5-2019

Insect populations across an urban-to-suburban land use gradient.

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Insect Populations Across an Urban-to-Suburban Land Use Gradient

By

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Submitted in partial fulfillment of the requirements for Graduation summa cum laude and for Graduation with Honors from the Department of Biology

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March 2019

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Abstract

Insect populations, especially those of pollinators, have been steadily declining across the globe in recent decades, a trend that is intensified in cities. Since the conservation of pollinators is crucial for maintaining ecosystems and ecological processes, new approaches are being promoted beyond those of conserving large natural areas. Urban native plant gardens could potentially offset some of these losses locally. This research attempts to set a local baseline for the insect diversity in urban gardens in Louisville and determine whether differences exist in garden insects in cities versus suburbs in Jefferson County, Kentucky. To address the land-use question we established 23 collection sites across the county ranging in degree of "urbanness", with four being established in local parks to serve as natural reference sites. We also addressed a methodological question concerning the abundance and types of insects caught using different colored bowls set at two different heights. Each collection site consisted of 6 bowls filled with detergent-water. Three were 100-cm above the ground and three were 15-cm above the ground. At each height we set up a blue, white and yellow bowl filled with detergent-water to capture insects. We collected insects caught over a 24-hour period at the end of June and again at the end of July in 2017. Identification was performed to taxonomic order, with additional subcategories below order for certain groupings. The impact of bowl color, bowl height, time period of capture, and degree of "urbanness" (measured by % Impervious Surface) on abundance and diversity of insects captured were assessed. We found little difference in insect abundance at the taxonomic order level among the native plant gardens and between gardens and the meadow reference sites. However, we did find evidence in July that bee abundance was lower in urban vs. suburban and meadow locations. We also found that yellow bowls captured the most insects, while height also played a significant role, with the high bowls capturing more than low bowls. More insects were captured in July than June. Our findings suggest that the creation of more native plant gardens in cities and suburbs may well be a viable conservation strategy for supporting insects, including pollinators.

Lay Summary

Over the past few decades, insect populations have been steadily decreasing, with such trends being worse in cities. This is grounds for alarm as insects are vitally important for their numerous biological roles in food webs and as pollinators. To stop these declining populations, native plant gardens may help provide shelter, reproductive habitat, and food for these insects. This research seeks to determine the impact of these gardens along the level of "urbanness" of a city, ranging from urban to suburban. Gardens were selected across Jefferson County and bowls of three colors and two heights were used to capture insects. These insects were then counted and identified to Taxonomic Order and some (bees, chalcid wasps) to the Family level. Overall, there was no clear relationship between the degree of urbanness surrounding gardens and the number of insects collected and their relative proportions at the Order level. However, our data suggest that bee abundance may be lower in the most urban gardens. We did find that more insects were captured in July as compared to June and that the color and height of placement of bowls used to capture insects differed, with yellow bowls placed 1-meter above the ground capturing the most insects. We conclude from this initial study that native plant gardens may be useful in supporting insects, including pollinators, in cities such as Louisville, Kentucky.

Introduction

Over the past several decades, ecological studies have shown that there has been a global trend towards loss in biodiversity to which ecologists have issued the appropriate levels of concern. With these rather alarming trends, the decreasing populations of terrestrial vertebrates (mammals, birds, reptiles, and amphibians) generally receive the bulk of attention from the mass media and general public (Ceballos, Ehrlich, and Dirzo, 2017). While such focus is important for raising awareness for conservation efforts, the decline in biodiversity of entomofauna, or insects, and other invertebrates can often be overlooked. Recent data clearly indicates worldwide decrease in insect populations, with 41% of all insect species having declining populations and 31% of insects being identified as threatened (Sánchez-Bayo and Wyckhuys, 2019). In addition, these trends have been observed in a variety of environments across the globe. For example, in Germany, researchers found that over the span of over 27 years, the biomass of flying insects, including butterflies, moths, and bees, in natural areas had declined by up to 76% (Hallmann et al., 2017). Likewise, in Puerto Rico, scientists recorded as much as a 60-fold drop in arthropod biomass after repeated collections in the island's rainforest over a period of three decades (Lister and Garcia, 2018). All of these studies illustrate the global trend of insect biomass and biodiversity loss, at rates that can be described as drastic and alarming.

Moreover, the causes for these declines can be difficult to determine as the factors that contribute to the loss of a species greatly depends on species biology, location, and temporal conditions. However, ecological research has demonstrated a myriad of potential causes for this documented decline in biodiversity, ranging from global to more local effects on populations. In relation to more local population declines, pesticides and herbicides have been linked to lower insect pollinator populations; pesticides were found to cause direct harm to honeybee populations and herbicides were found to indirectly harm monarch butterfly populations by killing their host plants (Gill, Ramos-Rodríguez, and Raine, 2012; Pleasants and Oberhauser, 2012). In relation to wider scale insect population declines, various factors have been noted to potentially contribute. For instance, alterations to the environment such as habitat loss primarily due to agriculture, urbanization, fragmentation and isolation of remaining habitat have been shown to cause harmful effects on insect pollinator populations (Aizen and Feinsinger, 2002). Likewise, pressures from habitat loss and climate change lead to declining diversity and abundance of insect species (Vanbergen and The Insect Pollinator Initiative, 2013). The effects of these factors can potentially be further compounded in urban environments, as urbanization has been linked to species extinction and the homogenization of insect populations (Buczkowski and Richmond, 2012). Taken as a whole, these factors both directly and indirectly contribute to the startling global declines in entomofauna abundance and diversity.

In regard to these insect population declines, a general response would be to wonder as to why such ecological trends matter or constitute much concern. Since a majority of the factors that are contributing to this declining biodiversity and biomass are derived from human action, some would argue that humankind has a moral imperative to address these problems. However, there would also be a large amount of enlightened self-interest in doing so, because allowing such trends to continue could result in more losses for humans. This is because insects provide society with many benefits ecologically referred to as ecosystem services (Schowalter, Noriega, and Tscharntke, 2017). These ecosystem services can range from cultural, such as the aesthetic values that can be found in nature, to more practical benefits, which impact both the environment and the economy (Schowalter, Noriega, and Tscharntke, 2017). For example, insects generally function as a food source for countless organisms, serving as the base of many distinct food chains, thus they help maintain numerous ecosystems by simply being prey. Additionally, the subset of insects known as pollinators provide ecosystem services that benefit both nature and humans as their act of pollination contributes both to the maintenance of their environment and large portions of human agriculture, as humans generally rely on pollinators to help fertilize the crops that they reap. Thus, pollinators are extremely important species and their declining populations should be grounds for alarm, both in an ecological and economic sense. Though pollinators are crucial to the well-being of our planet, insects as a whole provide a wealth of benefits that should not be downplayed.

Naturally, as insect populations decline, ecologists have been searching for and developing methods to offset these losses. One such solution proposed and studied is the plant gardens with an emphasis on native species, which contain a variety of plant species that could function as host plants for larvae and food and shelter for adult insects. For instance, with monarch butterflies, gardens with milkweed species as host plants for their caterpillars may partially replace their lost meadow habitat (Cutting and Tallamy, 2015). Likewise, native plant gardens surrounded by agricultural fields were found to lead to an increase in bee richness and abundance (Samnegård, Persson, and Smith, 2011). These gardens generally focus on native plants as opposed to exotics species as some research indicates that exotic species are not as beneficial to insect pollinators, such as butterflies, in comparison to native species (Bergerot et al., 2010). Thus, native plant gardens could potentially serve as partial conservation solutions for the global decline in insect biodiversity, as was determined with gardens planted in areas of South Africa (Anderson, Avlonitis, and Ernstson, 2014).

Unfortunately, while these native plant gardens may be beneficial in theory, the effects of urbanization on insect populations and communities in relation to such conservational efforts are not yet fully understood. However, some research suggests that pursuing such areas of study could prove beneficial as native plant gardens in urban areas of Ohio were found to positively correlate to native bee richness and abundance more so than their non-native plant garden counterparts, thus demonstrating the possible utility of such human-controlled habitats in cities (Pardee and Philpott, 2014). This indicates that further research into this topic is needed to provide a broader and deeper understanding of native garden benefits to insect pollinators. The study described in this paper seeks to contribute to this understanding.

In order to conduct such research a collection method must be determined. Reviewing other studies shows they have used primarily two trapping methods, those being netting and pan traps (Popic, Davila, and Wardle, 2013; Saunders and Luck, 2012; Vrdoljak and Samways, 2012). Though functionally different, both netting and pan traps have been found to be useful means of collecting insects. Some studies show that netting allows for more accurate capturing of insects compared to pan traps (Popic, Davila, and Wardle, 2013). However, while netting may be a more suitable method for insect collection in some situations, it proves to be far more time-consuming, more expensive, and less efficient than pan traps, while also risking damage to plants in private gardens. Thus, it was decided that pan traps would be a more appropriate collection method and one that could be more easily standardized across sites; if the pan traps consisted of colored bowls, insects would be attracted to them as their colors resemble flowers and could appear as a potential food source for many insects. Likewise, because there is a lack of scientific consensus on the most preferred type of pan trap, various colors and placement heights were designed to determine if these characteristics influenced the diversity and abundance of insects caught. This sampling would be conducted across two different months to also determine if time of collection had any influence on insects captured. Thus, in this study, there were three main research questions: 1) Does the degree of “urbanness” in an urban environment influence the diversity and abundance of the insect communities found therein? 2) Does the specific color or height placement of a pan trap impact the diversity and abundance of the organisms collected? 3) Will diversity and abundance obtained from insect collection differ across time?

Methods

This study was conducted in Jefferson County, Kentucky (Latitude 38°15'N, Longitude 85°46'W). Annual mean temperature is 14.6º C with a mean minimum in January of -2.8º C and a mean maximum in July of 31.7º C. Annual precipitation averages 114 cm and ranges from 7.6 to 13.4 cm monthly (Your Weather Service). Eighteen sites in June and 19 sites in July were established in a variety of native plant gardens across Jefferson County, KY in school and residential yards and natural areas (Figure 1). Three of the garden sites (Copper and Kings Distillery, Moore High School, and the Brown residence) were so much larger than the others that two collection stations were placed in them. In June there were a total of 16 gardens with a total of 19 collection stations and with the addition of the St. Francis School in downtown

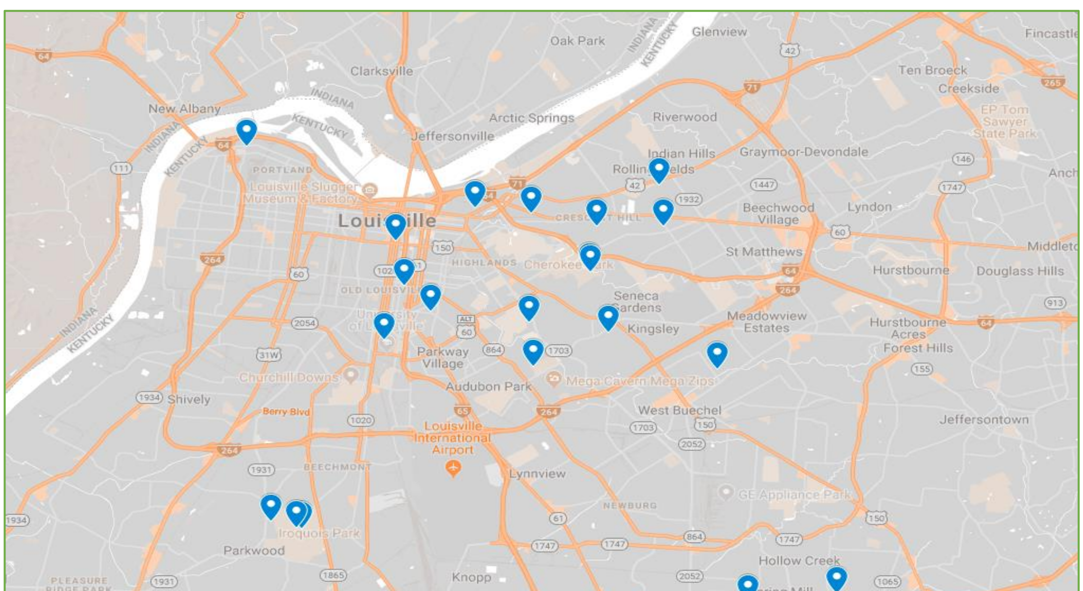

Figure 1. *Map of all collection sites across Jefferson County, demonstrating the urban-to-suburban land use gradient.*

