Biology/Environmental

An evaluation of pollinator diversity and vegetation analysis in the Solar Farm at Brookhaven National Laboratory, Upton, NY

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This investigation of pollinators and their preferred vegetation allows us to better understand how to reduce the negative trend in pollinator diversity from growing. Pollinators are essential for our ecosystem, as these organisms are responsible for the upkeep of crops and the well-being of vegetation. Studying the pollinators at the Long Island Solar Farm serves to help us better understand the pollinator species using the solar farm and identify any recently arrived pollinators. We looked at bees and other pollinators and how they vary with the vegetation in each solar field. During the field surveys, data were collected for a series of transects. Pollinators contribute to the ecosystem at Brookhaven National Laboratory (BNL) and it is important to record for future projects and possible changes in vegetation to facilitate management strategies. Using a 1m^2 quadrat, at 10 m intervals, diversity and cover of vegetation along designated 50 m line transects within the Long Island Solar Farm Arrays 1, 2, 4, and 6 were evaluated. Along these transects, we noted what pollinator species were present relative to the plants that grew there. Our findings established that the pollinators prefer

heavily vegetated and undisturbed areas with an abundance of wildflowers. We can conclude that the results obtained are a result of general pollinator preference and how human influence changes the environment. The intent is to provide data concerning pollinator use within solar fields that has not had significant attention thus far.

Introduction

Over the past 50 years, North American pollinator populations have decreased due to a variety of human and environmental factors.[1] The loss of species diversity poses a risk to humans because these organisms provide essential services that are key to our survival. This study aims to better understand pollinator use at a large-scale solar facility, as there is a lack of long-term data and research regarding this particular crisis.[2] Decreases in pollinators are suspected to be caused due to a variety of different stressors. Some of these stressors include disease, parasites, industrial agriculture, insecticides, invasive species, climate change, and other anthropogenic sources.[3] The question here is to determine if solar fields can provide suitable habitat and resources to support pollinators.

In particular, the honey bee (*Apis mellifera*) is responsible for pollinating crops all around the globe through management. This bee is utilized for about 90% of pollination services and our reliance on this particular species poses a risk for our food industries, especially because this organism is threatened by multiple factors. Parasitic diseases, habitat destruction, and the use of insecticides are just some of the major causes of pollinator species decline. According to the USDA, honeybee managed stocks of the honeybee have declined by 50% in the last 50 years due to mites.[4]

Bees are facing different pressures including a decline in abundance and diversity of wildflowers and agricultural chemical and parasitic exposure which is spread by humans.

Different sources of stress can impair both detoxification mechanisms and immune responses of bees, thereby making these organisms more susceptible to different stressors.[1] By focusing on the development of wildflower diversity and more sustainable maintenance strategies, humans can create a safer, more efficient environment for pollinators.

Bees are responsible for about 73% of crop pollination for plant species that require pollination and honey bees are essential generalist pollinators that aid the production of apples, cucumbers, peaches, pears, etc.[5] Bumble bees, however, have the ability to buzz-pollinate, a technique used to release pollen which is more or less firmly held on the anthers. This method is otherwise known as sonification and involves a contraction of indirect flight muscles which produce vibrations that push pollen out of the flower. This method is useful for pollinating tomatoes, peppers, melons etc.[6] It is imperative that efforts are targeted towards preservation because these species play a major role in food production.

Objectives

The objectives for this project are to: collect, collate, and analyze pollinator and demonstrated by Figure 4 and 5 correlations to identify any significant variations in the data. The scientific knowledge is based on the diversity of vegetation and pollinators. Studies are suggesting a decrease in honeybees and bumble bees within the next few years. Conducting this study at Brookhaven National Laboratory will show which pollinators are present and their preferred vegetation. The long-term goal is to understand whether the solar fields at Brookhaven National Lab can be managed appropriately to support pollinators. With each solar field being different it's important to understand the vegetation and preference for use by pollinators. Lastly, this project would add to existing studies, comparing results, and other scientific findings for the community as well. It is hypothesized that solar fields can provide an effective environment for pollinators and other species to prosper, given proper maintenance and little disturbance as there is space for many species of wildflowers to prosper.

