Danaus plexippus

FINAL

Butterfly and Pollinator Species Survey at Naval Support Activity Annapolis

Annapolis, Maryland

June 2020

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Butterfly and Pollinator Species Survey

at Naval Support Activity Annapolis, Maryland

N4008018F5125 Task 4

FINAL

June 2020

Prepared for

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EXECUTIVE SUMMARY

Native insects, particularly critical pollinators, are decreasing in many habitats across the United States and North America including monarch butterflies, native bees, and honey bees. Despite their importance to the health of natural and agricultural ecosystems, the full extent of their decline is difficult to measure. The most significant threat to pollinators is loss of habitat and attendant resources usually related to urbanization and/or agricultural practices. Thus, in 2015 the *National Strategy to Promote the Health of Honey Bees and Other Pollinators* was released to provide a "... comprehensive approach to tackling and reducing the impact of multiple stressors on pollinator health, including pests and pathogens, reduced habitat, lack of nutritional resources, and exposure to pesticides."

Naval Support Activity Annapolis is located near Annapolis, Maryland, across the Severn River from the US Naval Academy in the mid-Atlantic region of the United States. The mid-Atlantic region is home to a variety of bee species and butterfly species, along with a host of other beetles, flies, wasps, ants, and other insects that contribute to pollination services. The overall goal of the project was to conduct a survey assessing and documenting the presence of the butterflies, bees, and other pollinators at Naval Support Activity Annapolis. In particular, the survey was designed to detect the presence of rare, threatened, and endangered pollinator insect species.

In order to create as comprehensive of a survey as possible, investigators combined active and passive survey methods. Passive survey methods utilized cups with a mixture of glycol, water, and dish soap to capture passing pollinators, primarily bees. For active surveys, investigators used nets which allow for more targeted collection and typically sample groups that are unlikely to be collected by passive traps due to physiological or behavioral factors.

Potential sites/habitats for passive arrays were selected from aerial imagery and available GIS data (e.g. habitat and plant community coverages). All passive sites were also subjected to active surveys in order to collect species that may not be sampled by the passive arrays and to obtain a better measure of diversity of the site. During the survey efforts at Naval Support Activity Annapolis, monarch butterflies (*Danaus plexippus*) and their preferred host plants, milkweed (genus *Asclepias*), were assessed for the presence of all life stages of the monarch. In addition to the pollinator survey, flowering plants that provide floral resources (i.e. pollen and/or nectar) were identified and their abundance assessed.

In 2019, active and passive pollinator surveys were conducted at Naval Support Activity Annapolis on three separate occasions, 4–6 June, 23–25 July, and 30 September–2 October 2020, to capture the diversity of

pollinators and floral resources through the active flying season. The four passive sites were surveyed during each visit. In addition to the passive survey sites, all habitats were actively surveyed, with Greenbury Point receiving special attention due to the abundance of suitable pollinator habitat.

Suitable pollinator habitat was abundant, particularly on Greenbury Point, where land management and restoration activities have resulted in large areas of common milkweed and other forbs. The extensive milkweed colonies attracted large numbers of monarch butterflies, and Naval Support Activity Annapolis likely supports a robust local population and is an attractive waypoint during the spring and fall migrations.

During the 2019 pollinator survey at Naval Support Activity Annapolis, 37 species of diurnal lepidopterans (butterflies) representing five families, 14 genera, and 19 species of bees were positively identified. While butterflies were consistently identified to the species level, some of the bees could generally only be identified to the genus level, primarily because the taxonomy and phylogenetics of Apoidea are still not fully elucidated.

Butterfly and Pollinator Species Survey for Naval Support Activity Annapolis, Maryland

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ABBREVIATIONS AND ACRONYMS

Acronym	Definition
DOD	Department of Defense
GIS	Geographic Information System
NSAA	Naval Support Activity Annapolis
RT&E	Rare, Threatened, and Endangered

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1 INTRODUCTION

1.1 Background

Globally, insect populations have declined dramatically over the last 30 years, with many populations experiencing more than a 75 percent reduction in biomass (Conrad et al. 2006; Hallman et al. 2017). Insect pollinators, primarily species in the orders Hymenoptera (bees) and Lepidoptera (butterflies), have not been immune to this decline. Populations of butterflies, native bees, and honey bees have been steadily declining across the United States for the last 30 years, with estimates of a 23 percent decline in wild bee populations just since 2008 (Insu et al. 2016). While systematic research investigating the decline in butterfly populations is less common, Wepprich et al. (2019) found a 33 percent decrease in butterfly populations in Ohio since 1999. One species that has been studied extensively is the monarch butterfly (*Danaus plexippus*), where intensive research over the last 25-plus years has documented precipitous declines in their populations (Agrawal and Inamine 2018; Boyle et al. 2019).

The decline of pollinator populations can have critical conservation and ecological ramifications. Pollinators provide key ecological services that are essential to plant reproduction, agricultural productivity, and terrestrial biodiversity (Rhodes 2018). Pollinators play a key role in sustaining native ecosystems, with greater than 75 percent of known flowering plants relying on insect pollinators to reproduce (NRC 2007; Cameron et al. 2011). Economically, pollinators are critical to agricultural productivity. For example, honey bee hives are necessary contributors in the production of 29 billion dollars' worth of produce every year in the United States (Calderone 2012). Most commercial hives consist entirely of European honey bees (*Apis mellifera*), but studies have shown that native pollinators, such as bumble bees, leafcutter bees, and squash bees, are significantly more efficient at pollinating most crops (Garibaldi et al. 2014). Additionally, there are also plants that cannot be pollinated by honey bees and require the presence of native pollinators capable of buzz pollination, or sonication, to shake the pollen grains loose (Barth 1991). Furthermore, native pollinators that specialize on certain groups can influence seed set in their preferred plants. For example, many cucurbit species produce larger fruits and seed sets when visited by squash bees, members of the genus *Peponapis* and *Xenoglossa* (Garibaldi et al. 2014).

The most significant threat to pollinators is loss of habitat and attendant resources usually related to urbanization and/or agricultural practices (NRC 2007; Cameron et al. 2011; Grozinger and Evans 2015). Plants such as grasses and non-native forbs that usually dominate urban and suburban plant life turn these areas into "food deserts" for local pollinators (NRC 2007). Increased use of pesticides and some genetically modified crop varieties have also negatively affected pollinator populations near agricultural areas, where pollinators are often found in greater numbers (Grozinger and Evans 2015). Climate change poses a multifaceted threat to pollinator species. Changes in temperature and precipitation can alter flower phenology, shifting the availability of key floral resources. The alteration in phenology disproportionally affects pollinators dependent upon floral resources at the very early stages of the flowering period and at the very end of the active season.

1.2 National and DOD Strategy to Promote Pollinators

In 2015, the *National Strategy to Promote the Health of Honey Bees and Other Pollinators* was released to provide a "... comprehensive approach to tackling and reducing the impact of multiple stressors on pollinator health, including pests and pathogens, reduced habitat, lack of nutritional resources, and exposure to pesticides" (Pollinator Health Task Force 2015).

The following is from the *National Strategy to Promote the Health of Honey Bees and Other Pollinators,* "The strategy focused on four themes central to the June 2014 Presidential Memorandum 'Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators,' namely: conducting research to understand, prevent, and recover from pollinator losses; expanding public education programs and outreach; increasing and improving pollinator habitat; and developing public-private partnerships across all these activities. *A critical component of the Strategy is to advance the science underpinning the government's land management and regulatory decisions.*"

The national strategy set objectives for pollinators in general and identified specific objectives for two species: the honey bee and monarch butterfly. The objective for the monarch is to increase the population to 225 million individuals. To accomplish this objective, the strategy described a multitude of management actions to be taken by federal agencies, including identifying a role for the Department of Defense (DOD) through the development of the *Department of Defense Pollinator Protection Plan* (Pollinator Health Task Force 2015).