Louisville in July there were a total of 17 gardens with a total of 20 collection stations. In addition, in both June and July two collection stations were located in meadows at Cherokee Park and another two at Iroquois Park both of which served as natural reference sites, a form of control for this study. For June there was a total of 23 collection stations and for July a total of 24. For data analysis, we used each collection station as a separate replicate. The degree of "urbanness" surrounding the collection stations was determined by using Arc-GIS (ArcMap version 10.6) to calculate the percent impervious surface (IS) within a 0.5-kilometer radius around the collection site. Impervious surface refers to paved areas and buildings where water does not directly penetrate the ground. An IS layer was created by merging together building, road, and pavement layers for Jefferson County provided by the Louisville/Jefferson County Information Consortium (LOJIC) database. Each site was then categorized as urban (>30.00% IS), suburban (12.00-29.99%), and rural (<12.00%). This is similar to the divisions used in another Louisville study (White, Carreiro, Zipperer, 2014). Appendix Table 1 shows each site from most urban to least urban and the % IS associated with each. Since these native plant gardens were chosen with explicit permission from their owners or managers on more private and secluded spaces, disturbances to the bowls by human interaction were minimized.

Once the garden sites were established, the collection method using pan traps in the form of colored bowls was determined and arranged in each of the garden sites. The collection bowl method that was chosen utilized three distinct colors of blue, white, and yellow bowls, and two heights of 100-cm and 15-cm above the ground, which indicated the high and low bowls, respectively (Figure 2). In each of the garden sites, a bowl-array station was designed with the three high bowls being randomly organized in an equilateral triangle with one meter between each bowl, and the three low bowls were organized in the same manner directly beneath them.

Each of the station’s six collection bowls were supported by a holder bowl of the same color that was fastened onto a wooden stake of the appropriate height. During the process of collection, the collection bowls were secured in the holder bowls and filled with a solution of water mixed with six drops of unscented detergent per gallon of tap water, which would capture and hold any insects that landed in the solution. The collection period was standardized across all sites being twenty-four hours, with a one-hour margin of error.

Figure 2. *Example of the bowl-collection array in a garden*

Within a day plus or minus an hour of collection, insects from each bowl were placed in a cup of 70% ethanol and refrigerated until they were able to be sorted and counted under a microscope by taxonomic order Diptera (flies), Hymenoptera (bees, wasps, ants, sawflies), Coleoptera (beetles), and Hemiptera (true bugs) and Miscellaneous. Diptera were further divided into the Suborders Nematocera, Orthorrhapha, and Cyclorrhapha, based on antennae morphology. Hymenoptera were divided into the groups of bees, wasps, ants, sawflies and unknown. For some analyses, bumblebees (Genus *Bombus*) and the Chalcid wasps (most of which are parasitoids) were tracked since they are easily identified into these groups as they were sorted. Taxonomic data were tracked by site, bowl color and bowl height and month. Once the captured insects were sorted, they were stored in 70% ethanol for future taxonomic work.

Finally, once all the captured organisms were identified and documented, statistical analyses were performed on the data. Correlation and regression analyses (MS Excel v.2016) were used to establish if the captured insect abundances varied predictably with the percent impervious surface surrounding the native plant gardens and the natural meadows. The regression analyses comparing the data from the two months with land use were performed using the general linear model function in R (R Core Team 2016). To determine if the bowl color and bowl height had any statistically detectable influence on the insect abundance and taxonomic groups captured, a two-way ANOVA with replication in MS Excel Version 2016 was used. In some cases, data were analyzed separately by month (June and July) and in others the data for June and July were summed or averaged before analysis was performed.

Results

After the two collection periods, all captured organisms were identified and organized into their corresponding taxonomic order. A total of 14,600 organisms were collected from across all sites and bowls from both collection periods combined; of these, 10,338 were sorted into the orders Diptera (Flies), Hymenoptera (Bees, Wasps), Coleoptera (Beetles), and Hemiptera (True Bugs) (Figure 3A). Specifically, in June, 5,295 organisms were collected, 4,367 of which belonged to the four taxonomic orders (Fig. 3B). Likewise, in July, almost twice as many organisms (9,305) were collected, with 5,971 being in the four taxonomic orders of focus (Fig. 3C). As each of these figures illustrates, Diptera was the most abundant order of those collected, with each month and their combined total averaging over 40% of all four insect orders identified; this percentage is derived from just the four orders that were identified and excludes comparisons with insects outside these four taxa (Fig. 3A). After this, Hymenoptera (30%), Hemiptera (19%), and Coleoptera (8%) were most numerous for the two months combined (Fig. 3A). Outside the four taxonomic orders, from the total insects collected overall, the "Other" category constituted 17.5% in June, 35.8% in July, and 29.2% averaged across both months.

To address the question of whether insect abundance in total and for separate taxa varied with degree of "urbanness", linear regressions of insect abundance on % IS within a 0.5-km were performed separately for the June and July data as well as for the total for both months. Identical analyses were conducted with the orders Diptera and Hymenoptera, and with the Bees and Chalcid Wasps, both of which are subcategories within Hymenoptera. Once the linear regressions were performed, the p values were obtained to determine the statistical significance of the collected data, with a p value of 0.05 or lower signifying statistically significant data.

For the data of total organisms summed across both months from all native plant gardens in the study, there was no significant correlation found between the percentage of impervious surface (%IS) and the number of organisms that were captured. Likewise, there was no statistically significant correlations between the %IS and the total insects collected in June or July considered separately (Figure 4). However, when plotted together, there appears to be statistically significant interaction between the data from the two collection periods, with a p value of 0.016 (Appendix Figure 1), meaning that time had an impact on the collection data. For Diptera, similarly to the total insects across all sites, there was not a statistically significant correlation between %IS and the abundance of Diptera captured, with no trend favoring the lower or higher levels of urbanness. This lack of trend was also noted in the plots of both June and July, as they did not yield any statistically significant correlations between Diptera abundance and %IS.

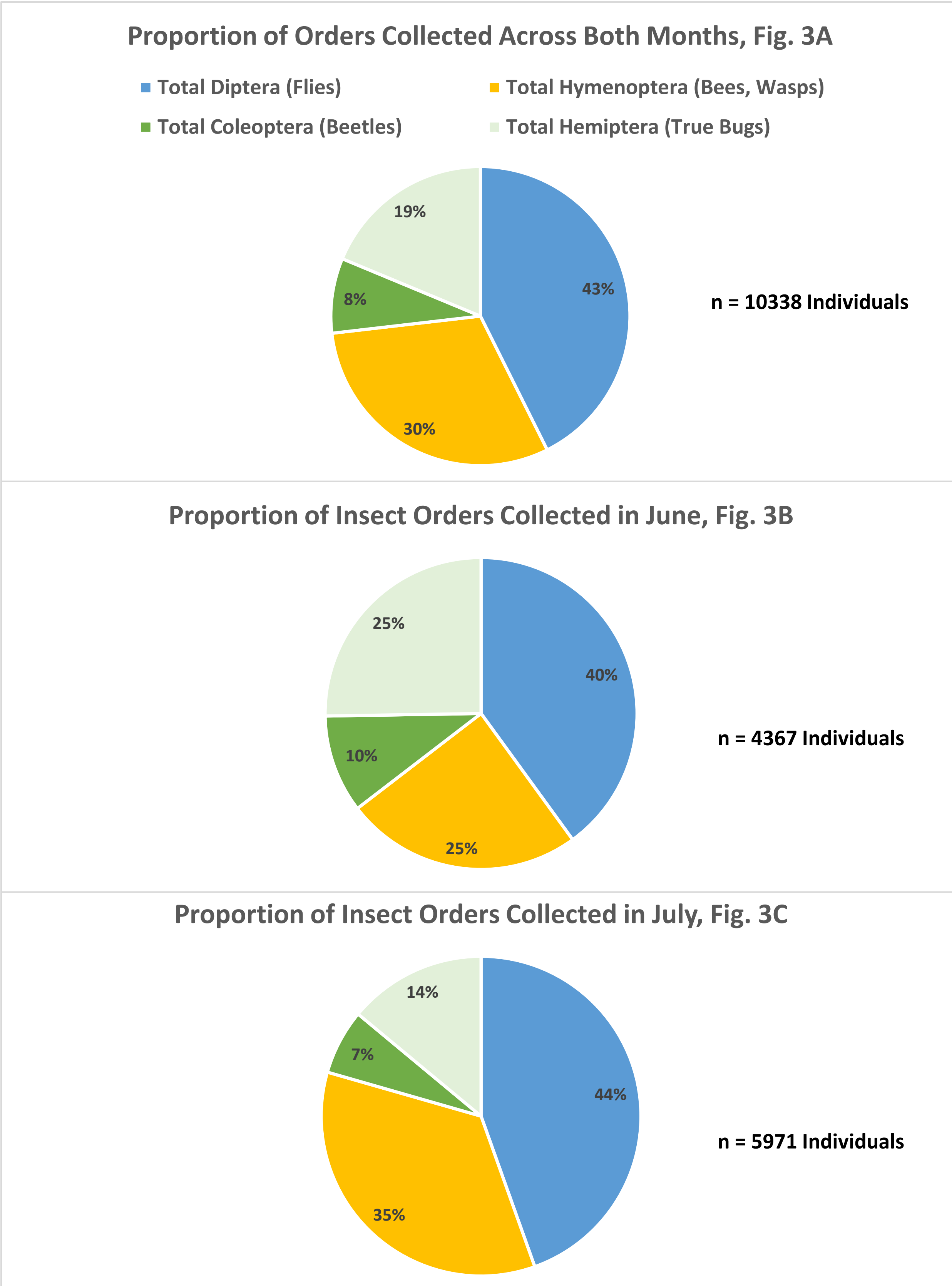

Figure 3. *Pie charts showing the distributions of taxonomic abundance collected.*

