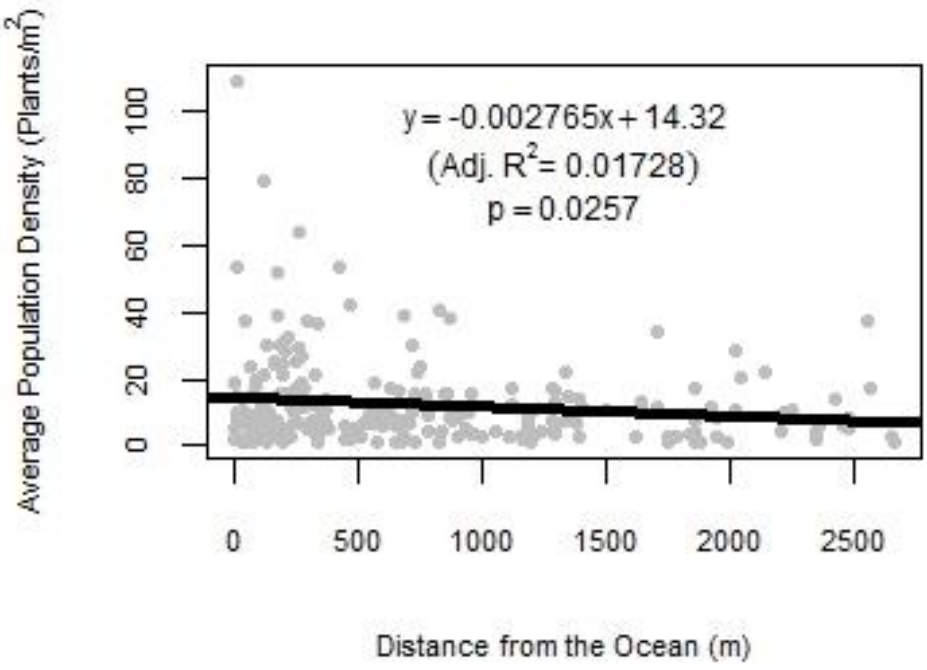


Figure 4. *Daucus carota* pollinator family distribution.