Prior to the strategy document being issued, the DOD issued a memorandum in September 2014 *(DOD Policy to Use Pollinator-Friendly Management Prescriptions)* to military services reinforcing the executive memorandum on pollinators. The memorandum stated that the DOD "… will use native landscaping, when possible; avoid using herbicides and pesticides in sensitive habitats; and coordinate with other agencies and non-governmental organizations on habitat and pollinator issues." These goals were emphasized and expanded upon in the *Department of Defense Pollinator Protection Plan* through inclusion in regulations and a directive related to natural resource and installation management (Pollinator Health Task Force 2015).

1.3 Environmental Setting

Naval Support Activity Annapolis (NSAA) is located across the Severn River from the U.S. Naval Academy in Annapolis, Maryland (Figure 1-1). Its primary purpose is to provide support to the U.S. Naval Academy, as well as other tenant commands. The facility was established in 1851, six years after the founding of the Naval Academy, as the Naval Air Station at Greenbury Point. The facility was absorbed into the Severn River Naval Command in 1941 to allow midshipmen attending the academy to receive training in aviation. In 1962, the Severn River Naval Command was disbanded, and the base transferred to the commanding officer of Naval Station Annapolis. NSAA was officially established as its own facility in 2006 and continues to provide training to midshipmen in underway seamanship and sail training, small arms weapons familiarization, and navigation and engineering professional development. The primary natural area of NSAA is Greenbury Point, a 231-acre peninsula at the mouth of the Severn River. The peninsula has a variety of habitats including wooded coves, shallow wetland ponds, forests, scrub/shrub areas, and open fields of various disturbance levels. Reforestation efforts have been carried out in some areas in an attempt to reintroduce native plant species to the peninsula, as well as to conserve habitat for various wildlife species and to control the spread of invasive species.

Located in the mid-Atlantic region, NSAA lies between the northern and southeastern United States with a native species composition drawn from each of those regions. The mid-Atlantic region typically consists of the states of Delaware, Maryland, New Jersey, Pennsylvania, Virginia, and West Virginia, and also the District of Columbia. The mid-Atlantic region is home to a variety of bee species and butterfly species, along with a host of other beetles, flies, wasps, ants, and other insects that contribute to pollination services of plant communities. Mitchell’s satyr (*Neonympha mitchelli*) and the rusty patched bumble bee (*Bombus affinis*) are the only pollinators protected by federal regulations, but other species of concern are listed for state protections (NatureServe 2019). Other species, such as the monarch butterfly (*Danaus plexippus*), regal fritillary (*Speyeria idalia*), and the yellow-banded bumble bee (*Bombus terricola*), are under consideration for protection in the future, once ongoing research into their population status has been completed (NatureServe 2019).

1.1 Goals and Objectives

The overall goal of the project was to conduct a survey of rare, threatened, and endangered (RT&E) pollinator insect species at NSAA. There were three specific objectives of the project:

- Assess and document the presence of the monarch butterfly (*Danaus plexippus*).
- Assess and document the presence of bees (common and RT&E species) and other lepidopterans.
- Assess and document the presence of other pollinators, including but not limited to, beetles, flies, and odonates.

Figure 1-1. Geographic Location

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2 METHODS

In order to create a comprehensive pollinator survey, investigators combine passive trapping (i.e. cups or pans) and active expert trapping (nets) in suitable habitat (Cane et al. 2000; Roulston et al. 2007; Wilson et al. 2008; Droege et al. 2016).

Passive trapping is an effective technique because it allows the collection of a relatively unbiased sample of insect pollinators within a specific habitat, since there is no human collection bias (Roulston et al. 2007). Because passive traps do not require constant monitoring after they are deployed, investigators are free to perform other tasks, such as setting traps at other sites, active netting, or collecting habitat data (Wilson et al. 2008).

In order for passive pan traps to be effective, they must be placed in open habitat, preferably with full exposure to sunlight (Droege et al. 2016). Traps can be set even if little to no floral resources are available in the immediate area, as long as the traps are visible to passing insects. The habitats that best meet these criteria are early successional grasslands, shrubby areas, and open woodlands, particularly if the vegetation is not too dense to obscure the visibility of the traps. Trails and forest openings are also suitable, but often carry a higher risk of interference and disturbance from vertebrates (Droege et al. 2016).

Active survey methods allow for targeted collection and typically collect insect pollinators that are unlikely to be captured by passive traps due to physiological or behavioral factors. Hand netting is the most effective technique for collecting and identifying butterflies and larger bees and can allow for release of the captured individual once identified. While active surveys are not as restrictive in terms of suitable habitat as passive surveys, open grasslands and forest openings are still the preferred habitats to search for insect pollinators. These habitats tend to support a diversity of flowering plants that have floral and pollen available for insect pollinators (Wratten et al. 2012; Kammerer et al. 2016). In addition, bare soil, which is often more common in open habitat, is used as nesting areas by bees and puddling spots for butterflies. Searches within these habitats allow for the collection of species that may not often visit or be captured near flowers (Droege et al. 2016).

2.1 Survey Site Allocation

2.1.1 Passive Site Selection

Potential sites/habitats for passive arrays were selected from aerial imagery and available geographic information system (GIS) data (e.g. habitat and plant community coverages). After the preliminary sites were identified, each was verified with installation personnel to determine if there were access and/or safety issues. If the site was deemed safe to access, then it was visited by the survey team to assess the suitability of the site for passive surveys. Factors for site selection included available floral and nectar resources, habitat type and quality, and disturbance level. At NSAA, a variety of sites were chosen in order to maximize the diversity of pollinators, and every suitable habitat that was accessible was surveyed. Passive survey locations were established at Site 001, Site 002, Site 003, and Site 004 (Figure 2-1).

2.1.2 Active Site Selection

The zone surrounding each passive survey site was also subjected to active surveys in order to collect species that may not be sampled by the passive arrays and to obtain a better measure of diversity of the site. Locations not selected for passive sampling were evaluated for suitability of active sampling. If the area represented a novel habitat or had significant floral resources, then active surveys were performed in that zone. Survey zones NSAA Zone 001 through NSAA Zone 004 are the areas surrounding Sites 001-004, whereas NSAA Zone 005 and NSAA Zone 006 represent additional habitat zones where only active surveys were performed (Figure 2-1).