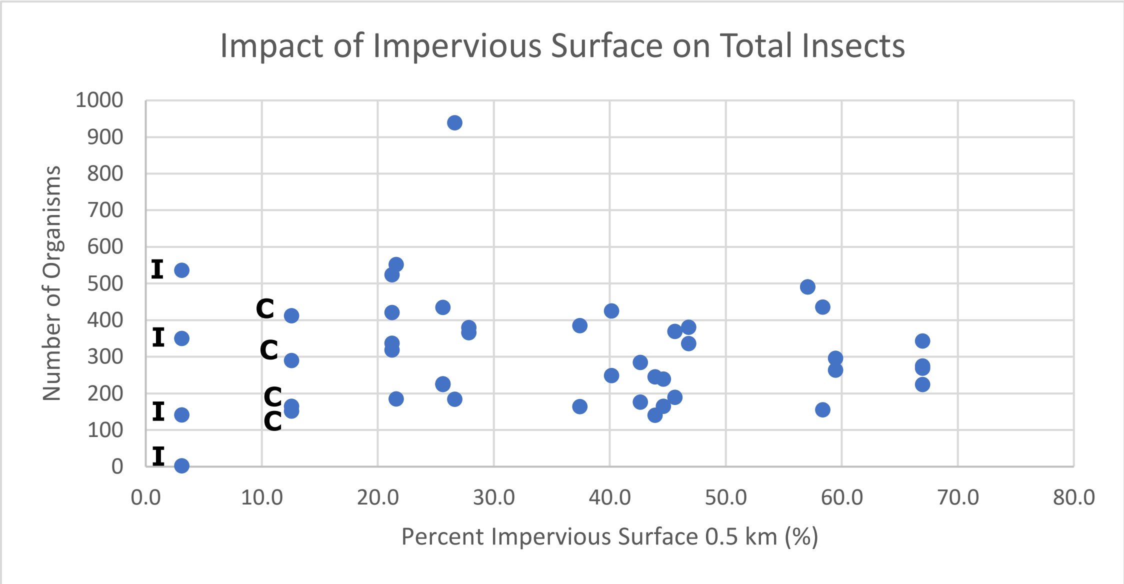

Figure 4. *No correlation found between %IS and the total organisms from both months. C and I labels denote the Cherokee and Iroquois meadow reference sites, respectively.*

For Hymenoptera, there again was no statistically significant correlation between the number of organisms captured and the %IS for the combined total of both collection period. In the June regression for total Hymenoptera collected against %IS yielded a statistically significantly positive correlation, with the number of Hymenoptera captured increasing as the %IS increased; this regression yielded an R^2 value of 0.2391 and a significant p value of 0.0179 (Figure 5). However, in July the Hymenoptera regression was not significant. For the total bee subcategory of Hymenoptera, there was not a statistically significant correlation between the number of bees collected from both months and the %IS; nonetheless, there was a negative trend ($p=0.0836$) in captured specimens as the %IS increased (Appendix Figure 2). For the June data, there is no correlation between total bees and %IS. However, for July, the linear regression demonstrated a statistically significant negative relationship between the abundance of bees in that month and %IS, with a R^2 value of 0.2539 and a p value of 0.012 (Figure 6). Finally, for the total chalcid wasp subcategory of Hymenoptera, there is a statistically significant positive

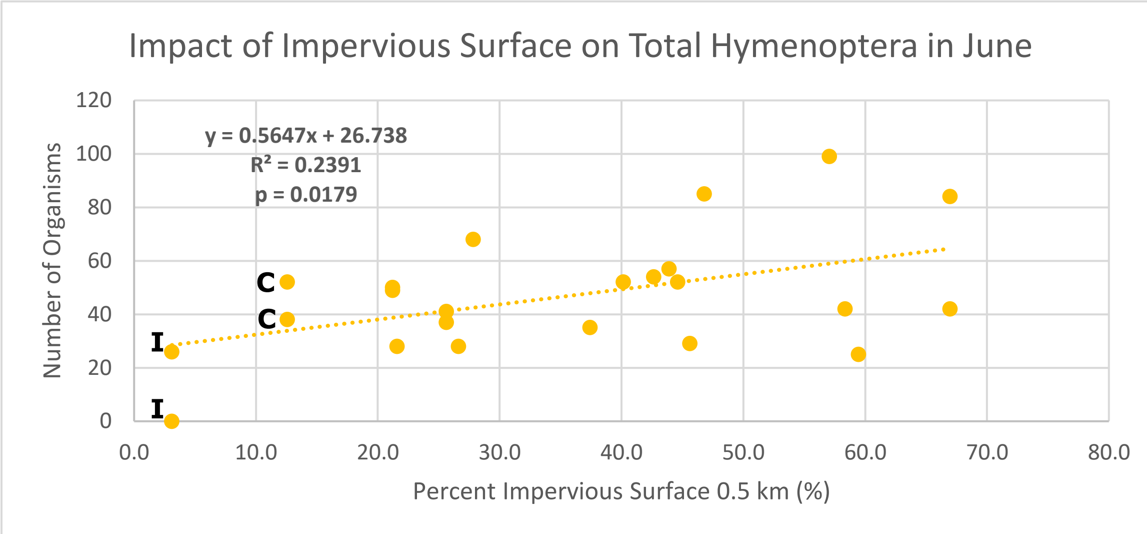

Figure 5. *Positive correlation found between %IS and the total Hymenoptera in June collection. C and I labels denote the Cherokee and Iroquois meadow reference sites, respectively.*

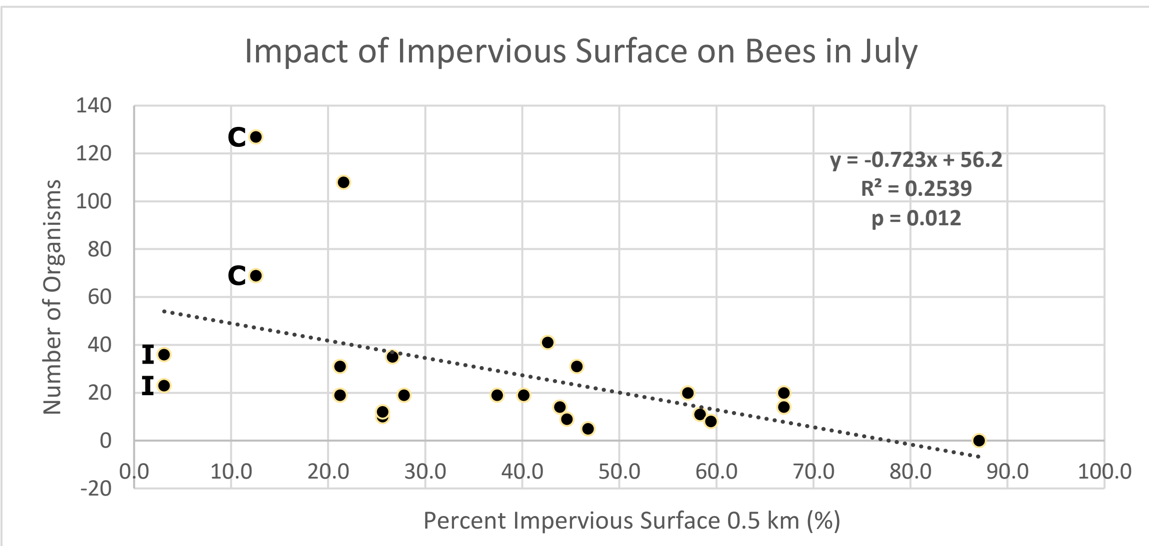

Figure 6. *Negative correlation found between %IS and the number of bees in July collection. C and I labels denote the Cherokee and Iroquois meadow reference sites, respectively.*

correlation between the chalcid wasp abundance in the combined collection time periods and %IS, with an R^2 value of 0.1027 and a p value of 0.0299 (Figure 7). This correlation was not demonstrated in the regressions from the June and July datasets separately. Despite this, it should be noted that the July chalcid wasp data did present a p value of 0.0528, and while not statistically significant, is still fairly close to the cutoff value for significance and should thus be noted (Appendix Figure 3).

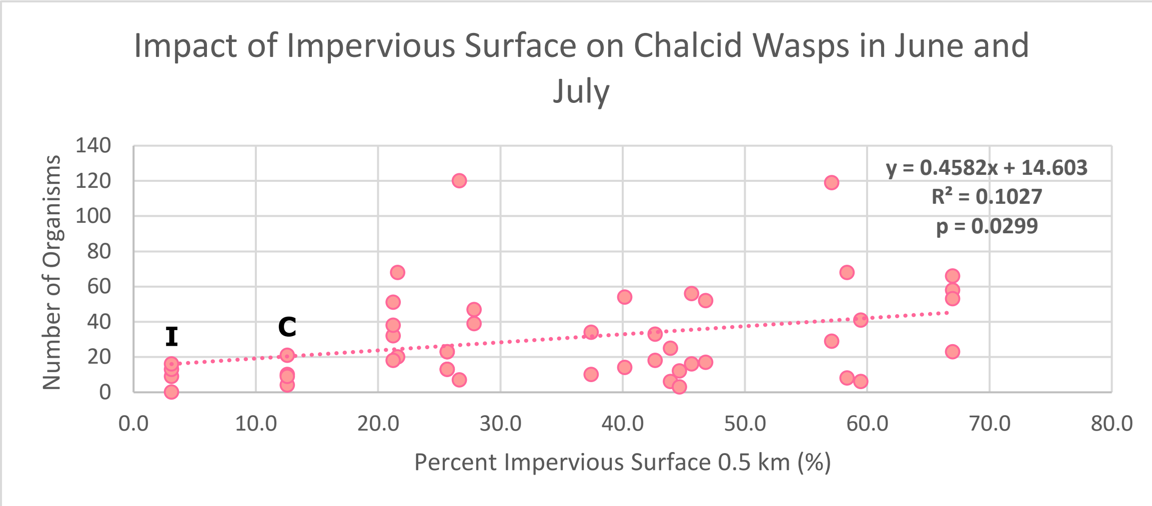

Figure 7. *Positive correlation found between %IS and the total chalcid wasps from both months. C and I labels denote the Cherokee and Iroquois meadow reference sites, respectively.*

In regard to the question addressing the methodology involving both bowl color and bowl placement height, double bar graphs were constructed and two-way ANOVA with replication statistical analyses were conducted to determine if bowl characteristics influenced the abundance of organisms collected. These tests were performed for the combined data from both the June and July collection periods for the total insects captured, along with Diptera, Hymenoptera, bees, and chalcid wasps; in addition, a subset of bees in the genus *Bombus*, or colloquially bumblebees, were also included for analysis. With the total insects collected across all sites and both months, a statistically significant influence was found between bowl color and the abundance of captured organisms ($p < 0.0001$), as yellow bowls, regardless of height, caught the greatest number of organisms overall (Figure 8). Likewise, there also seems to be an impact of bowl height on the abundance of captured organisms ($p < 0.0001$), with higher bowls capturing more than their lower counterparts (Fig. 8). These same trends can be observed in the data for Diptera, which has a p(color) value of less than 0.0001 and a p(height) value of 0.001 (Figure 9). With this dataset, though, there does appear to be a statistically significant interaction between color and height, represented by a p value of 0.031 (Fig. 9). This interaction is likely explained by the by the difference in the heights between the two yellow bowls being larger than those of the blue or white bowls.

With the bowl effects for Hymenoptera and its subcategories, there appears to have been statistically significant influence of some bowl characteristics on the total organisms collected. For Hymenoptera specifically, there was the similar trend of influence as the total insect data, with both color and height influencing the capture of organisms, with high yellow bowls yielding the greatest collection ($p < 0.0001$); The higher bowls also caught more Hymenoptera ($p = 0.007$; Figure 10). Within Hymenoptera, more bees were caught in the higher bowls ($p<0.0001$), but there was not a statistically significant difference with the three bowl colors as they all captured similar numbers of bees (Figure 11). Moreover, within the bee subcategory, more individuals in the genus *Bombus* were caught in blue bowls ($p=0.001$) and the higher bowls ($p=0.004$; Figure 12). Lastly, yellow bowls caught the greatest number of the chalcid wasps ($p< 0.0001$), while there was no statistically significant effect of height because the low yellow bowls caught more chalcids, while the low bowls of other colors did not (Figure 13).

Overall, when compared, the abundances collected from the reference site meadows and the native plant gardens were fairly comparable, with the average abundance with the native plant gardens ranging from similar to or more than their reference site counterparts (Appendix Table 12, Appendix Table 13). The average abundance for total insects in the reference sites from both months combined was 256, while the native plant garden abundance was 321.8; this trend of higher garden mean abundances was also observed in the Hymenoptera, Diptera, and chalcid wasps (Appx. Table 12, Appx. Table 13). However, the average abundance of bees was noticeably lower in the native plant gardens in comparison to the reference sites for both June and July (Appx. Table 12, Appx. Table 13).