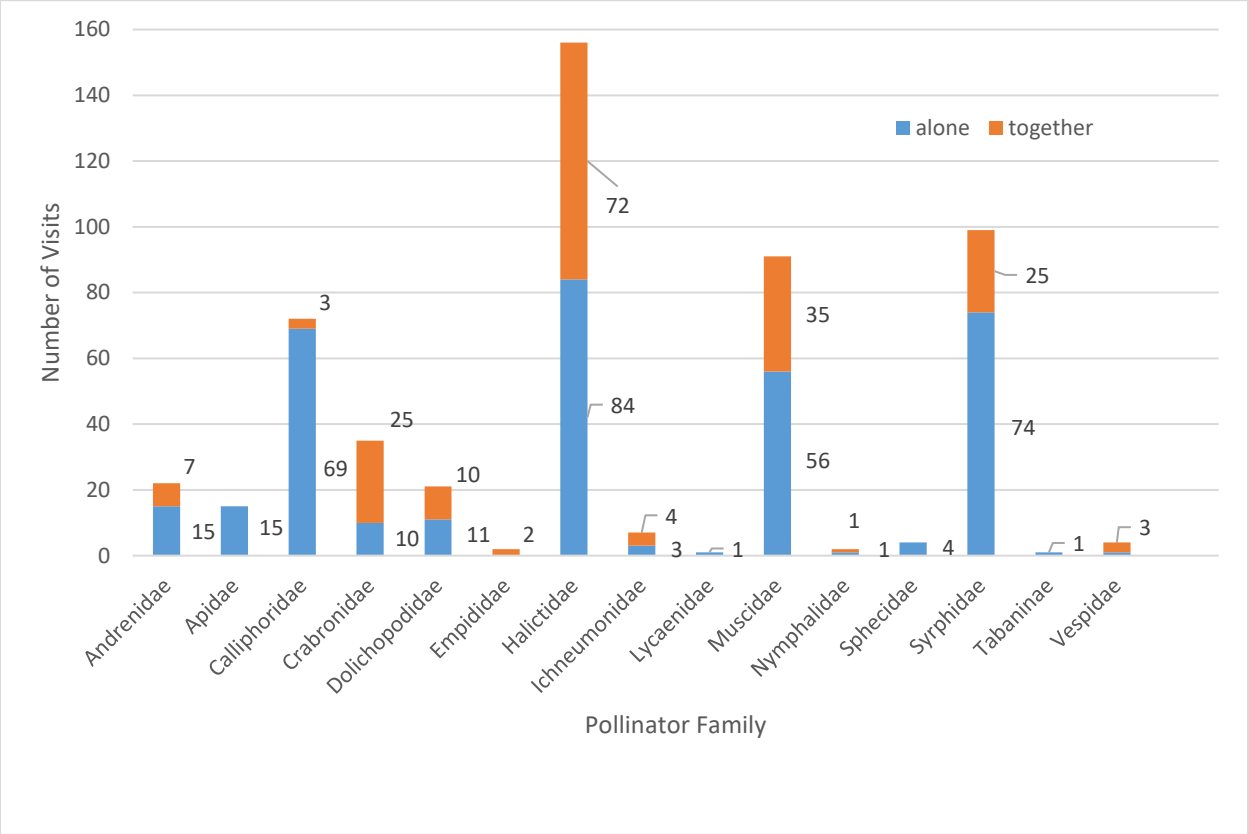


Figure 5. *Sericocarpus asteroides* pollinator family distribution.

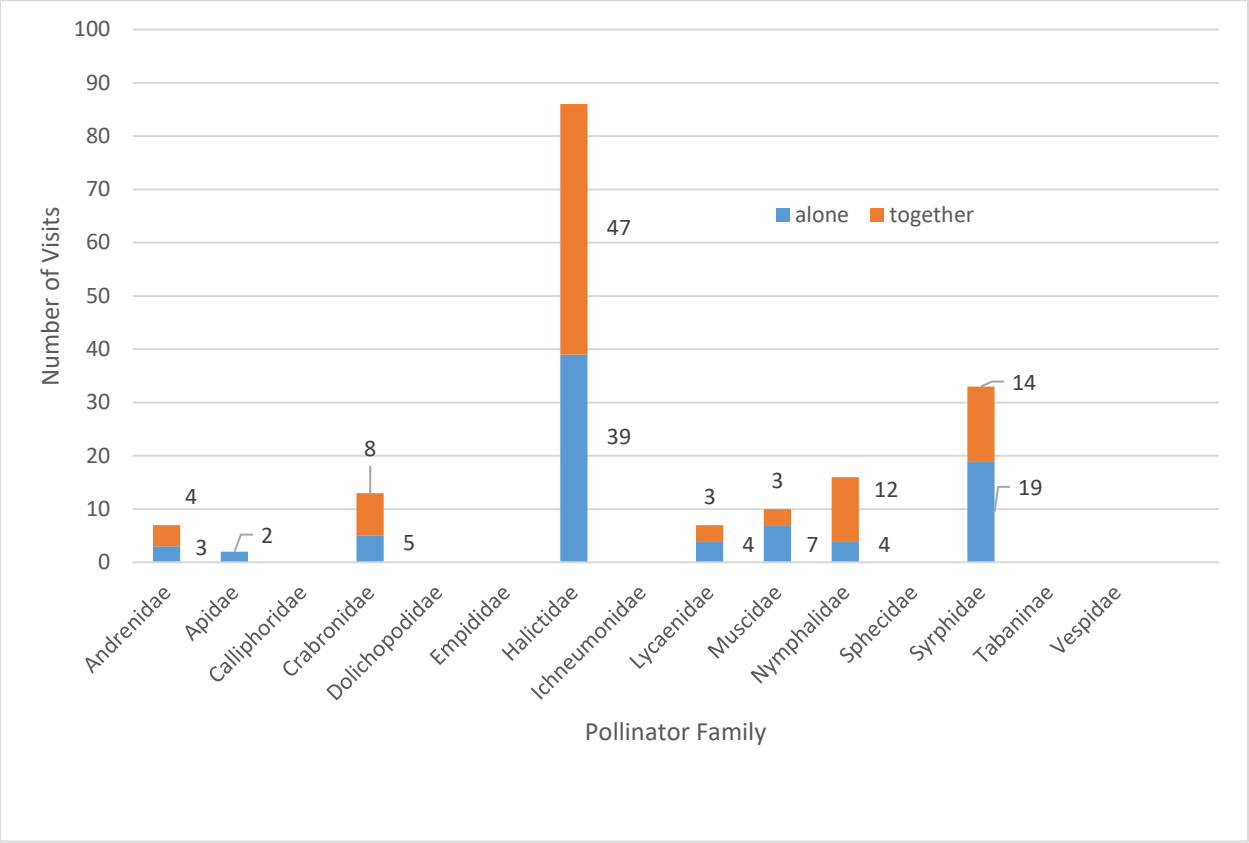


Figure 6. Number of pollinator visits standardized to the number of inflorescences per site and the number of pollinator families per site. Number of families is not significantly different between treatments. For number of visits per inflorescence, A, B and C are significantly different based on ANOVA and * and ** are different based on a t-test.