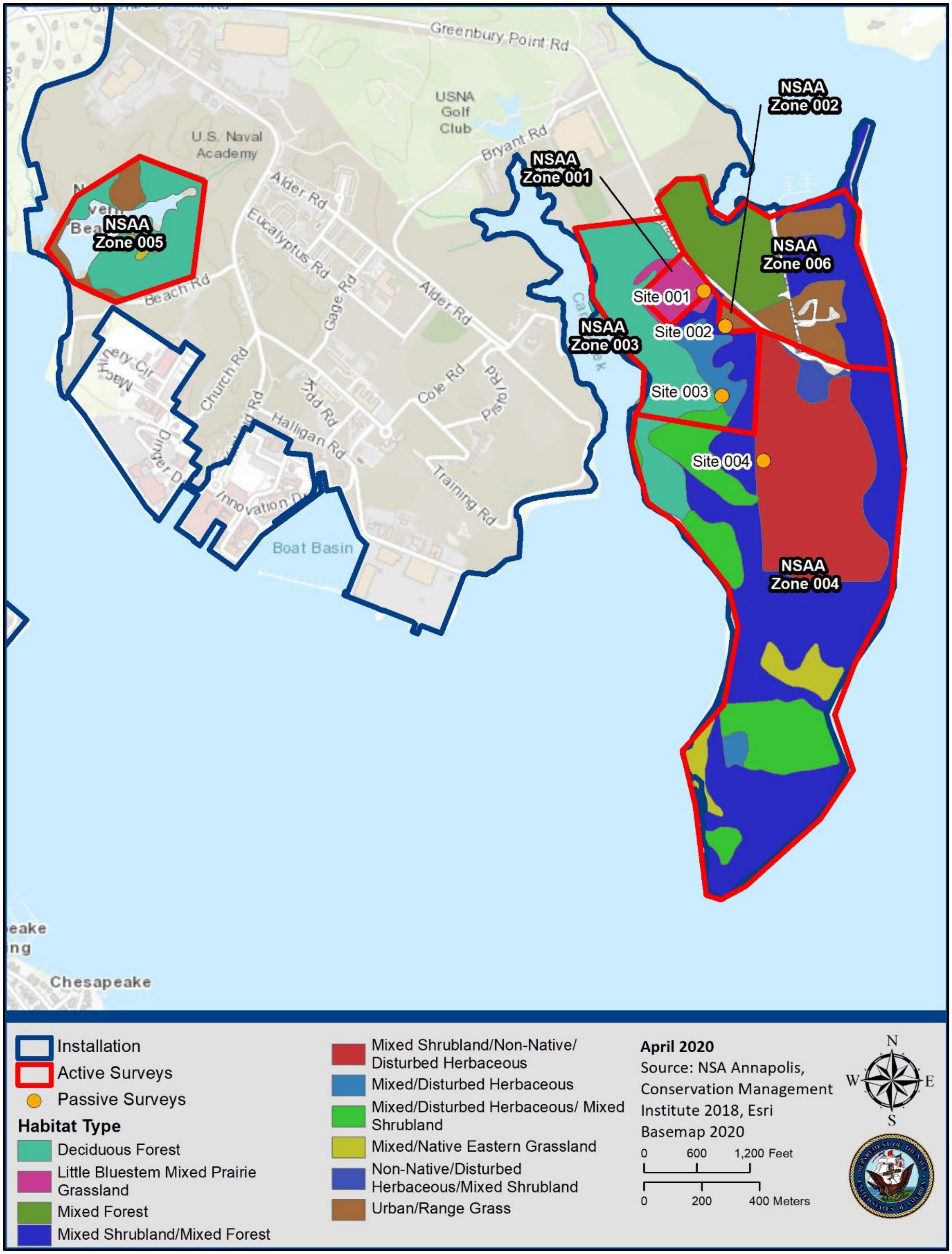

Figure 2-1. Passive and Active Survey Locations at Naval Support Activity Annapolis

2.2 Field Survey Methods

2.2.1 Passive Pollinator Survey

The passive survey arrays at NSAA were linear, with a total length of 50 meters. The cups were placed on the ground or on stakes a minimum of 5 meters apart to reduce competition between cups and increase visibility to passing pollinators. Cups were colored white, yellow, or blue, painted with fluorescent paint, and were alternated so that no traps of the same color were adjacent. The colors of the cups mimic the natural coloration of flowers to insect eyes and the alternation of trap colors also reduces the amount of competition between the traps. The cups were filled with a mixture of 50 percent propylene glycol and 50 percent water with a small amount of dish soap. The mixture served as both the trapping fluid, which killed any insects that fell into the cup, and as a preservative to protect the insects until they were collected. The glycol/water/soap mix allowed the traps to remain active over a longer period without maintenance compared to the standard soap/water mix (Droege et al. 2016).

At the beginning of each survey period, a datasheet was completed for each array deployed. The trap datasheet documented the identification number of each array and the observers responsible for deploying the array. The date and time of deployment was noted, and atmospheric data was collected once all traps were filled with the glycol mixture. Atmospheric data included the current temperature (in degrees Celsius), the wind speed (in miles per hour), and the cloud cover (in percent of sky covered by clouds). At the end of each survey period, all traps were emptied, and any insects found in the trap were collected. The number of bees and butterflies found in each color trap was recorded, and the trap liquid was filtered to collect any insects in the trap. The insects were placed in a labeled Whirl-Pak and filled with ethanol for preservation. After the traps were collected, the stop time and date were recorded, as well as the atmospheric data that was collected at the start of the trapping period (i.e. temperature, wind speed, and cloud cover).

2.2.2 Active Pollinator Survey

During the active survey phase at NSAA, observers attempted to capture any pollinator species they encountered in the appropriate habitats using aerial hand nets. Throughout the expert searches, each observer kept track of pollinator species captured and/or encountered. All bees that were captured were taken to the lab, since identification for many bees is not possible under field conditions. Butterflies were identified to species level in the field, when possible, and released. However, at least one voucher specimen for each butterfly species was collected if possible. Other non-bee, non-butterfly insect species encountered on flowering plants were collected for identification in the lab. At the end of the survey, all non-butterfly insects were placed in a labeled Whirl-Pak filled with ethanol for preservation until pinning. Butterflies were placed in individual glassine envelopes and labelled with the site and date collected.

2.2.3 Laboratory Methods

After returning from the field sites, all collected insects were prepared for identification and storage. Insects stored in ethanol were washed and dried before pinning. Once dried, all insects were pinned. Pinning, the process of mounting specimens on a stainless-steel pin, is primarily used to prepare delicate insect specimens for identification, long-term storage, and is the standard method of preservation. All butterflies collected as vouchers from the active survey were pinned and spread after undergoing a 24-hour quarantine period in a freezer. The quarantine period was necessary to ensure that the specimens were truly dead and free of any parasites or mold. Once each insect was pinned, it received a preliminary label with the date and site ID. All bees were identified to genus level and subsequently to species level, if possible, and given an identification tag. After final identification, the preliminary labels were replaced with a final tag displaying the date, locality, and collector information. Each collected insect was also given an identification number that allows for individuals to be tracked and easily located in the pinned collection and database.

2.2.4 Floral Resources and Habitat

Our objective for the habitat assessment at NSAA was to identify species comprising pollinator habitat and providing floral resources (nectar and pollen). Within each active and passive survey area identified above, investigators systematically surveyed the habitat and identified flowering forbs and other plants potentially providing floral resources for pollinators. Each species identified was assigned a relative abundance for each habitat in which they occurred (Table 2-1).

Table 2-1. Criteria and Codes Used to Describe the Relative Abundance of Forb Floral Resources at Naval Support Activity Annapolis

Abundance Code	Description
1 (Rare)	A single occurrence, or if more than one, just a few individuals with very low vegetative cover (<1%) within the habitat being surveyed.
2 (Isolated)	Few occurrences with low vegetative cover (< 5%) throughout the habitat being surveyed.
3 (Scattered)	Occurring sporadically throughout the habitat being surveyed, with moderate vegetative cover (>5%).
4 (Common)	Frequent and well distributed throughout the habitat being surveyed, with vegetative cover up to 25%.
5 (Abundant)	Dominant or co-dominant forbs throughout the habitat, with relatively high vegetative cover (>25%).

In addition to forbs and woody shrubs, flowering trees providing floral resources were identified, and their relative abundance assessed, when appropriate. At the conclusion of the fieldwork, vegetative communities occurring within each surveyed habitat were mapped in a GIS and named based upon their dominant species.