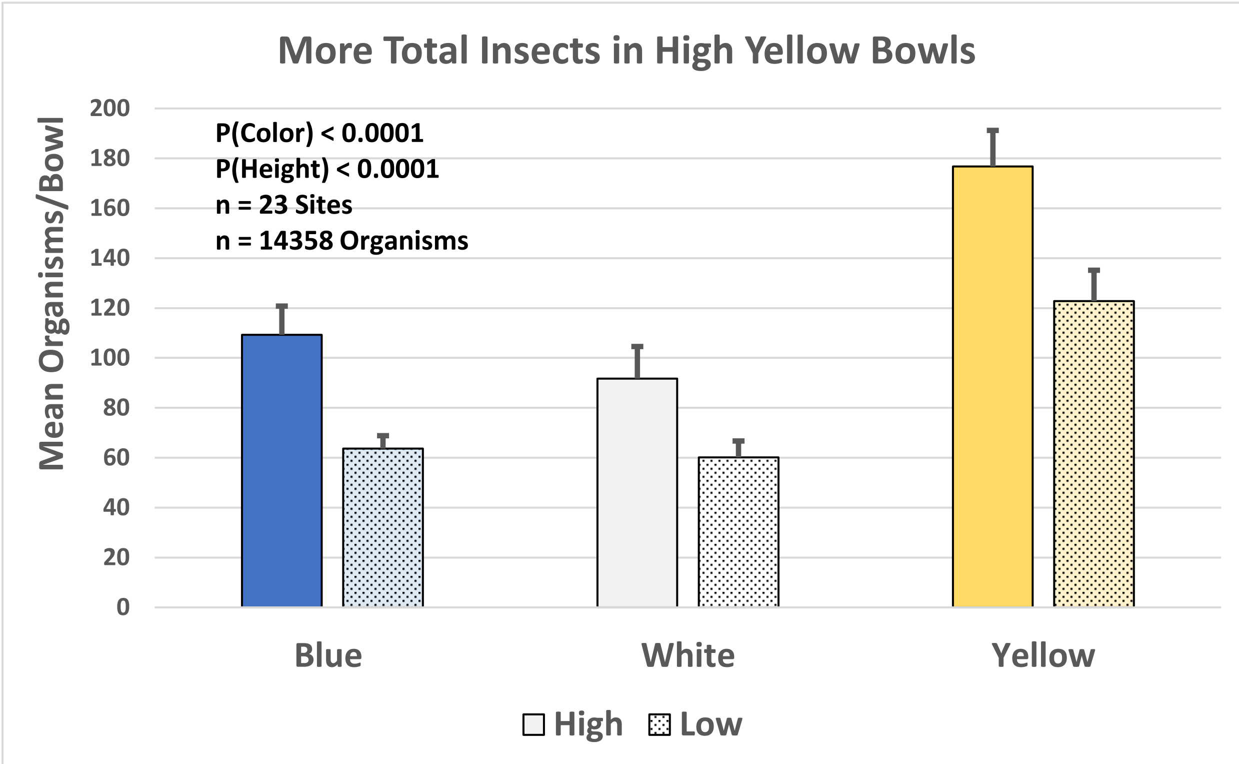

Figure 8. *Distribution of total insects from both months into the six types of bowls.*

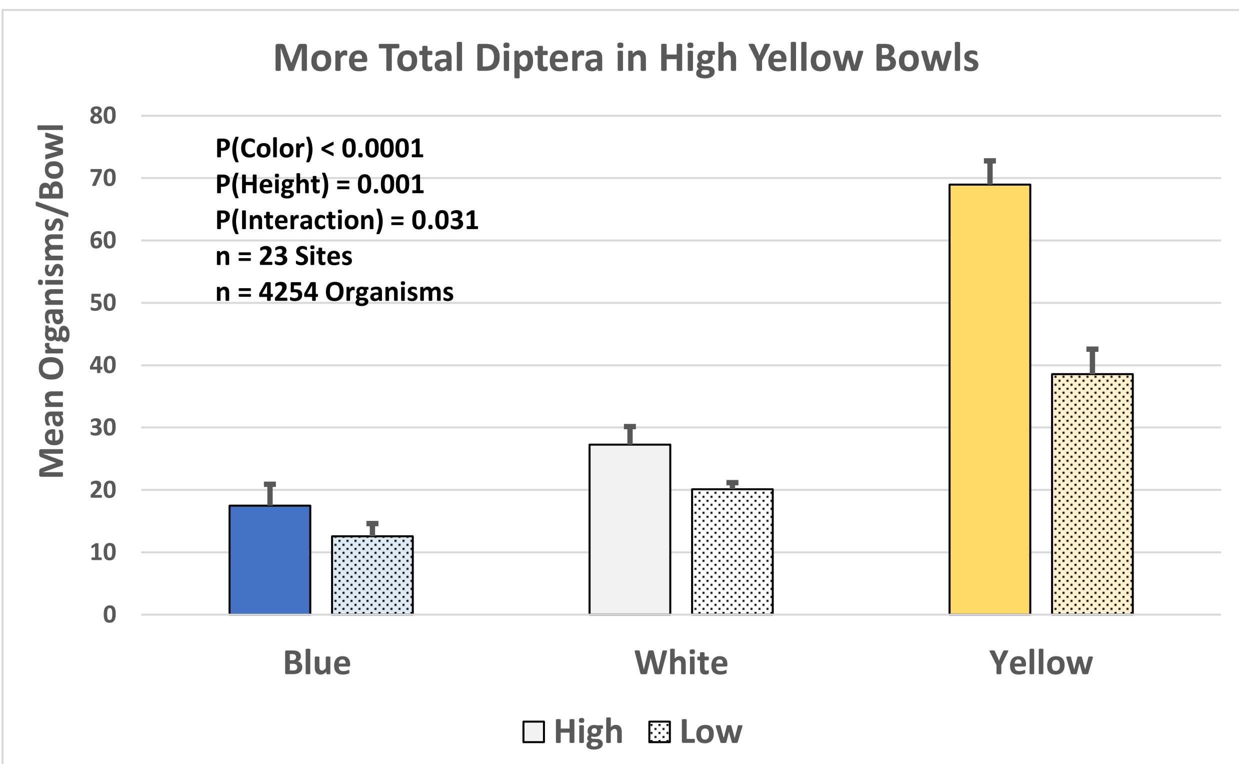

Figure 9. *Distribution of total Diptera from both months into the six types of bowls.*

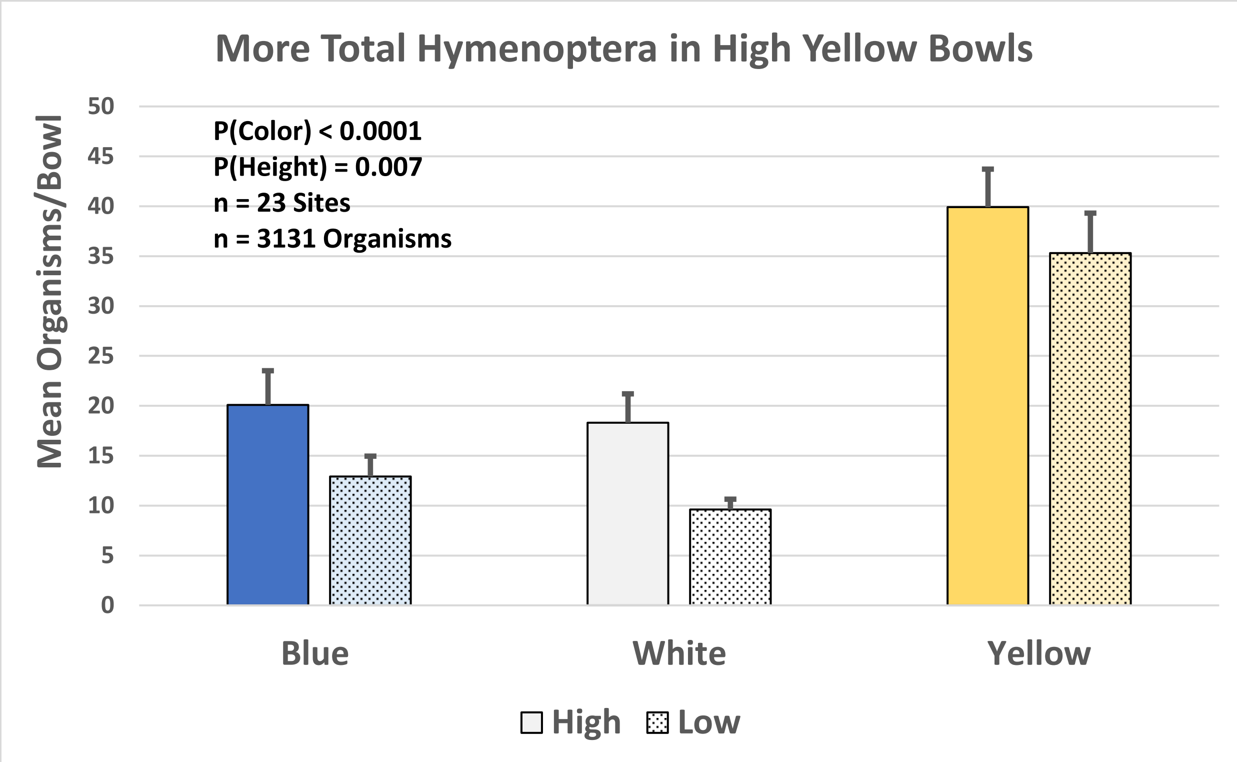

Figure 10. *Distribution of total Hymenoptera from both months into the six types of bowls.*

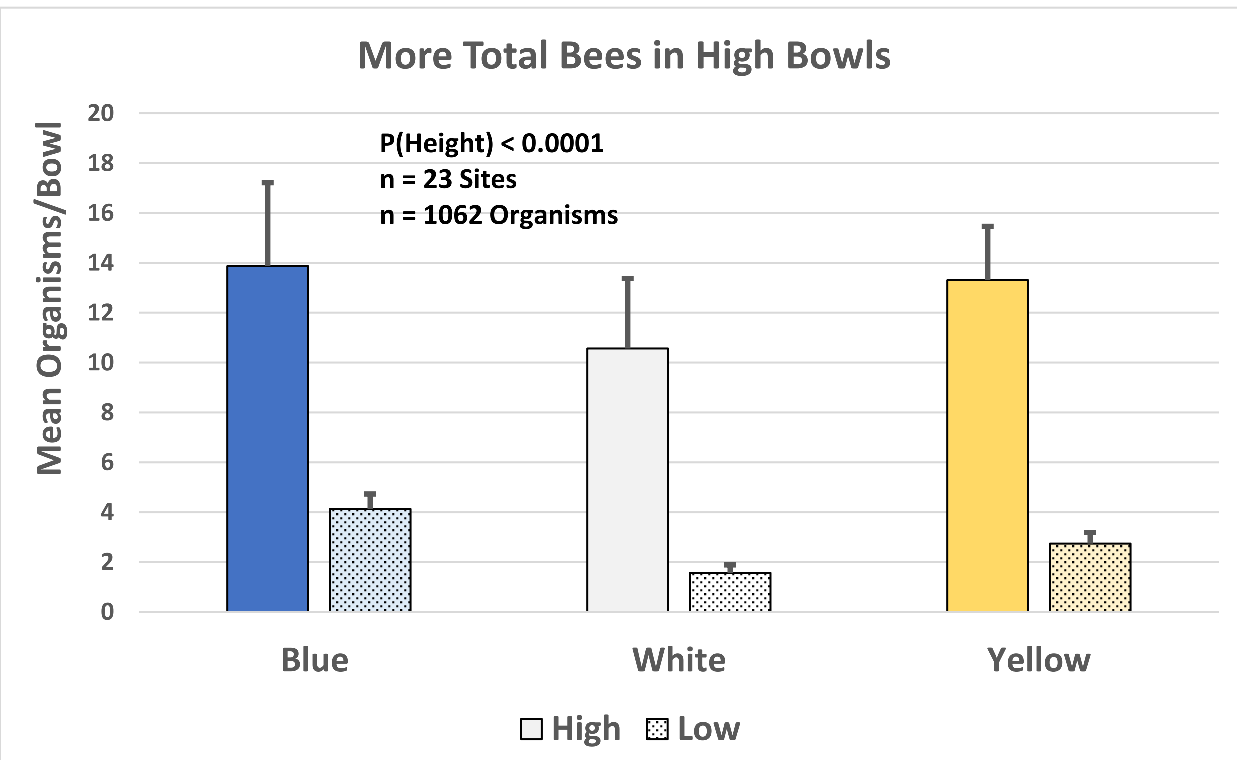

Figure 11. *Distribution of total bees from both months into the six types of bowls.*