Methods

Data on pollinators and vegetation in a solar farm were collected over a six week period. The Solar fields 1, 2, 4, and 6 at the Long Island Solar Farm located at Brookhaven National Laboratory were used. 50 meter transects were established and vegetation along the transects was identified and quantified. Using a 50 meter long tape; starting from the first pole of a solar array the tape was stretched 50 meters establishing a transect. Starting at the zero and every 10 meters thereafter a 1 meter square quadrat was placed and all vegetation was identified and quantified for percent cover. Once all of this information is gathered, pollinators were identified and if honeybees, bumble bees, or any bee is found; the plant it was using was recorded. To identify bees it was important to properly catch it. Using an insect net, you catch the bee by placing the net over it. After placing the net, a test tube is used to capture and contain the bee. Next, the bee can be put on ice for a minimum of ten minutes. (Using ice slows the bee down for proper identification). Once the bee is identified, it is released back to the plant from which it was captured. Additional information collected included: wind speed, time, temperature, cloud cover, and humidity.

Results

Based on the results, the data show a difference between the solar fields. Figures 1-3, show a comparison between each solar field. The purpose of these graphs is to show how many and what kinds of pollinators were found at each transect. The idea of the project is to identify which pollinators and what resources they are using in the solar farm and, over time, determine if there is an increasing or decreasing trend in pollinators. By observing Figure 1, solar fields 4 and

6; had the most bees accounted for. Whereas, solar field 1 and 2 had the least number of bees; in fact other pollinators were found. For example, in solar field 1 brown-tail moth was found the most and in solar field 2 the Owlet moth was found. In solar field 4, the Eastern bumblebee was found the most and solar field 6 the same number of Eastern bumble bee as Gypsy moth. Moths are known to be pollinators, but not harmful to the bees.

There are other factors that must also be accounted for when looking at the four solar fields. These solar fields have conditions that are responsible for the difference in vegetation. For example, solar field 1 was rich with pollinator species due to the abundance of different plant species preferred by pollinators. We saw a change in conditions as we moved to different solar fields. Solar fields 2 and 4 were marsh-like due to retention of water whereas solar fields 1 and 6 were drier sustaining pollinator resource plants and were more suitable for pollinators. It was also observed that solar field 6 lacked plants that were flowering. Significant amounts of knotweed, white clover, and other leafy plants were found at early stages that covered the ground without much vertical growth and flowering.

Figure 5, shows how the vegetation in the various solar fields compare. Mugwort and White Clover was found most abundantly in solar fields 1 and 2. *Bombus impatiens* and *Bombus bimaculatus* was found on the White Clover. At solar field 4, honeybees were found on the wild indigo plant. Lastly, at each solar field grass accounted for the majority of plant coverage. Grass is abundant for both years and appeared to be the most prominent vegetation located throughout every solar field.

When comparing all of the figures, the trend between wildflower abundance and pollinator abundance can be seen. Pollinators were mostly found flying near, or on flowering plants and were lacking in more grassy/leafy areas. For example, solar field 6 contained mostly grass and undeveloped leafy plants (Figure 3&4) and lacked virtually any pollinators at all (Figure 3). Not only was there a variation between solar fields, there is variation between the two years. We mapped out the same transects, however there is no sure way to ensure the exact same spots were used for the quadrat locations. This being said, even with accuracy, plant cover and species dominance can easily change from year to year. It is worth noting that there was a lack of crown vetch found in 2019 (Figure 5), however this species was plentiful in 2018 (Figure 4). There was similarity for the presence of grass, mugwort, and fox grape found demonstrated by Figure 4 and 5.

Figure 1. This is graph explain how Solar Array one and two differ. As shown, Solar Array one have more Moths than Solar Array two. The same amount of bees were found at each location.