2.2.5 Monarch and Milkweed Survey

During the survey efforts at NSAA, monarch butterflies (*Danaus plexippus*) and their preferred host plants, milkweed species (genus *Asclepias*), received special attention. Each time a milkweed plant was encountered, either during the active survey phase or floral resource assessment, it was identified to species level and examined to determine the presence of any of the non-adult life stages (egg, caterpillar, or pupa) of monarch butterflies[1]. The life stage of all individuals detected was recorded along with the survey site location where the plant was found. Adult monarchs were documented in the same manner as other butterflies and if possible, their gender determined. A few adult individuals captured at NSAA during the spring and summer were kept as voucher specimens, but the remaining adults were released. No adult monarchs were kept from the fall survey, in order to avoid any adverse effects on the migrating, overwintering population.

[1] Originally the plan was to examine all milkweed plants encountered. However, because of the thousands of milkweed plants occurring at NSAA, particularly on Greenbury Point, it simply was not possible to examine every individual plant. Thus, we randomly examined individual plants throughout the study during the course of the active survey.

3 RESULTS

In 2019, active and passive pollinator surveys were conducted at NSAA on three separate occasions, 3–7 June, 22–26 July, and 30 September–3 October, to capture the diversity of pollinators and floral resources through the active flying season. Four sites were selected for passive surveys. Three of the four sites were visited and surveyed during all three visits. The remaining site (Site 002) was a small demonstration transect that was placed for educational purposes adjacent to the Greenbury Point Nature Center; this site was not productive.

NSAA Zone 001 (containing Site 001) was a planted native warm season grassland near the Greenbury Point Nature Center. It was actively and passively surveyed during all three visits due to the presence of floral resources during the entire field season. NSAA Zone 002 (containing Site 002) was located directly behind the nature center. Passive survey Site 002 was only surveyed during the spring visit; this demonstration transect was meant primarily for educational purposes. NSAA Zone 003 (containing Site 003) was a field along the Bobwhite Trail behind the nature center. It was predominately milkweed but had floral resources available during all three visits. NSAA Zone 004 (containing Site 004) was a large grassy field out on the peninsula that had been cleared of woody vegetation. Zones 001, 002, 003, and 004 and Sites 001, 003, and 004 were surveyed during all visits, while Site 002 and NSAA Zone 006 (a small forested area and trails near the marine and nature center) were only sampled during the spring and fall survey periods. NSAA Zone 005 (a campground area) was only sampled during the fall survey period due to training activities during the other survey periods.

3.1 Habitat and Floral Resources

Based upon field visits, aerial photo interpretation, and ancillary GIS data, 10 potential pollinator habitat types covering a total of 269.53 acres were identified (Table 3-1).

Table 3-1. Pollinator Habitat and Associated Acreages on Naval Support Activity Annapolis

Habitat	Acreage
Mixed Shrubland/Mixed Forest	90.06
Deciduous Forest	46.83
Mixed Shrubland/Non-Native Disturbed Herbaceous	41.81
Mixed Disturbed Herbaceous/Mixed Shrubland	26.28
Urban/Range Grass	19.98
Mixed Forest	16.85
Mixed Native Eastern Grassland	12.70

Habitat	Acreage
Little Bluestem Mixed Prairie Grassland	6.41
Mixed/Disturbed Herbaceous	6.25
Non-Native Disturbed Herbaceous/Mixed Shrubland	2.35
Total	269.53

3.1.1 Mixed Shrubland

The mixed shrubland community/habitat is not dominated by a single species. Sweetgum (*Liquidambar styraciflua*), loblolly pine (*Pinus taeda*), various oaks (*Quercus* spp.), tulip poplar (*Liriodendron tulipifera*) and sassafras (*Sassafras albidum*) are all common constituents of this community/habitat type, though none will dominate a particular site. This community shows evidence of disturbance from mowing and/or fire. Herbaceous ground cover is greater than 75 percent, with a composition similar to mixed eastern grassland, though some non-native species such as the legume bicolor lespedeza (*Lespedeza bicolor*) are present.

3.1.2 Mixed Forest

Mixed forest is defined as having greater than 60 percent aerial vegetative cover above 6 meters and a mixture of cold deciduous (less than 80 percent) and conifer (less than 80 percent) cover in the canopy. These forests typically exist in the transition zone between coniferous and deciduous forest types, as the latter stages of old field succession and/or experiencing a moderate level of disturbance from silvicultural activities.

3.1.3 Deciduous Forest

Deciduous forests were defined as vegetative communities/habitat with greater than 60 percent aerial vegetative cover above 6 meters and 80 percent or more cold deciduous cover in the canopy.

3.1.4 Non-native Disturbed Herbaceous Habitat

Various non-native species such as Korean lespedeza (*Lespedeza cuneata*) and spotted knapweed (*Centaurea maculosa*) dominate this herbaceous forb community. In addition, non-native tall fescue (*Festuca arundinacea*) and other cool season grasses are the dominant grasses. Disturbance is relatively constant (primarily mowing) in this community type, and many of these sites are former lawns, hayfields, or athletic fields.

3.1.5 Mixed Disturbed Herbaceous

This herbaceous community/habitat is normally maintained by mowing or other physical means, though prescribed fire is sometimes utilized, and is dominated by a combination of perennials and annual herbs and forbs. Significant amounts of bare ground are present at some sites. The species composition in this community is similar to the mixed native eastern grassland (below) but is differentiated by the relative dominance of forbs instead of graminoids.

3.1.6 Urban/Range Grass Habitat

This habitat can be found along major roadways, in maintained areas, and on some ranges. This habitat is mowed on a regular schedule, though not as often as a household lawn.

3.1.7 Mixed Native Eastern Grassland

The mixed native eastern grassland, as the name suggests, is the most variable of the herbaceous communities/habitat identified. This type is typically maintained by either physical disturbance (mowing) and/or fire. Bare ground is common. Native perennial grasses are present but compose less than 40 percent of vegetative cover. Common associates that co-dominate this community/habitat include little bluestem (*Schizachyrium scoparium*), broomsedge (*Andropogon virginicus*), *Panicum* spp., and poverty grass (*Danthonia spicata*). Winged sumac and other shrubs are common but low cover constituents. This community/habitat type is very similar to the mixed shrubland described below. The two communities represent different seral stages and are often intermixed.

3.1.8 Little Bluestem Mixed Prairie Grassland

This mixed prairie grassland community is a mixture of little bluestem (*Schizachyrium scoparium*) and other warm season grasses. The aerial vegetative cover of little bluestem ranges from 25–45% in this grassland and is co-dominant with other herbaceous species. The mixture of other warm season grasses is composed of various panic grasses (*Panicum* and *Dicanthelium* spp.) and Indian grass (*Sorghastrum nutans*), among others. Other associates of note include various native bush clovers (*Cuscuta* spp.), *Rubus* spp., *Solidago* spp., and occasional shrubs.

3.1.9 Floral Resources

Common milkweed (*Asclepias syriaca*) was widespread and abundant throughout the majority of the areas surveyed during both the late spring and early summer survey periods. Common milkweed formed extensive “colonies” in many locations on Greenbury Point where it was the dominant species in “mixed native disturbed herbaceous" habitat. The spring survey period had the highest diversity of floral resources. In addition to common milkweed, butterfly milkweed (*Asclepias tuberosa*), hemp dogbane (*Apocynum cannabinum*), black-eyed Susan (*Rudbeckia hirta*), and Canada thistle (*Cirsium arvense*) were all widespread and relatively common among the habitats surveyed on Greenbury Point (Appendix A). During the summer survey period, common milkweed was still flowering and providing floral resources along with scattered black-eyed Susan and various species of thistle. (*Cirsium* spp.) However, by the early fall survey period, the floral resources were limited to primarily goldenrod (*Solidago* spp.) and species of thistle, due in part to the abnormally hot and dry weather in the late summer and early fall.