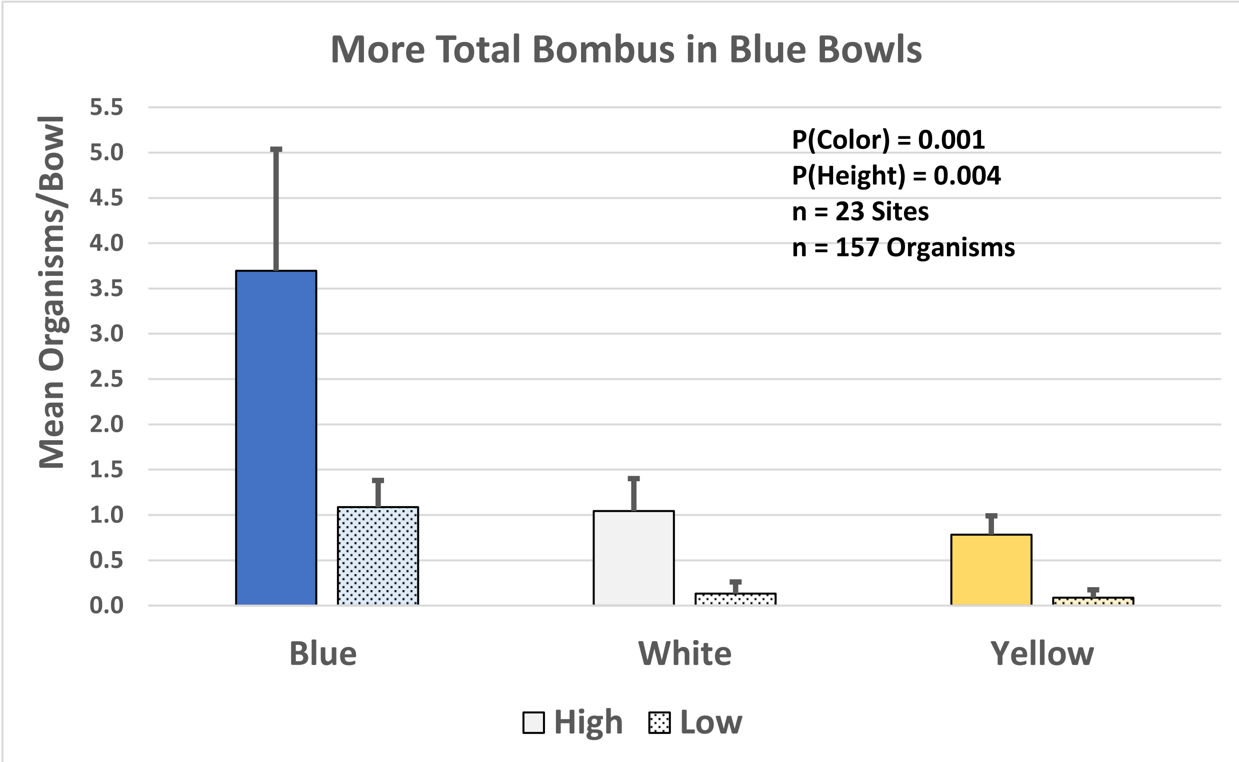

Figure 12. *Distribution of total Bombus from both months into the six types of bowls.*

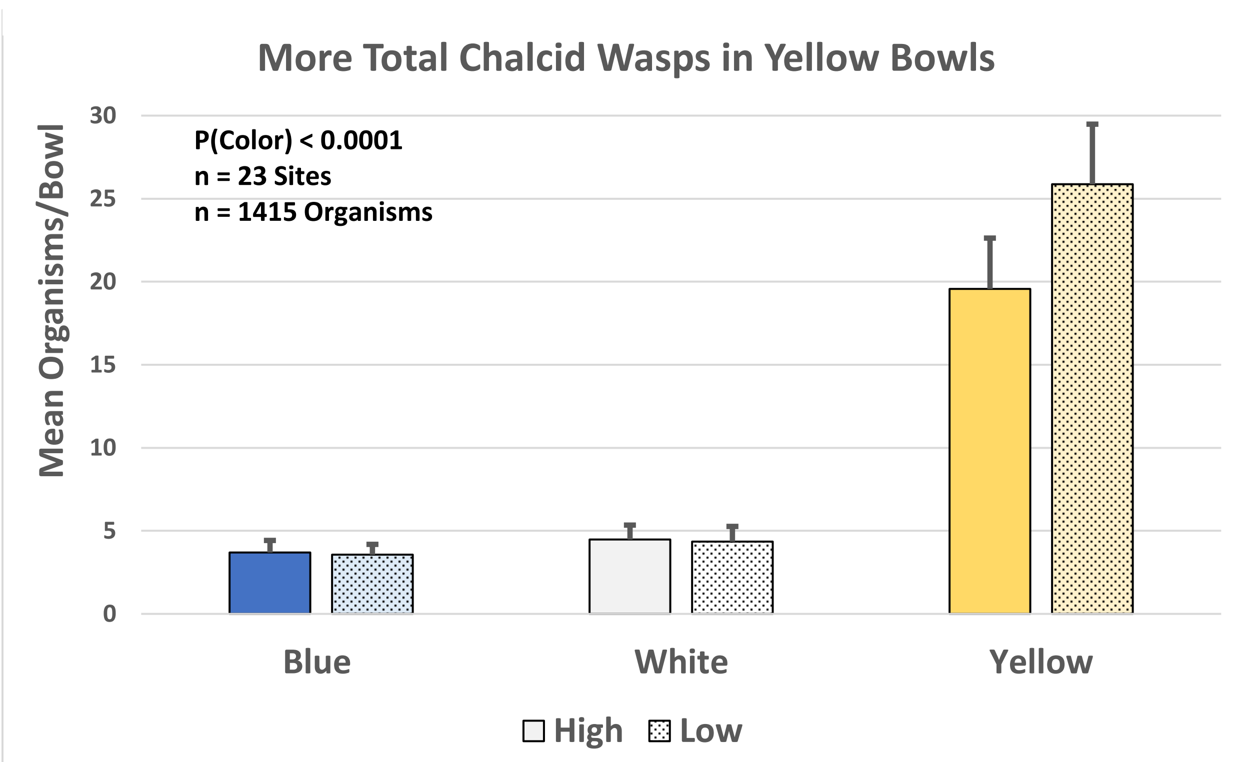

Figure 13. *Distribution of total chalcid wasps from both months into the six types of bowls.*

Discussion

It would appear that this research was able to address the three primary questions established in the introduction. In response to the landscape level question about urbanness surrounding gardens and insect abundance, it is quite evident that there was an overall lack of correlation between percent impervious surface within a 0.5-km radius and most of the identified insect abundances. This lack of relationship or influence with the degree of urbanness in the urban and suburban collection sites in this study may suggest that there is not a substantial impact of urbanness with the insect populations found in and visiting gardens (Fig. 4). While Buczkowski and Richmond found that urbanization can potentially contribute to negative population trends in numerous insect populations, Order level data seems to indicate that populations could be somewhat consistent along a gradient of urbanness in Jefferson County (2012). Thus, the implementation and usage of native plant gardens in cities, such as the gardens in this study could prove to be quite beneficial in potentially offsetting the widescale insect population decline as there were no significant differences in abundances among the collection sites, even including the meadow reference sites in Cherokee and Iroquois Parks. While most current research in relation to insects is relatively gloomy, this conclusion provides somewhat of a silver lining, as the insect abundances collected across Jefferson County suggest native plant gardens can attract and provide potentially viable spaces for insect populations despite the urban setting.

Moreover, in relation to pollinators specifically, the orders of Diptera and Hymenoptera represent a large portion of the insect population that function as pollinators in their ecosystems. Within both of the data sets from these two orders, there is a lack of a clear, overall correlation between either order and the %IS that defines urbanness, so potentially a native plant garden in a more urban area of a city could benefit these organisms just as well as one that is more suburban within that same metropolitan area. However, with the dataset from total bees collected in July, the statistically significant negative correlation suggests that the degree of urbanness may actually be disadvantageous for these pollinators, though it could be that there is simply a lack of bees in more urban areas due to the general lack of sustainable or useful vegetation and bare soil where most solitary bees live. More ecological research needs to be conducted in urban environments to firmly establish similar trends before any grand conclusions can be made.

Equally, with the methodology question of the bowls, the results from the research directly addressed the questions that were presented at the start. Specifically, the total insect collections across all sites and both months followed a clear, statistically significant influence, with both bowl color and bowl placement height impacting the average number of total insects captured. Overall, the color yellow and the height of 100-cm above the ground both contributed to the largest total insect collections, as high, yellow bowls captured more than any other bowl for the total insect collections (Fig. 8). These trends were fairly consistent among the insect orders observed as well, as both the Diptera and Hymenoptera followed the same influences as the total insect dataset, with high, yellow bowls being the collection method that acquired the largest portion of their collections, with their large percentages of the collection likely driving these trends (Fig. 9, Fig. 10). Thus, the question as to whether bowl characteristics have any impact on the insect abundance collected can be answered with a strong affirmative.

It is interesting to note that these specific trends are not the case for the subcategories of Hymenoptera. This can be observed with how the mean bee abundance appears to only be significantly affected by the height of the bowl, but not by the color (Fig. 11). Additionally, the data for *Bombus* should be discussed as it does not follow the trends of high and yellow bowls capturing the largest abundance of insects; instead the high, blue bowls appeared to result in the (Fig. 12). This could be due to the fact that *Bombus* bees may prefer flowers that are closer to the ultraviolet end of the electromagnetic spectrum, so their results remain one of the few exceptions to the defined trend (Raine and Chittka, 2007). With this, if future studies of this kind were to be conducted, yellow and blue bowls placed 100-cm above the ground would be recommended as the most efficient method in capturing the largest insect abundance for such collections. This would allow for more effort afforded towards locating more garden sites without vastly increasing the work load. However, because different placement heights and colors may attract differing types of insect populations, the more bowl types that are present for collections could improve the species richness and diversity obtained.