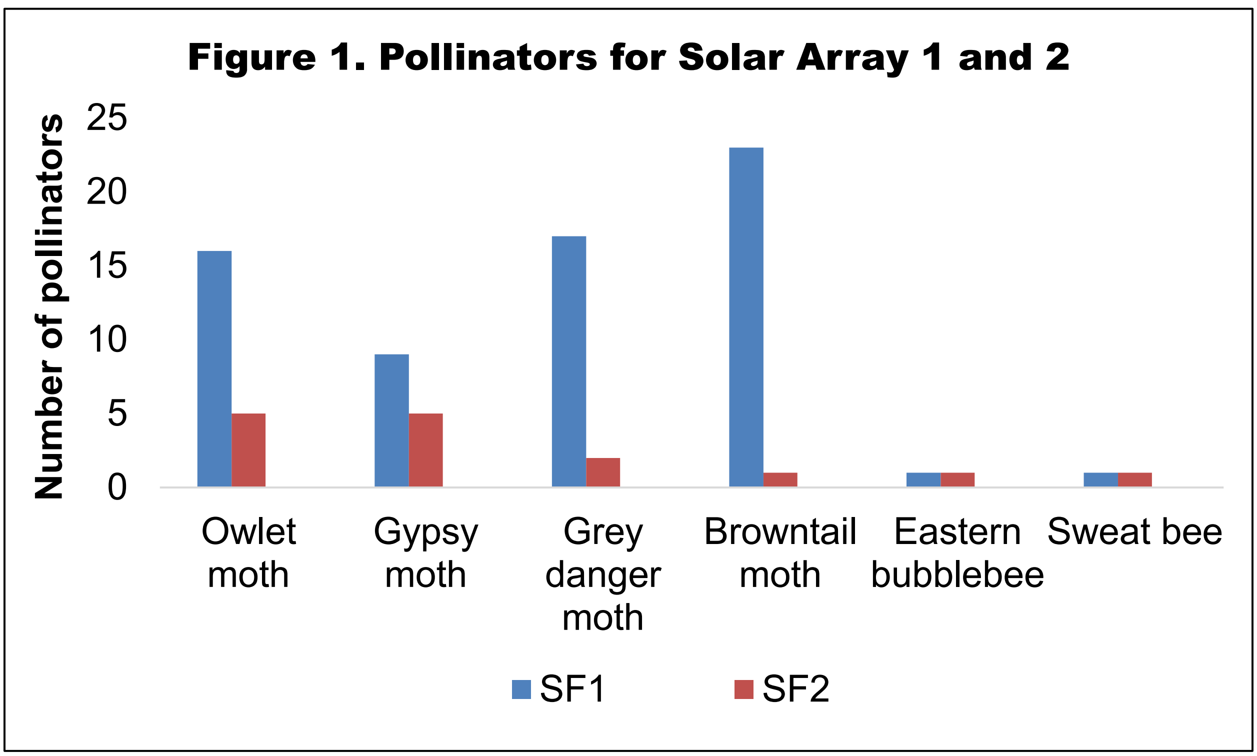


Figure 2. This graph explain how Solar Array four and six differ. As shown, Solar Array four have many bees than Moths. Solar Array six had a mixture of both.