3.2 Lepidoptera

3.2.1 Monarch Butterfly

Monarch butterflies were abundant throughout all survey periods in 2019, and all life stages were detected. During the spring and early fall survey periods, greater than 50 adults were observed each day (Table 3-2). Unsurprisingly, monarch butterflies were concentrated in areas of high milkweed density, particularly on Greenbury Point (Figure 3-1). Investigators took great care to not double count adults during the active survey, thus the estimates in Table 3-2 actually represent a conservative estimate of adult numbers.

Figure 3-1. Dense Common Milkweed Colony on Greenbury Point with a Photo of Female Monarch Taken at That Location at Naval Support Activity Annapolis

Table 3-2. Gender and Life Stage of Monarch Butterflies Positively Identified

Zone	Spring				Summer				Fall				
	M	F	U	Larvae	M	F	U	Larvae	M	F	U	Larvae	Total
NSAA Zone 001	0	0	2	0	0	0	1	0	0	0	1	0	4
NSAA Zone 002	1	0	0	0	0	0	0	0	0	0	0	0	1
NSAA Zone 003	20	27	10	2	15	17	0	3	7	9	4	0	114
NSAA Zone 004	23	28	12	3	9	19	0	3	99	120	0	0	316
NSAA Zone 005									0	0	8	0	8
NSAA Zone 006									0	0	0	0	0

Key: M=male, F=Female, U=unknown gender, Larvae=present if any of the five instars were observed.
Note: See Appendix B for photographs comparing male and female monarch butterflies. Other Butterflies

3.2.2 Other Lepidopterans

Investigators documented 37 species of butterflies over the three survey periods in 2019 (Table 3-3). Butterfly diversity was highest during the spring and fall surveys (Figure 3-2) The most common species were the pearl crescent *(Phyciodes tharos)*, eastern tailed-blue *(Cupido comyntas)*, and the orange sulphur (*Colias eurytheme*). Five of the six major butterfly families, Papilionidae, Lycaenidae, Pieridae, Nymphalidae, and Hesperiidae, were all well represented. The remaining family, Riodinidae, is not typically found in the region, so its absence was unsurprising. There were no RT&E butterfly species detected on the installation. The only species of interest from a conservation perspective was the monarch butterfly, which is being considered for listing as an Endangered Species. At the moment, this species has no formal protection.

Table 3-3. Abundance Rankings for Butterfly Species Found on Naval Support Activity Annapolis

Species	Ranking
American lady (*Vanessa virginiensis*)	U
Black swallowtail (*Papilio polyxenes*)	R
Cabbage white (*Pieris rapae*)	C
Cloudless sulfur (*Phoebis sennae*)	R
Common buckeye (*Junonia coenia*)	C
Common checkered-skipper (*Pyrgus communis*)	U
Clouded skipper (*Lerema accius*)	U
Dun skipper (*Euphyes vestris*)	U
Eastern comma (*Polygonia comma*)	R
Eastern tailed-blue (*Cupido comyntas*)	C
Eastern tiger swallowtail (*Papilio glaucus*)	C
Fiery skipper (*Hylephila phyleus*)	C
Gray hairstreak (*Strymon melinus*)	R

Species	Ranking
Least skipper (*Ancyloxypha numitor*)	R
Little glassywing (*Pompeius verna*)	U
Little wood-satyr (*Megisto cymela*)	U
Long-tailed skipper (*Urbanus proteus*)	R
Monarch (*Danaus plexippus*)	C
Northern cloudywing (*Thorybes pylades*)	R
Northern pearly-eye (*Enodia anthedon*)	R
Orange sulfur (*Colias eurytheme*)	C
Painted lady (*Vanessa cardui*)	R
Pearl crescent (*Phyciodes tharos*)	C
Pecks skipper (*Polites peckius*)	U
Pipevine swallowtail (*Battus philenor*)	R
Question mark (*Polygonia interrogationis*)	U
Red admiral (*Vanessa atalanta*)	U
Red-banded hairstreak (*Calycopis cecrops*)	R
Red-spotted admiral (*Limenitis arthemis*)	R
Sachem (*Atalopedes campestris*)	C
Silver-spotted skipper (*Epargyreus clarus*)	C
Sleepy orange (*Abaeis nicippe*)	C
Spicebush swallowtail (*Papilio troilus*)	C
Summer azure (*Celastrina neglecta*)	U
Variegated fritillary (*Euptoieta claudia*)	U
Viceroy (*Limenitis archippus*)	R
Zabulon skipper (*Poanes zabulon*)	C

Key: R=Rare (1-3 individuals), U=Uncommon (4-7 individuals), C=Common (7+ individuals), and O (Occasional stray)

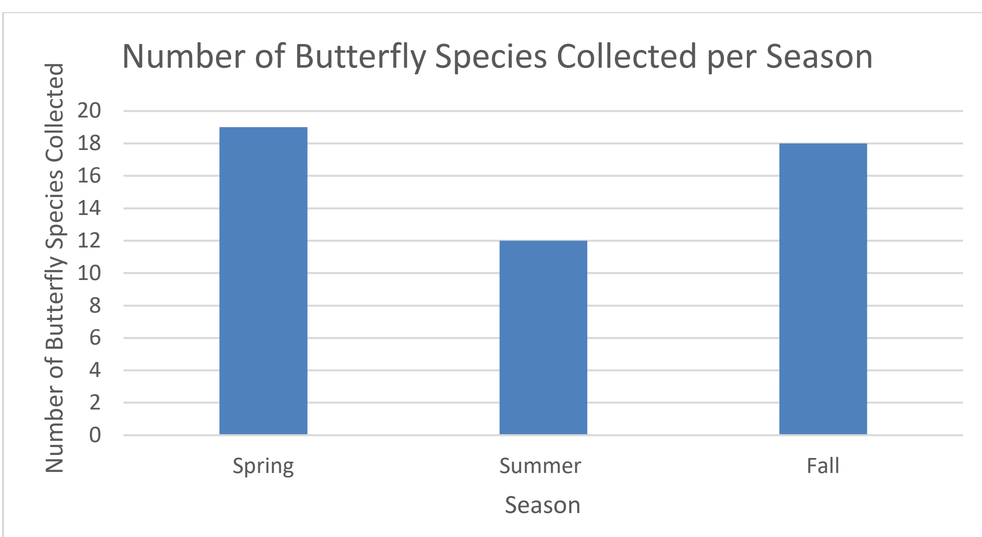

Figure 3-2. Number of Butterfly Species Collected per Season

3.3 Hymenoptera

Investigators documented 19 species of bees representing four families during the 2019 survey at NSAA (Table 3-4). No RT&E bee species were detected in any habitat or during any survey period at NSAA. Members of the genus *Bombus*, the bumble bees, and *Ceratina*, the small carpenter bees, were the most abundant at NSAA, followed by *Lasioglossum*, a group of small metallic sweat bees (Figure 3-3).