Finally, the question whether there would be a distinction between the collection time periods between June and July as clearly answered. Before even reviewing statistics, it is clear that July resulted in a tremendously larger set of organisms captured than June, with 4367 and 5971, respectively (Fig. 3). Likewise, when comparing the two regression from the data, the difference between the two collection periods can clearly be identified, with June's dataset trending positively with the increased %IS while July's dataset trends negatively, though these trends were not significant; the July dataset could be explained by the lower insect abundance captured at St. Francis, which had an 87% IS (Appendix Fig. 1). This, along with the statistically significant interaction between regressions, demonstrates that there was a clear distinction between the two months. Although this research did not search into possible causes for this difference, a variety of possible factors could have contributed, such as differences in species/population availability during time of year, weather, and the flora available for insects within each month.

Furthermore, in response to the data as a whole, it must be noted that while it should be regarded as thorough, there may have been a potential “oasis effect” that contributed to these specific insect abundance patterns. Wherein, the brightly colored collection bowls surrounded by native plant garden vegetation could have attracted higher numbers of insects than they would have in a more rural environment, due to their potential resemblance to flowers. Thus, the native plant gardens, and the bowls therein, could be oases and attractors in more urban neighborhoods, thus leading to greater insect numbers caught in the more urban collection sites. Since the native plant gardens that are located in the more urban areas of Louisville in Jefferson County are surrounded by vast network of buildings and roads, their presence for insects could be like an oasis in a desert. Insect populations in such urban areas could be drawn to these native plant gardens as they are the only possible sites with the necessary resources for their needs; thus, the data collected from these garden spaces could have been influenced by such an effect and may explain why gardens caught more insects that their meadow reference site counterparts.

Conclusion

The global population declines of both insects and pollinators should be immediate grounds for ecological alarm. Regardless of the specific factors that are contributing to these well-defined losses, the cultural, economic, and environmental benefits provided by such incredible creatures cannot go overlooked for much longer. Likewise, as agricultural and urban expansion continues to occur, the effects of such urbanization on the surrounding environments is also needed to better understand how to address ecological issues that may arise. This findings provide support for the community conservation movement, which promotes the idea of individuals and communities being important for the conservation of many species, with which the usage of native plant gardens is supported. This research was conducted with the desire to help further such causes with the results obtained in an under-represented area of biology. Overall, the research discussed can be regarded as productive as it succeeded in addressing the three primary questions established in its onset. With the bigger picture question, there was no consistent relationship between degree of urbanness and the abundance of organisms captured across collection sites, nor their abundance at the higher Order level, suggesting a low level of impact of urbanness on insects within Jefferson County. However, this was not a species level determination and, thus, there could be differences at the species level with the observed orders that are not yet apparent. Moreover, a distinct difference between the June and July datasets suggests some influence of the time period. Finally, the methodology question was properly answered as total insects collected generally favored the higher bowl placement height and the yellow bowl color; such information could prove beneficial for future studies. Of course, more ecological research is required to further support or disprove the information concluded from this research.

Acknowledgements

Special thanks should be given to the individuals and organizations who generously provided their garden spaces for this research experiment. Likewise, special thanks should be given to Lindsay Nason who assisted with some of the statistics and Haleigh Arnold who calculated the percent impervious surface data. Special thanks should also be given to Dr. Margaret Carreiro and Dr. Eason who help guide and direct this research towards completion. Appreciation should also be extended to Amy Cherry, Lauren Kappel, Olivia Rumble, and Jacob Holtgrewe, who assisted in the field and the lab during the course of this research.

Literature Cited

Aizen MA, Feinsinger P. 2002. "Bees Not to Be? Responses of Insect Pollinator Faunas and Flower Pollination to Habitat Fragmentation." *How Landscapes Change Ecological Studies*. **162**: 111–129. doi:10.1007/978-3-662-05238-9_7.

Anderson PM, Avlonitis G, Ernstson H. 2014. "Ecological Outcomes of Civic and Expert-Led Urban Greening Projects Using Indigenous Plant Species in Cape Town, South Africa." *Landscape and Urban Planning*. **127**:104–113. doi:10.1016/j.landurbplan.2014.03.007.

Bergerot B, Fontaine B, Renard M, Cadi M, Julliard R. 2010. "Preferences for Exotic Flowers Do Not Promote Urban Life in Butterflies." *Landscape and Urban Planning*. **96**(2): 98–107. doi:10.1016/j.landurbplan.2010.02.007.

Buczkowski G, Richmond D. 2012. "The Effect of Urbanization on Ant Abundance and Diversity: A Temporal Examination of Factors Affecting Biodiversity." *PLoS ONE* **7**(8): e41729. doi:10.1371/journal.pone.0041729.

Ceballos G, Ehrlich P, Dirzo R. 2017. "Biological Annihilation via the Ongoing Sixth Mass Extinction Signaled by Vertebrate Population Losses and Declines." *PNAS*. **114(**30: E6089-E6096. doi.org/10.1073/pnas.1704949114.

Cutting B, Tallamy DW. 2015. "An Evaluation of Butterfly Gardens for Restoring Habitat for the Monarch Butterfly (Lepidoptera: Danaidae)." *Environmental Entomology*. **44**(5): 1328–1335. doi:10.1093/ee/nvv111.

Gill RJ, Ramos-Rodríguez O, Raine N. 2012. "Combined Pesticide Exposure Severely Affects Individual- and Colony-Level Traits in Bees." *Nature*, **491**: 105–108., doi:10.1038/nature11585.

Hallmann CA, Sorg M, Jongejans E, et al. 2017. "More than 75 Percent Decline over 27 Years in Total Flying Insect Biomass in Protected Areas." *PLoS ONE*. **12**(10): e0185809. doi:10.1371/journal.pone.0185809.

Lister BC, Garcia A. 2018. "Climate-Driven Declines in Arthropod Abundance Restructure a Rainforest Food Web." *PNAS*. **115**(44): E10397-E10406. doi:10.1073/pnas.1722477115.

Pardee GL, Philpott SM. 2014. "Native Plants Are the Bee's Knees: Local and Landscape Predictors of Bee Richness and Abundance in Backyard Gardens." *Urban Ecosystems*. **17**(3):641–659. doi:10.1007/s11252-014-0349-0.

Pleasants JM, Oberhauser, KS. 2012. "Milkweed Loss in Agricultural Fields Because of Herbicide Use: Effect on the Monarch Butterfly Population." *Insect Conservation and Diversity*. **6**(2):135–144. doi:10.1111/j.1752-4598.2012.00196.x.

Popic TJ, Davila YC, Wardle GM. 2013. "Evaluation of Common Methods for Sampling Invertebrate Pollinator Assemblages: Net Sampling Out-Perform Pan Traps." *PLoS ONE*, **8**(6):e66665. doi:10.1371/journal.pone.0066665.

R Development Core Team. 2016. The R Project For Statistical Computing: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Raine NE, Chittka L. 2007. "The Adaptive Significance of Sensory Bias in a Foraging Context: Floral Colour Preferences in the Bumblebee Bombus Terrestris." *PLoS ONE*. **2**(6):e556 doi:10.1371/journal.pone.0000556.

Samnegård U, Persson A, Smith HG. 2011. "Gardens Benefit Bees and Enhance Pollination in Intensively Managed Farmland." *Biological Conservation*. **144**(11):2602–2606. doi:10.1016/j.biocon.2011.07.008.

Sánchez-Bayo F, Wyckhuys KAG. 2019. "Worldwide Decline of the Entomofauna: A Review of Its Drivers." *Biological Conservation*. **232**: 8-27. doi:10.1016/j.biocon.2019.01.020.

Saunders ME, Luck GW. 2012 "Pan Trap Catches of Pollinator Insects Vary with Habitat." *Australian Journal of Entomology*. **52**(2):106–113. doi:10.1111/aen.12008.

Schowalter TD, Noriega JA, Tscharntke. 2017. "Insect Effects on Ecosystem Services-Introduction." *Basic and Applied Ecology*. **26**:1-7. doi:10.1603/ice.2016.95289.

Your Weather Service. 2019. "US Climate Data for Louisville, Kentucky." Version 2.3. https://www.usclimatedata.com/climate/louisville/kentucky/united-states/usky1846

Vanbergen AJ, and The Insect Pollinators Initiative. 2013. "Threats to an Ecosystem Service: Pressures on Pollinators." *Frontiers in Ecology and the Environment*. **11**(5):251–259. doi:10.1890/120126.

Vrdoljak SM, Samways MJ. 2012. "Optimising Coloured Pan Traps to Survey Flower Visiting Insects." *Journal of Insect Conservation*. **16**(3):345–354. doi:10.1007/s10841-011-9420-9.

White RJ, Carreiro MM, Zipperer WC. 2014. "Woody Plant Communities Along Urban, Suburban, and Rural Streams in Louisville, Kentucky, USA. *Urban Ecosystems*, **17**(4):1061-1094. doi:10.1007/s11252-014-0376-x.

Appendix

Table 1. *Collection sites were selected across Jefferson County to demonstrate a gradient of urbanness, as defined by percent impervious surface in a 0.5-km radius surrounding the bowl array station.*

Collection Site	Percent Impervious Surface (% IS 0.5KM)
St. Francis	87.1
Copper & Kings	67.0
University of Louisville	59.5
Smith	58.4
Old Louisville Community Garden	57.1
Scroggins	46.8
Holy Spirit	45.6
Carreiro	44.6
Portland Elementary	43.9
Word	42.7
John Paul II	40.2
Chenoweth	37.4
Louisville Nature Center	27.8
St. Agnes	26.6
Brown	25.6
Fuselier	21.6
Moore High School	21.2
Cherokee Park	12.6
Iroquois Park	3.1

Table 2. *Total insects collected across all sites in the month of June 2017.*

Total Insects for June							
Garden	**High Blue**	**High White**	**High Yellow**	**Low Blue**	**Low White**	**Low Yellow**	**SUM**
Brown Back	44	27	70	15	40	28	**224**
Brown Front	22	21	48	20	31	84	**226**
Carreiro	22	15	70	20	8	30	**165**
Chenoweth	23	8	36	13	23	61	**164**
Cherokee 1	34	29	28	18	23	33	**165**
Cherokee 2	22	19	36	18	13	44	**152**
Copper & Kings Large	47	33	89	18	11	26	**224**
Copper & Kings Small	47	72	109	32	15	68	**343**
Fuselier	60	14	48	9	9	45	**185**
Holy Spirit	4	9	97	5	6	68	**189**
Iroquois Large	14	10	55	9	30	23	**141**
Iroquois Small	0	0	1	0	1	0	**2**
John Paul II	35	32	82	16	28	56	**249**
Louisville Nature Center	70	55	126	35	47	47	**380**
Moore Left	47	92	155	20	35	72	**421**
Moore Right	26	79	78	31	28	77	**319**
Old Louisville Community Garden	82	76	98	54	35	146	**491**
Portland Elementary	7	8	60	26	9	30	**140**
Scroggins	33	30	107	99	13	54	**336**
Smith	23	10	41	25	14	42	**155**
St. Agnes	45	17	55	6	15	46	**184**
University of Louisville	29	33	82	19	10	91	**264**
Word	32	24	51	17	16	36	**176**
SUM	**768**	**713**	**1622**	**525**	**460**	**1207**	**5295**