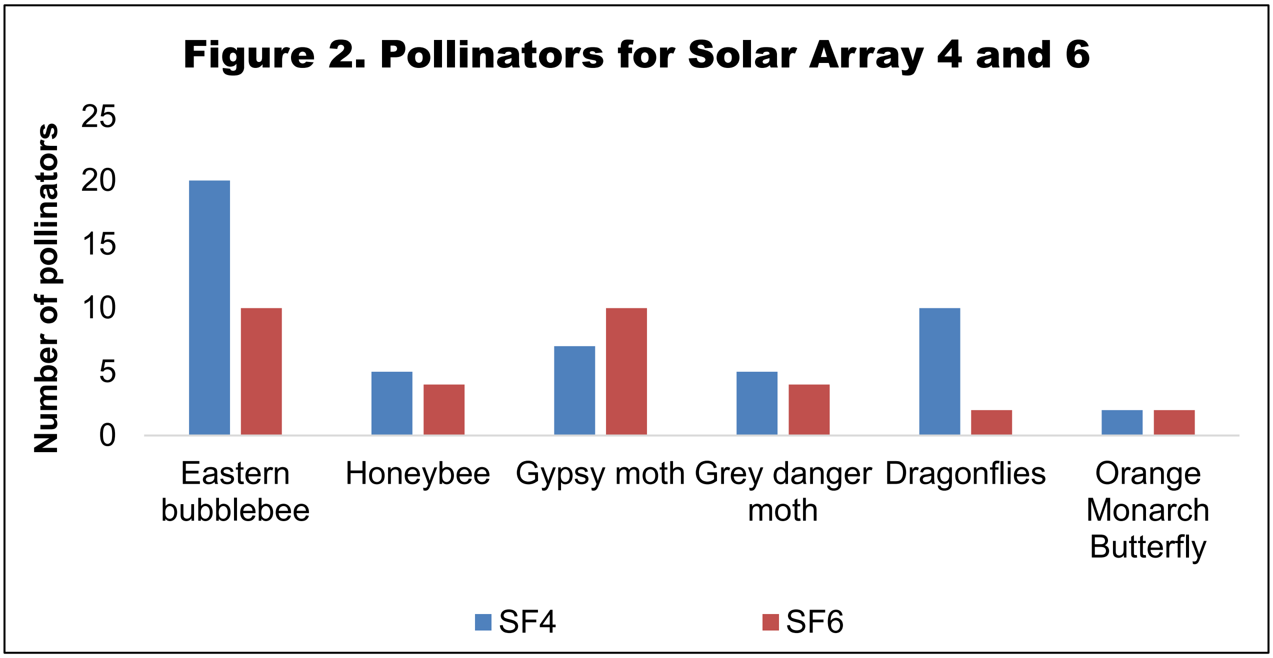
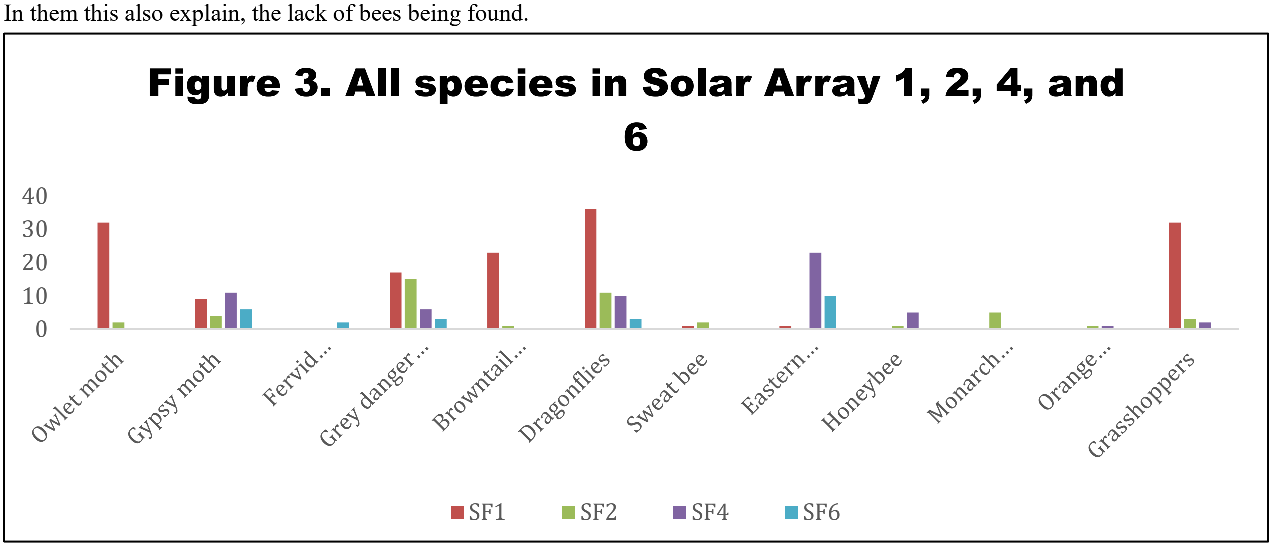


Figure 3. This graph is showing how all species found in each Solar Array is different and how to each site had different species In them this also explain, the lack of bees being found.