Table 3-4. Familiy, Genus, Species, and Common Name of Bees Identified at Naval Support Activity Annapolis in 2019

Family	Genus	Species	Common Name	Number
Andrenidae	*Andrena*	spp.	A miner bee	5
Apidae	*Apis*	*melllifera*	European honey bee	2
	Bombus	*bimaculatus*	Two-spotted bumble bee	1
	Bombus	*griseocollis*	Brown-belted bumble bee	5
	Bombus	*impatiens*	Common eastern bumble bee	2
	Bombus	*pensylvanicus*	American bumble bee	3
	Bombus	spp.	A bumble bee	4
	Ceratina	*calcarata*	Spurred ceratina	3
	Ceratina	*calcarata/mikmaqi*	Spurred/Mikmaq ceratina	1
	Ceratina	*mikmaqi*	Mikmaq ceratina	11
	Peponapis	*pruinosa*	Squash bee	1
	Ptilothrix	*bombiformis*	Hibiscus bee	3
	Xylocopa	*virginica*	Eastern carpenter bee	8
Halictidae	*Agapostemon*	*virescens*	Bicolored striped sweat bee	7
	Augochlora	*pura*	Pure green sweat bee	4
	Augochlorella	*aurata*	Golden sweat bee	8
	Halictus	*ligatus/poeyi*	Ligated gregarious/Poey's sweat bee	1
	Lasioglossum	spp.	A metallic sweat bee	12
Megachilidae	*Coelioxys*	*sayi*	Say's cuckoo leafcutter bee	1
	Megachile	spp.	A leafcutter bee	3

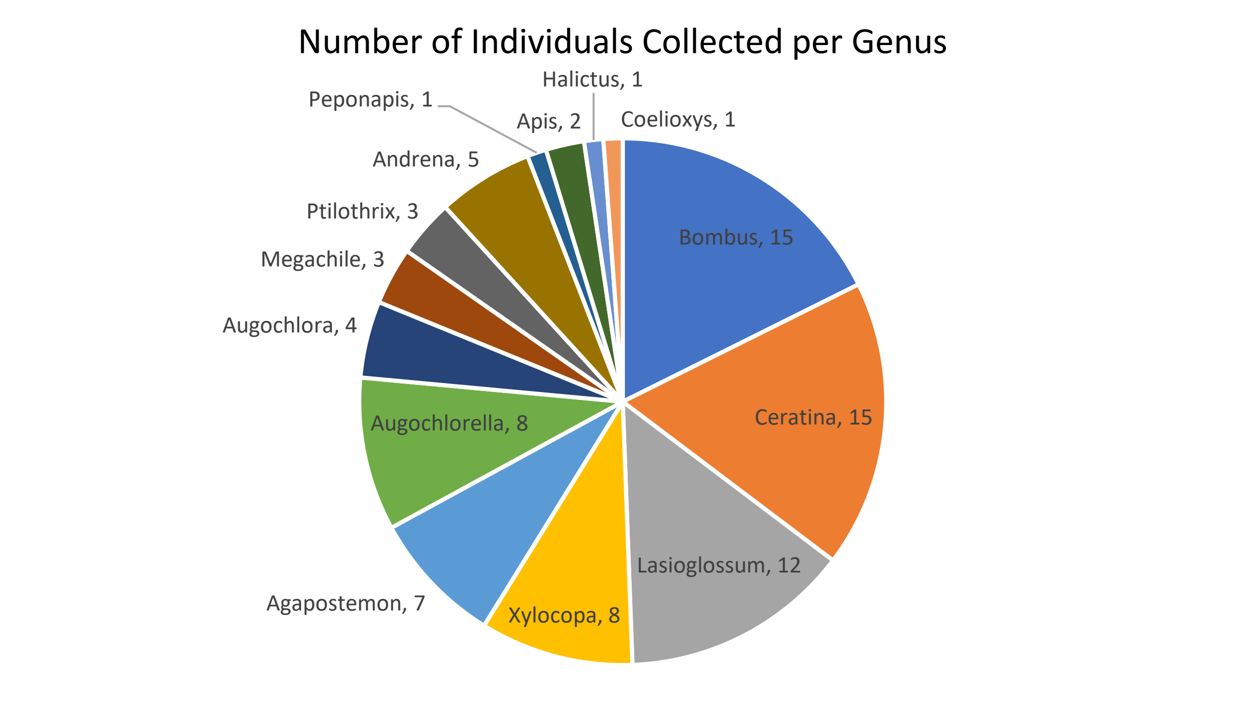

Figure 3-3. Number of Individuals Collected in Each Bee Genus Across All Sites on Naval Support Activity Annapolis

Overall, the diversity and abundance of bees peaked during the summer, and abundance decreased as the seasons progressed into the fall (Figure 3-4). A least one individual from most genera was captured during multiple seasons. The exceptions were *Andrena* and *Peponapis*, which were only detected during the spring survey period, and *Agapostemon*, which was only detected during the summer survey period. *Andrena* often emerge in early spring to take advantage of the early flowering species when many other bees are not active. *Peponapis* is not a seasonal specialist, but relies on squash and other cucurbits, and is active as long as those plants are in blossom. *Agapostemon* species are active during most of the year, so it is unclear why it was only collected during the summer.

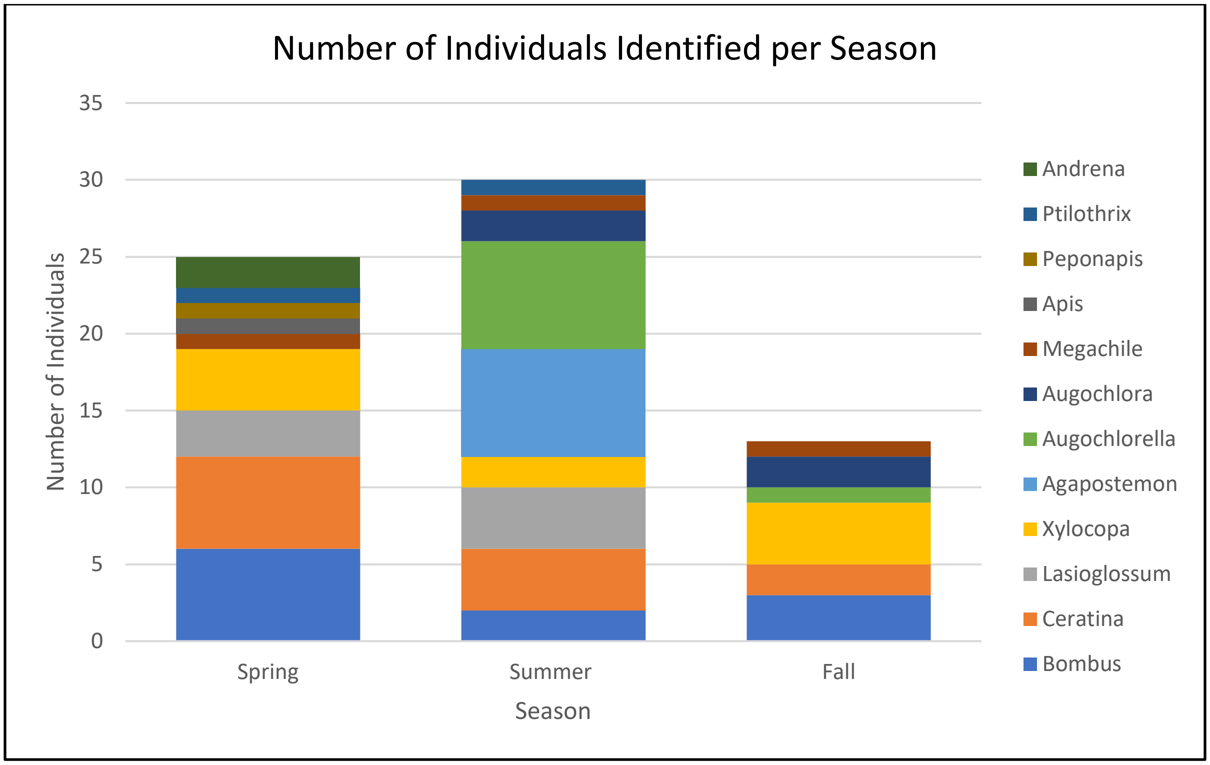

Figure 3-4. Number of Individuals Within Each Bee Genera Identified Across All Sites During All Three Survey Seasons in 2019 at Naval Support Activity Annapolis