Table 3. *Total insects collected across all sites in the month of July 2017.*

Total Insects for July							
Garden	**High Blue**	**High White**	**High Yellow**	**Low Blue**	**Low White**	**Low Yellow**	**SUM**
Brown Back	65	88	71	58	117	36	**435**
Brown Front	22	21	48	20	31	84	**226**
Carreiro	40	39	77	25	16	42	**239**
Chenoweth	29	23	76	62	41	154	**385**
Cherokee 1	66	51	66	43	30	34	**290**
Cherokee 2	127	92	75	35	30	53	**412**
Copper & Kings Large	64	24	71	34	24	58	**275**
Copper & Kings Small	66	38	88	18	23	36	**269**
Fuselier	115	108	163	60	36	70	**552**
Holy Spirit	24	16	110	57	25	137	**369**
Iroquois Large	224	53	108	50	61	40	**536**
Iroquois Small	109	64	89	33	33	22	**350**
John Paul II	87	47	137	43	38	73	**425**
Louisville Nature Center	79	85	144	6	27	25	**366**
Moore Left	61	75	237	50	49	52	**524**
Moore Right	43	12	111	42	74	55	**337**
Old Louisville Community Garden	90	106	169	31	19	76	**491**
Portland Elementary	47	15	94	35	18	36	**245**
Scroggins	23	66	79	41	72	100	**381**
Smith	50	34	85	56	71	140	**436**
St. Agnes	177	278	165	104	55	160	**939**
St. Francis	30	15	87	12	17	81	**242**
University of Louisville	50	25	85	20	16	100	**296**
Word	87	36	95	16	17	34	**285**
SUM	**1745**	**1396**	**2443**	**939**	**923**	**1617**	**9063**

Table 4. *Total Hymenoptera collected across all sites in the month of June 2017.*

Total Hymenoptera for June							
Garden	**High Blue**	**High White**	**High Yellow**	**Low Blue**	**Low White**	**Low Yellow**	**SUM**
Brown Back	1	3	13	2	6	12	**37**
Brown Front	4	1	6	6	7	17	**41**
Carreiro	7	3	13	14	1	14	**52**
Chenoweth	7	4	6	5	4	9	**35**
Cherokee 1	13	15	5	5	3	11	**52**
Cherokee 2	7	9	8	2	3	9	**38**
Copper & Kings Large	10	3	14	4	4	7	**42**
Copper & Kings Small	7	6	14	9	3	45	**84**
Fuselier	5	1	7	3	3	9	**28**
Holy Spirit	1	2	10	1	3	12	**29**
Iroquois Large	9	4	6	3	3	1	**26**
Iroquois Small	0	0	0	0	0	0	**0**
John Paul II	6	5	17	4	3	17	**52**
Louisville Nature Center	6	9	17	2	8	26	**68**
Moore Left	11	3	13	3	6	13	**49**
Moore Right	6	6	11	5	1	21	**50**
Old Louisville Community Garden	36	11	18	6	9	19	**99**
Portland Elementary	5	3	26	7	0	16	**57**
Scroggins	2	1	18	47	3	14	**85**
Smith	6	5	11	12	2	6	**42**
St. Agnes	3	4	9	2	0	10	**28**
University of Louisville	3	4	6	4	1	7	**25**
Word	7	2	21	3	4	17	**54**
SUM	**162**	**104**	**269**	**149**	**77**	**312**	**1073**

Table 5. *Total Hymenoptera collected across all sites in the month of July 2017.*

Total Hymenoptera for July							
Garden	**High Blue**	**High White**	**High Yellow**	**Low Blue**	**Low White**	**Low Yellow**	**SUM**
Brown Back	1	10	15	3	4	4	**37**
Brown Front	4	1	6	6	7	17	**41**
Carreiro	13	4	15	7	3	15	**57**
Chenoweth	4	7	17	13	5	29	**75**
Cherokee 1	35	21	18	8	11	5	**98**
Cherokee 2	64	51	23	4	7	9	**158**
Copper & Kings Large	15	5	30	11	13	30	**104**
Copper & Kings Small	7	11	33	2	3	12	**68**
Fuselier	19	44	69	11	7	37	**187**
Holy Spirit	5	9	32	10	5	52	**113**
Iroquois Large	11	12	22	8	5	7	**65**
Iroquois Small	12	13	10	1	3	0	**39**
John Paul II	16	10	16	8	9	27	**86**
Louisville Nature Center	12	14	28	3	4	8	**69**
Moore Left	15	14	35	6	4	16	**90**
Moore Right	7	3	36	5	21	9	**81**
Old Louisville Community Garden	15	23	63	9	9	45	**164**
Portland Elementary	5	5	31	4	4	9	**58**
Scroggins	1	5	22	3	6	34	**71**
Smith	8	9	23	14	4	45	**103**
St. Agnes	20	24	55	5	7	68	**179**
St. Francis	3	2	8	0	0	15	**28**
University of Louisville	6	6	18	3	2	14	**49**
Word	5	16	32	4	1	8	**66**
SUM	**300**	**317**	**649**	**148**	**144**	**500**	**2058**

Table 6. *Total Diptera collected across all sites in the month of June 2017.*

Total Diptera for June							
Garden	**High Blue**	**High White**	**High Yellow**	**Low Blue**	**Low White**	**Low Yellow**	**SUM**
Brown Back	7	7	11	3	9	5	**42**
Brown Front	4	11	27	6	17	36	**101**
Carreiro	6	2	21	2	2	8	**41**
Chenoweth	1	0	28	6	13	28	**76**
Cherokee 1	10	9	12	4	15	3	**53**
Cherokee 2	5	5	12	4	3	7	**36**
Copper & Kings Large	10	4	14	2	2	5	**37**
Copper & Kings Small	6	12	13	3	1	6	**41**
Fuselier	7	4	26	5	2	16	**60**
Holy Spirit	2	2	29	3	2	29	**67**
Iroquois Large	4	4	25	0	9	6	**48**
Iroquois Small	0	0	1	0	0	0	**1**
John Paul II	22	20	30	9	12	14	**107**
Louisville Nature Center	31	16	43	17	20	6	**133**
Moore Left	21	49	82	11	16	30	**209**
Moore Right	14	49	34	6	11	12	**126**
Old Louisville Community Garden	23	39	34	39	23	58	**216**
Portland Elementary	2	2	20	10	6	13	**53**
Scroggins	5	5	19	3	4	11	**47**
Smith	9	2	7	8	6	14	**46**
St. Agnes	5	3	17	1	9	18	**53**
University of Louisville	15	17	25	9	7	37	**110**
Word	19	1	4	3	8	9	**44**
SUM	**228**	**263**	**534**	**154**	**197**	**371**	**1747**

Table 7. *Total Diptera collected across all sites in the month of July 2017.*

Total Diptera for July							
Garden	**High Blue**	**High White**	**High Yellow**	**Low Blue**	**Low White**	**Low Yellow**	**SUM**
Brown Back	3	9	23	4	12	19	**70**
Brown Front	4	11	27	6	17	36	**101**
Carreiro	10	14	39	3	3	10	**79**
Chenoweth	4	7	45	11	16	44	**127**
Cherokee 1	6	21	32	5	4	11	**79**
Cherokee 2	7	16	40	6	3	15	**87**
Copper & Kings Large	13	6	13	7	4	15	**58**
Copper & Kings Small	11	8	26	5	6	16	**72**
Fuselier	3	6	35	9	9	13	**75**
Holy Spirit	2	3	51	7	9	53	**125**
Iroquois Large	24	15	42	5	19	7	**112**
Iroquois Small	6	9	34	6	5	3	**63**
John Paul II	1	18	51	8	20	16	**114**
Louisville Nature Center	11	51	84	1	9	4	**160**
Moore Left	8	24	169	13	13	18	**245**
Moore Right	17	1	53	5	7	17	**100**
Old Louisville Community Garden	23	48	67	11	6	16	**171**
Portland Elementary	5	5	28	6	9	10	**63**
Scroggins	1	53	24	1	14	12	**105**
Smith	7	7	28	6	30	49	**127**
St. Agnes	3	10	63	5	38	66	**185**
St. Francis	12	8	60	11	14	51	**156**
University of Louisville	3	12	43	2	5	53	**118**
Word	2	10	35	3	8	13	**71**
SUM	**174**	**364**	**1052**	**135**	**266**	**516**	**2507**

Table 8. *Total bees collected across all sites in the month of June 2017.*

Total Bees for June							
Garden	**High Blue**	**High White**	**High Yellow**	**Low Blue**	**Low White**	**Low Yellow**	**SUM**
Brown Back	1	1	2	1	1	1	**7**
Brown Front	2	1	0	3	3	0	**9**
Carreiro	9	0	0	5	1	6	**21**
Chenoweth	2	3	4	1	1	0	**11**
Cherokee 1	9	13	3	3	2	0	**30**
Cherokee 2	7	8	8	0	0	3	**26**
Copper & Kings Large	7	0	3	2	1	0	**13**
Copper & Kings Small	5	1	5	1	1	4	**17**
Fuselier	2	0	1	3	0	0	**6**
Holy Spirit	1	0	2	1	0	2	**6**
Iroquois Large	5	4	3	0	0	0	**12**
Iroquois Small	0	0	0	0	0	0	**0**
John Paul II	3	1	9	4	1	2	**20**
Louisville Nature Center	4	2	2	1	1	1	**11**
Moore Left	11	3	6	2	0	1	**23**
Moore Right	3	5	3	0	0	0	**11**
Old Louisville Community Garden	32	5	4	5	4	2	**52**
Portland Elementary	3	0	4	4	0	0	**11**
Scroggins	0	0	6	5	2	2	**15**
Smith	4	0	4	11	0	1	**20**
St. Agnes	2	3	6	1	0	5	**17**
University of Louisville	2	1	2	1	0	2	**8**
Word	3	2	7	3	1	0	**16**
SUM	**117**	**53**	**84**	**57**	**19**	**32**	**362**

Table 9. *Total bees collected across all sites in the month of July 2017.*

Total Bees for July							
Garden	**High Blue**	**High White**	**High Yellow**	**Low Blue**	**Low White**	**Low Yellow**	**SUM**
Brown Back	0	1	9	0	0	0	**10**
Brown Front	2	1	3	3	3	0	**12**
Carreiro	4	0	3	2	0	0	**9**
Chenoweth	0	2	10	4	1	2	**19**
Cherokee 1	33	19	11	3	3	0	**69**
Cherokee 2	63	49	9	3	2	1	**127**
Copper & Kings Large	8	3	8	0	0	1	**20**
Copper & Kings Small	3	8	1	2	0	0	**14**
Fuselier	17	33	51	3	2	2	**108**
Holy Spirit	3	4	18	2	1	3	**31**
Iroquois Large	10	6	5	1	1	0	**23**
Iroquois Small	10	10	14	1	1	0	**36**
John Paul II	6	1	8	4	0	0	**19**
Louisville Nature Center	4	4	10	0	0	1	**19**
Moore Left	12	9	5	2	0	3	**31**
Moore Right	5	0	11	0	0	3	**19**
Old Louisville Community Garden	4	7	6	2	0	1	**20**
Portland Elementary	4	2	3	1	1	3	**14**
Scroggins	0	0	3	1	0	1	**5**
Smith	2	3	2	1	0	3	**11**
St. Agnes	6	12	9	2	2	4	**35**
St. Francis	0	0	0	0	0	0	**0**
University of Louisville	3	2	1	1	0	1	**8**
Word	3	14	22	0	0	2	**41**
SUM	**202**	**190**	**222**	**38**	**17**	**31**	**700**

Table 10. *Total chalcid wasps collected across all sites in the month of June 2017.*