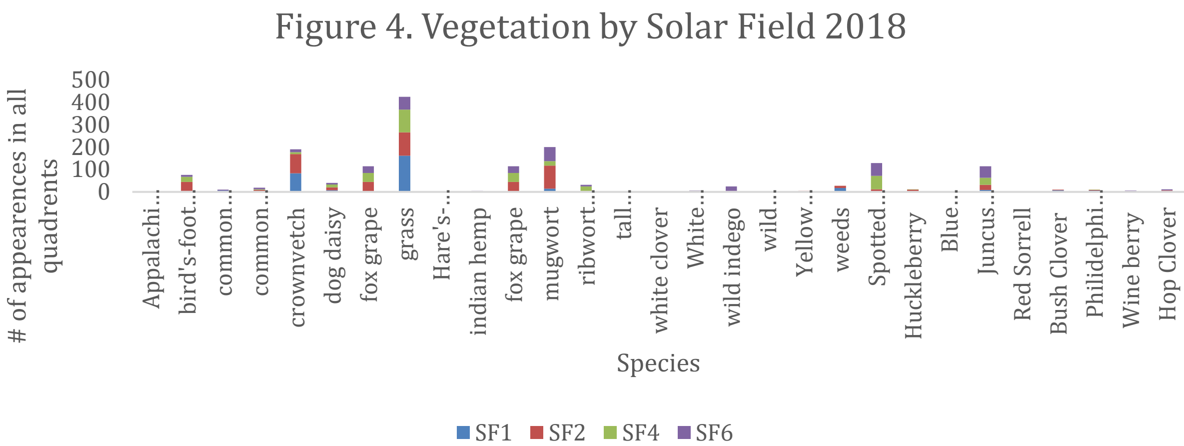


Figure 4. Vegetation by Solar Field 2018

Figure 5. This graph explain how Grass, White clover and Mug wort were the dominant vegetation being found at each site.

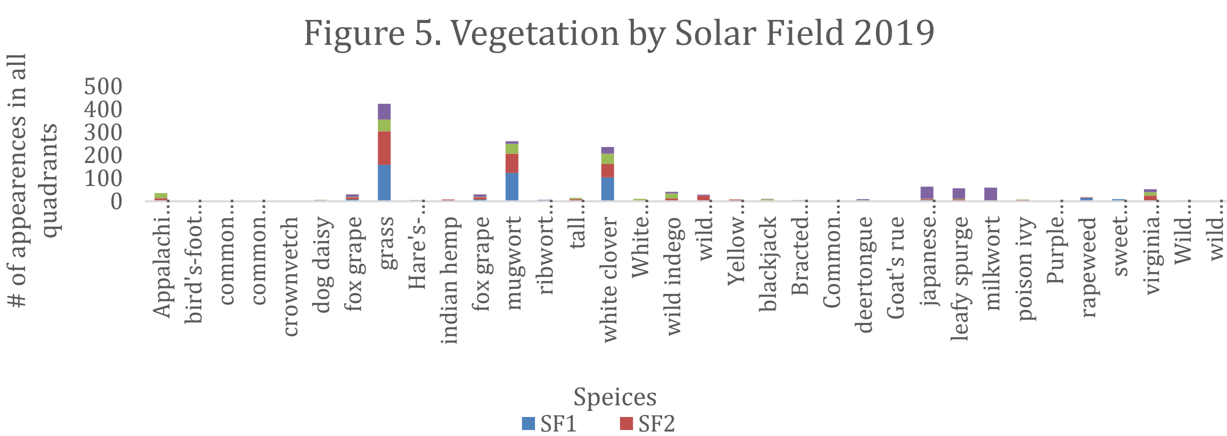


Figure 6. Explains how 2018 is different from 2019 because grass, Crown Vetch, and Fox Grape were the dominant vegetation that was found at each site.

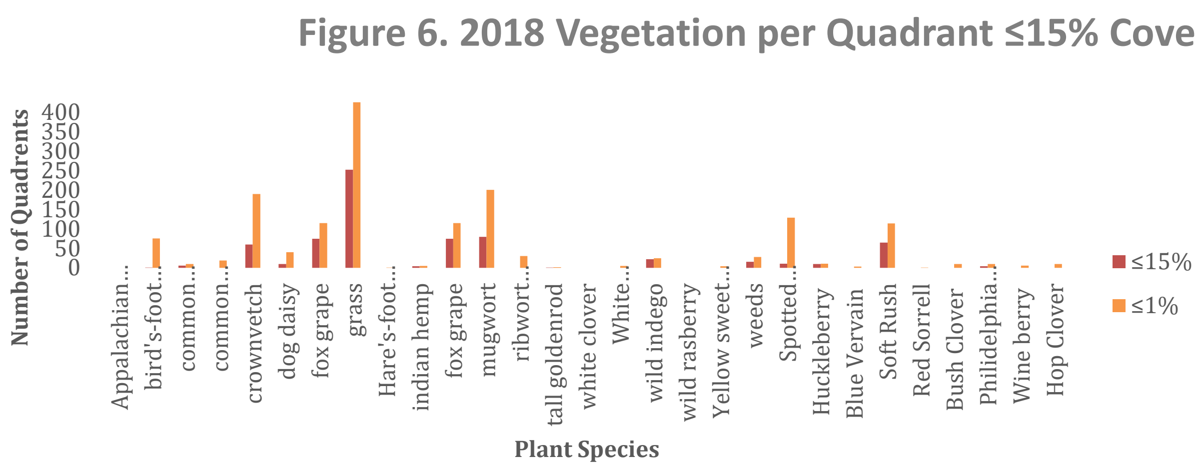


Figure 7. Explains how each Solar Array differ from the amount of vegetation being found at each site.