In the fall visit to NSAA Zone 005 and NSAA Zone 006, investigators captured individuals of *Apis*, *Coelioxys*, *Andrena*, and *Ceratina* from NSAA Zone 006, but no bee species from NSAA Zone 005 (Figure 3-5). *Coelioxys* is a parasitic genus that targets members of the family Megachilidae, so it is safe to assume that at least one of those genera was in the area of NSAA Zone 006 as well. NSAA Zone 001 (Site 001) and NSAA Zone 004 (Site 004) had the greatest bee diversity over the entire survey period, with NSAA Zone 001 (Site 001) having the highest number of individuals collected. *Coelioxys* and *Peponapis* were the only genera that were unique to a site, with *Coelioxys* only collected in NSAA Zone 006 and *Peponapis* at NSAA Zone 003 (Site 003). *Ceratina* was the only genus that was found across all sites/zones, followed by *Bombus*, which was found at all sites/zones except NSAA Zone 006. Though only a few *Apis* individuals were collected, individuals belonging to this genus were found at all sites/zones during the course of the survey. Because *Apis* (i.e. European honey bee) is not a native pollinator, individuals observed may have belonged to commercial hives or feral colonies. Collection of individuals was thus limited.

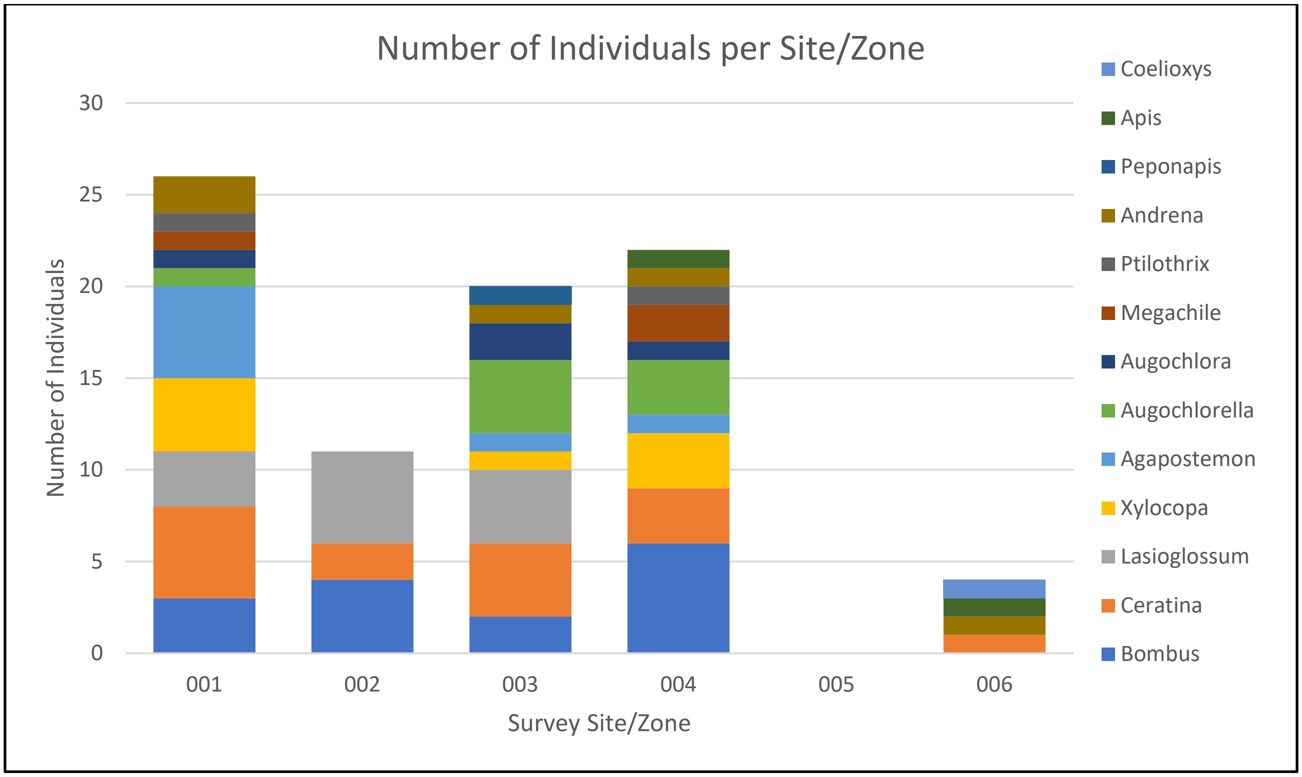

Figure 3-5. Number of Individuals Within Each Bee Genera Captured at Each Passive Survey Site/Zone During All Three Survey Seasons in 2019 at Naval Support Activity Annapolis

4 DISCUSSION

The most striking feature investigators recognized immediately upon beginning field work was the abundance of common milkweed. Land management practices employed by NSAA (i.e. the clearing of non-native woody species) have benefitted common milkweed and thus not only monarch butterflies, which rely on milkweed to complete their life cycle, but other pollinator species who use the abundant floral resources.

4.1 Lepidoptera

The abundance of monarch individuals (Table 3-2) is due to the abundance of milkweed throughout Greenbury Point. Breeding adults were noted during both the spring and summer survey periods, so it is likely that the area is serving as a high-quality breeding ground for local populations, as well as for monarchs during the spring and fall migrations.

In addition to monarch butterflies, two other species of butterfly are dependent on milkweed and are occasionally found in the mid-Atlantic region. The queen butterfly (*Danaus gilippus*) and soldier butterfly (*Danaus eresimus*) are predominantly tropical and subtropical species, but occasionally appear as far north as New York (Brock et al. 2006), though neither was detected during the 2019 survey.

A majority of the other common butterfly species (Table 3-3) are grassland species that are tolerant of, and in some cases dependent upon, some form of ecological disturbance to maintain desired habitat conditions. The exceptions are the eastern tiger swallowtail (*Papilio glaucus*) and the spicebush swallowtail (*Papilio troilus*). Each of these species relies upon woody plant species as both food sources and larval hosts and are more commonly found in woodlands and forest openings.

Other notable butterflies detected include the eastern comma, question mark, northern pearly-eye, and the long-tailed skipper. The comma and the question mark (genus *Polygonia*) are referred to as “sap sippers,” since they rarely take floral from flowers. Instead, individuals obtain their dietary sugar from tree sap. The pearly-eye butterfly is common in deciduous forests, especially in clearings along rocky streams. The long-tailed skipper is the only longtail skipper species to reach the northern portions of the country and prefers legumes as food plants and larval hosts.

Butterfly biodiversity was highest during the spring and fall surveys. While some species will fly throughout the active flight season (usually March through October), many species are limited to smaller window(s) during that time (Brock et al. 2006). For example, the falcate orangetip (*Anthocharis midea*) flies only during the early spring, while Leonard's skipper (*Hesperia leonardus*) won't appear until the late summer and early fall. Even the species that have longer flight windows will appear to have dips in occurrences while the larvae grow to maturity.