Total Chalcid Wasp for June							
Garden	**High Blue**	**High White**	**High Yellow**	**Low Blue**	**Low White**	**Low Yellow**	**SUM**
Brown Back	0	1	3	0	1	8	**13**
Brown Front	1	0	3	2	2	15	**23**
Carreiro	1	0	4	0	0	7	**12**
Chenoweth	4	1	1	0	0	4	**10**
Cherokee 1	1	1	1	0	0	7	**10**
Cherokee 2	0	0	0	0	1	3	**4**
Copper & Kings Large	2	2	9	2	1	7	**23**
Copper & Kings Small	2	3	5	5	2	41	**58**
Fuselier	2	1	5	0	3	9	**20**
Holy Spirit	0	1	5	0	3	7	**16**
Iroquois Large	3	0	3	0	2	1	**9**
Iroquois Small	0	0	0	0	0	0	**0**
John Paul II	0	2	2	0	0	10	**14**
Louisville Nature Center	2	5	14	1	5	20	**47**
Moore Left	0	0	6	1	1	10	**18**
Moore Right	1	0	7	4	0	20	**32**
Old Louisville Community Garden	4	4	5	1	2	13	**29**
Portland Elementary	0	0	5	0	0	1	**6**
Scroggins	0	1	7	2	0	7	**17**
Smith	0	1	3	0	0	4	**8**
St. Agnes	1	1	1	0	0	4	**7**
University of Louisville	0	0	0	1	1	4	**6**
Word	3	0	14	0	2	14	**33**
SUM	**27**	**24**	**103**	**19**	**26**	**216**	**415**

Table 11. *Total insects collected across all sites in the month of July 2017.*

Total Chalcid Wasps for July							
Garden	**High Blue**	**High White**	**High Yellow**	**Low Blue**	**Low White**	**Low Yellow**	**SUM**
Brown Back	0	3	4	2	3	1	**13**
Brown Front	1	0	3	2	2	15	**23**
Carreiro	0	0	0	3	0	0	**3**
Chenoweth	0	1	5	7	3	18	**34**
Cherokee 1	0	1	4	0	0	4	**9**
Cherokee 2	1	2	11	0	1	6	**21**
Copper & Kings Large	5	1	22	11	11	16	**66**
Copper & Kings Small	4	3	32	0	2	12	**53**
Fuselier	1	9	18	5	4	31	**68**
Holy Spirit	0	2	0	6	4	44	**56**
Iroquois Large	2	5	5	0	1	0	**13**
Iroquois Small	1	1	7	2	0	5	**16**
John Paul II	10	7	4	4	3	26	**54**
Louisville Nature Center	3	9	16	2	2	7	**39**
Moore Left	2	5	18	1	1	11	**38**
Moore Right	1	2	23	3	20	2	**51**
Old Louisville Community Garden	10	10	54	4	3	38	**119**
Portland Elementary	1	0	20	0	1	3	**25**
Scroggins	1	5	12	1	6	27	**52**
Smith	3	1	19	5	3	37	**68**
St. Agnes	7	8	45	2	2	56	**120**
St. Francis	2	0	7	0	0	13	**22**
University of Louisville	3	3	16	2	1	16	**41**
Word	2	1	9	1	1	4	**18**
SUM	**58**	**79**	**347**	**63**	**74**	**379**	**1000**

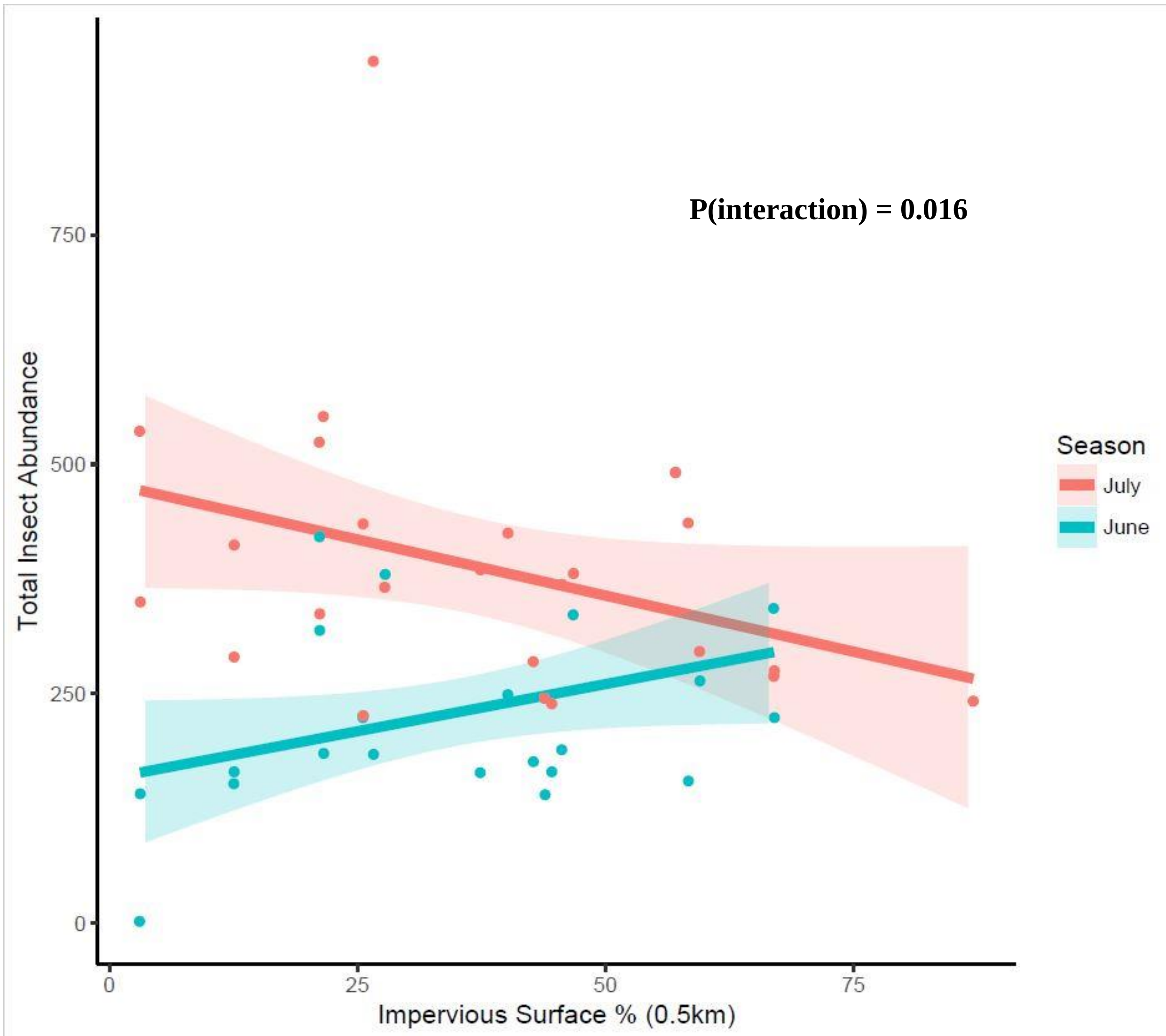

Figure 1. *Regression lines for June and July show a statistically significant interaction*

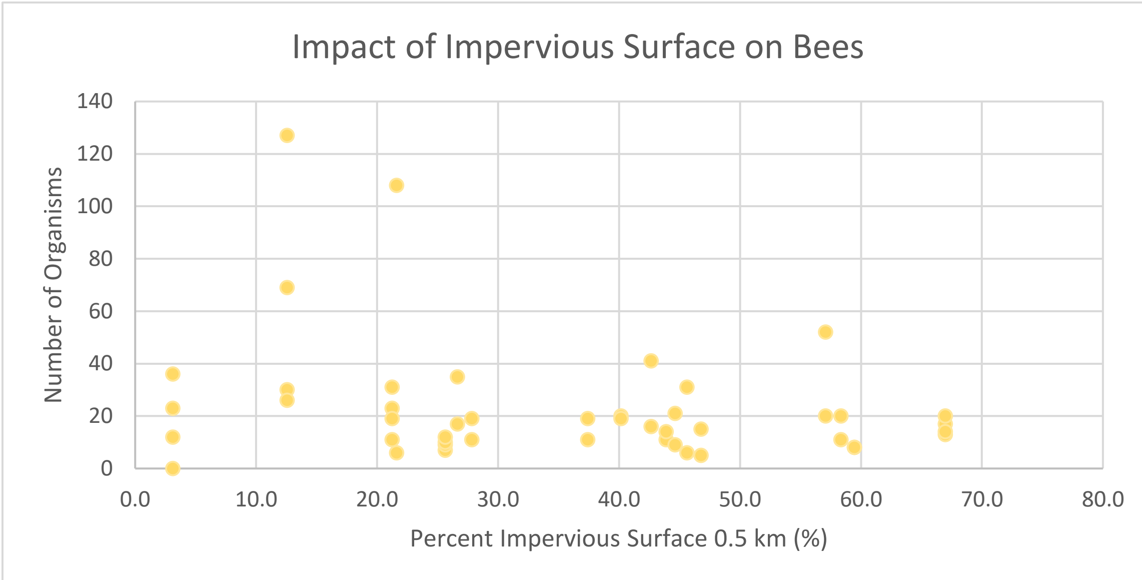

Figure 2. *Not significant, but still an evident negative trend with increased %IS on total bees.*

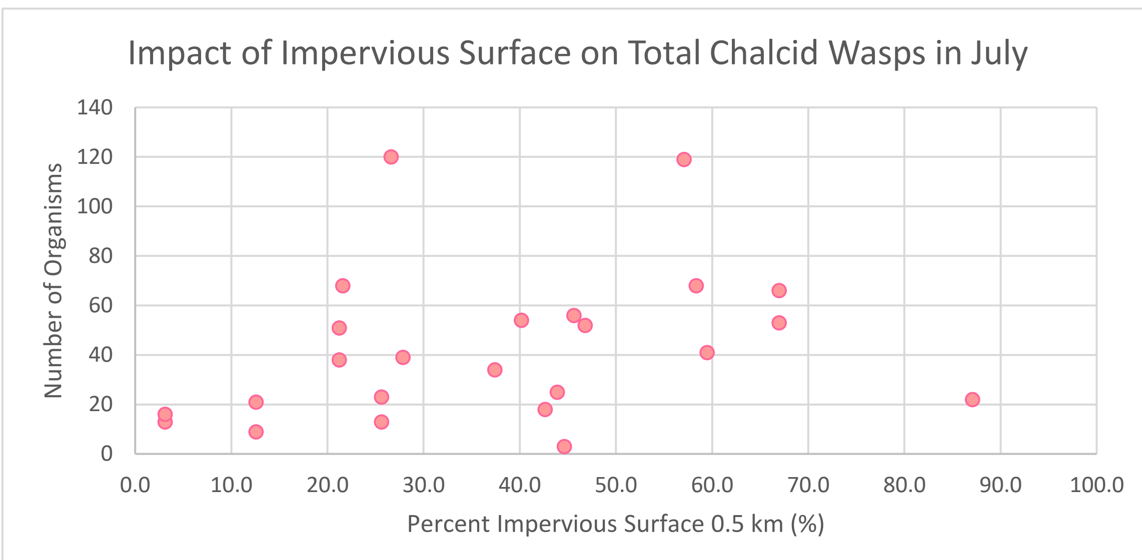

Figure 3. *Not significant, but a noticeable positive trend on July chalcid wasps with increased %IS.*

Table 12. *Table shows the average abundances that were collected from the reference site meadows of Cherokee and Iroquois Parks.*

	Reference Site Meadow Average Abundances for Each Group				
Collection Time	Total Insects	Hymenoptera	Diptera	Chalcid Wasps	Bees
June Data	115	29	34.5	5.8	17
July Data	397	90	85.3	14.8	63.8
Both Months Combined	256	59.5	59.9	10.3	40.4

Table 13. *Table shows the average abundances that were collected from the native plant garden sites, thus excluding the reference site meadows of Cherokee and Iroquois Parks.*

	Native Plant Garden Average Abundances for Each Group				
Collection Time	Total Insects	Hymenoptera	Diptera	Chalcid Wasps	Bees
June Data	254.5	50.4	84.7	20.6	15.5
July Data	385.9	86.3	116.1	48.2	22.3
Both Months Combined	321.8	68.8	100.8	34.7	18.9