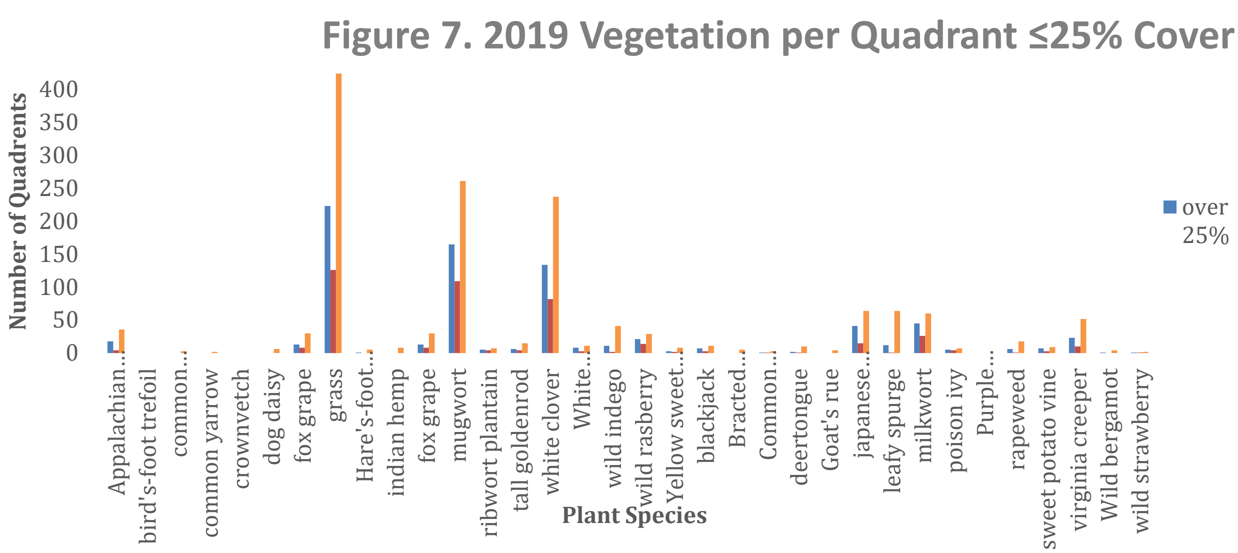


Figure 8. Table of Species Common Names and Respective Scientific Names that were found at Brookhaven National Laboratory.

Common Name	Scientific Name	Plant Common Name	Scientific Name
Western-honeybee	*Apis mellifera*	Appalachian sedge	*Carex appalachica*
Two-spotted bumblebee	*Bombus bimaculatus*	bird's-foot trefoil	*Lotus corniculatus*

Brown-belted bumblebee	*Bombus griseocollis*	blackjack	*Bidens pilosa*
Eastern Bumblebee	*Bombus impantiens*	Bracted plantain plantain	*Plantago aristata*
Sweat bee	*Halictidae*	Common cinquefoil	*Potentilla simplex*
Leaf cutter bee	*Megachilidae*	Common nightshade	*Solanum ptychanthum*
Honey bee	*Apis mellifera*	Common yarrow	*Achillea millefolium*
Cabbage White Butterfly	*Pieris rapae*	Crown vetch	*Securigera varia*
Orange Monarch Butterfly	*Danaus plexippus*	Deertongue	*Dichanthelium clandestinum*
Black Swallowtail	*Papilio polyxenes*	Dog daisy	*Leucanthemum vulgare*
Eastern Tiger Butterfly	*Papilio glaucus*	Fox grape	*Vitis labrusca*
Browntail Moth	*Euproctis chrysorrhoea*	Goat's rue	*Galega officinalis*
Owlet moth	*Noctuidae*	Grass	(varies)
Gypsy Moth	*Lymantria dispar dispar*	Hare's-foot clover	*Trifolium arvense*
Fervid Plagodis	*Plagodis feridaria*	Indian hemp	*Apocynum cannabinum*
Brown Panopoda Moth	*Panopoda cameicosta*	Japanese knotweed	*Fallopia japonica*
Buck Moth	*Hemileuca mala*	Leafy spurge	*Euphorbia esula*
Dragonfly	*Anisoptera*	Milkwort	*Polygala myrtifolia*
Bush Cricket	*Tettigoniidae*	Mugwort	*Artemisia vulgaris*
Grasshopper	*Acridomorpha*	Philadelphia Daisy	*Erigeron philadelphicus*
Wood Frog	*Lithobates sylvaticus*	Pink deptford	*Dianthus armeria*
Red Fox	*Vulpes vulpes*	Poison ivy	*Toxicodendron radicans*
Garter Snake	*Thamnophis*	Purple Loosestrife	*Lythrum salicaria*
Black racer	*Coluber constrictor*	Rapeweed	*Brassica napus*
		Red sorrel	*Rumex acetosella*
		Ribwort plantain	*Plantago lanceolata*
		Spotted knapweed	*Centaurea stoebe*
		Sweet potato vine	*Ipomoea Batatas*
		Tall goldenrod	*Solidago altissima*
		Virginia creeper	*Parthenocissus quinquefolia*
		White clover	*Trifolium repens*
		White sweet clover	*Melilotus albus*
		Wild bergamot	*Monarda fistulosa*
		Wild indigo	*Baptisia viridis*
		Wild raspberry	*Rubus idaeus*
		Wild strawberry	*Fragaria vesca*
		Wine Berry	*Rubus phoenicolasius*
		Yellow sweet clover	*Melilotus officinalis*

Discussion

There is data to support the idea that solar fields are a habitable place for pollinators to thrive. Our results showed that there is a variety of wildflowers and other grassy plants in the designated transects. All of these transects were located between solar panels where it was evident that there were more grassy plants than wildflowers. Based on general observations, most of the wildflowers were located next to the ends of the solar panels and along the edges of the fences surrounding the fields.

This general observation included an abundance of un-identified pollinators frequenting plants such as white sweet clover and crown vetch. There were patches of these wildflowers in areas that we did not perform transects, therefore to get a better understanding of the habitat, future transects should be performed in pollinator preferred areas. For the transects performed, there were few to no pollinators present because they were frequenting areas with flowering plants.

The basis of this study and to determine whether or not further research should be performed on solar fields can be supported due to the overall conclusion that these solar fields at Brookhaven National Laboratory host a variety of pollinator species and plants as seen by the graphs. Each solar field studied had distinctive traits, whether it was the wetness, type of plants present or relative location. For example, solar field 6 was entirely dry with little wildflowers present. It can be concluded that the deficiency of wildflowers present is the reason for the lack of pollinators present. However, solar field 1 was rich in wildflower species; therefore there was a larger sample size of pollinators recorded.

When comparing 2018 and 2019, there is disparity observed between both the types and percent coverage for vegetation. Crown vetch was prominent in 2018, however our findings in 2019 lead to no crown vetch observations (Figure 4&5). The majority of bees were found on other plants such as white sweet clover and wild indigo, however much of the data collected included bees that were seen not on any vegetation at all. Overall, the same types of plant and pollinator species were observed with *Bombus impatients* being a dominant species at BNL. This consistency leads us to believe that this bumblebee species is thriving.

It is important to record what species pollinators prefer to better understand how we can help these essential organisms prosper. Since these organisms have such a large impact on humans and the ecosystem, we must find ways to preserve and improve their habitats. Solar fields are good habitats for these pollinators due to little human disturbance and availability of sunlight. Besides the annual mowing that occurs and routine maintenance, these pollinators face little disturbance.

We must provide areas for pollinators to exist because new studies are showing declines in pollinator diversity and abundance. For example, the rusty patched bumblebee (*Bombus affinis*), was officially declared to be endangered in 2017. This is the first bumblebee species to be added to the endangered species list and has declined over 87% in the last 20 years.[7] This fact reveals that bees are at risk from multiple stressors and must further be reviewed for the sake of both humans and the pollinators themselves.

Acknowledgements

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