4.2 Hymenoptera

While butterflies are consistently identified to the species level, the bees were identified to species if possible. If not, the bees were identified to the genus level. This is mainly due to the fact that the taxonomy and phylogenetics of Apoidea are still not fully understood. Species are being added, dissolved, or moved between groups as we learn more about their relationships and ecology. Furthermore, positive species identification of certain groups requires genetic analysis and sequencing, which was not included in the scope of work for this project. Other groups that are more taxonomically stable and well characterized have been identified to species. For the most part, members of a single genus are ecologically similar, performing the same services, consuming the same resources, and utilizing the same habitats. Though specialist species do exist in most genera, they are few and typically only common in certain small areas.

Most of the genera encountered were broad generalists, but a few genera of specialists were captured. One individual was collected that belonged to *Peponapis*, a genus that specializes on squash and other cucurbits. Several individuals were captured belonging to *Ptilothrix*, a genus that specializes on members of the plant genus *Hibiscus*. In addition, a member of *Coelioxys*, a parasitic genus that mainly targets members of Megachilidae was also captured.

Bee diversity generally declined from summer through fall and was most likely due to reduced floral resources and plant phenology. Floral resources tend to be most abundant in the spring and summer months and decline thereafter. The quality of floral resources may also play a role in the trend, with higher quality floral resources being available earlier in the year and decreasing in quality as the year continues.

Much like the trend illustrated in Figure 3-3, the changes in genera presence are likely related to changes in floral resources but were also probably influenced by the biology of the bees themselves. *Andrena*, for example, is predominantly a spring genus and is a specialist on early flowering plants like willow (genus *Salix*) (Michener 2007). They typically disappear by the end of the summer, with the exception of a few species that appear in the fall. *Nomada*, a parasitic genus, uses *Andrena* and other members of Andrenidae as hosts (Michener 2007). Once its potential hosts disappear, *Nomada* species often become scarce as well. *Coelioxys* shares a similar parasitic relationship to members of *Megachile* and other genera belonging to Megachilidae (Michener 2007).

Members of Andrenidae, represented by the genus *Andrena*, are often referred to as mining bees because of their ground nesting behavior. Members of this genus dig burrows ranging from six inches to a few feet below ground level (Michener 2007). The genus represents a variety of floral specialists, from broad generalists to species that only visit flowers of certain genera. *Andrena* are often some of the first bees to emerge in the spring (Wilson and Carril 2016).

The family Apidae contains some of the most well-known bee groups, including *Bombus*, the bumblebees, *Xylocopa*, the carpenter bees, and the ubiquitous European honeybee (*Apis mellifera*). Members of this family can be broad specialists, visiting whatever floral resources are available, specialists on certain plant genera, or not visit plants at all (Michener 2007). *Bombus*, *Xylocopa*, and *Apis* are all broad generalists and utilize a variety of floral resources (Wilson and Carril 2016).

Bees belonging to the family Halictidae are collectively called sweat bees for their curious behavior of drinking sweat from humans. The members of this family vary broadly in plant preference, ranging from visiting only a handful of species of plant to over 60 species (Michener 2007). The genera *Augochlora* and *Augochlorella* belong to the Augochlorinae subfamily, are characterized by their metallic green coloration, and are broad generalists (Wilson and Carril 2016). *Halictus* displays a broad range of sociality based upon the climate, elevation, and other environmental variables (Michener 2007). Unlike other genera, *Halictus* contains no known specialist species (Wilson and Carril 2016). *Lasioglossum* represents the largest genus in this family. The genus has become problematic for scientists, since no specific morphological feature can be identified to unify the group. Thus, most species identifications must rely on genetic sequencing, which was not included in the scope of work for this project (Gonzalez et al. 2013). A majority of the genus are broad generalists, with only a small handful of specialists (Wilson and Carril 2016).

Bees in the family Megachilidae are broadly known as cutter bees. They are named for the enlarged jaws that allow them to chew into wood and cut pieces of leaf and petals to line their nests. The genus Megachile, leafcutter bees, contains some of the most common members of the family. Many females have special pollen-collecting hairs on the undersides of their abdomens to collect pollen from a variety of plants (Michener 2007). Most members of the genus are broad generalists, but a few specialize on a single genus or species of plant (Wilson and Carril 2016). *Hoplitis* is a member of Megachilidae. Feeding habits of species within this genus range from broad generalist to foraging on a single plant family.

Specialist species exist that rely on deervetches (*Acmispon* and *Hosakia*) and beardtongues (*Penstemon*) (Michener 2007). The bees in this genus are solitary ground nesters and will take advantage of cracks in rocks, holes in twigs, and even abandoned burrows from other insects to build their nests. They get their common name, mason bee, from the behavior of gathering small pebbles and cementing them together with mud or resin to separate nest cells (Michener 2007).

In addition to target pollinator groups, investigators also noted the presence of other insects that interacted with pollinators. Large numbers of dragonfly species, which are predators of pollinators, were observed during the spring and summer survey period, which was expected due to the location of the survey sites. In addition to milkweed butterflies, milkweed leaf beetles (genus *Labidomera*), milkweed bugs (genus *Oncopeltus*), and milkweed longhorn beetles (genus *Tetraopes*) also feed on milkweed species (Pearse et al. 2019). Each species primarily feeds on the stalk and other vegetative portions of the plant in order to sequester the toxins the plant produces (Pearse et al. 2019). They provide little to no pollination services and may harm monarch eggs and caterpillars they encounter on the plants as they feed.

Investigators noted a large number of non-native/invasive Chinese and European mantids (i.e. praying mantis) in the fall, particularly around the few remaining floral resources. Given the large number of monarch wing sets observed, investigators believe that the mantid are likely ambushing butterflies as they stop to feed from the flowers on their fall migration.

5 RECOMMENDATIONS

Recent studies have indicated that monarch reproduction may benefit from periodic mowing of the milkweed patches, provided that the mowing occurs prior to their peak breeding period (Alcock et al. 2016, Knight et al. 2019). Monarch females prefer to lay eggs on young or regenerating milkweed stalks compared to tall, mature plants and will lay more individual eggs on these young stalks compared to tall stalks (Alcock et al. 2019). Mowing the patches of milkweed once just (one to three weeks) before the peak laying period (typically July for the mid-Atlantic region) has been shown to increase laying in females (Knight et al. 2019). However, not all patches should be mowed at the same time, so some plants still have resources available for laying females (leave one patch unmowed and rotate the patches every year) (Knight et al. 2019). Furthermore, mowing has also been shown to decrease predator abundance on milkweed plants, so mowing may help address the mantid problems (Haan and Landis 2019). Frequent mowing, however, is undesirable as it jeopardizes the eggs and larvae directly and prevents the milkweed from regenerating to a sufficient level to support monarch breeding.

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6 REFERENCES

Alcock, J., L.P. Brower, and E.H. Williams Jr. 2016. “Monarch Butterflies Use Regenerating Milkweeds for Reproduction in Mowed Hayfields in Northern Virginia.” *Journal of the Lepidopterists’ Society* 70(3):177-181.

Barth, F.G. 1991. *Insects and Flowers: The Biology of Partnership*, translated by M.A. Biederman-Thorson. Page 408. Princeton: Princeton University Press.

Brock, J.P., K. Kaufman, R. Bowers, N. Bowers, and L. Hassler. 2006. *Kaufman Field Guide to Butterflies of North America.* Page 392. New York: Houghton Mifflin.

Calderone, N.W. 2012. “Insect Pollinated Crops, Insect Pollinators and U.S. Agriculture: Trend Analysis of Aggregate Data for the Period 1992-2009 and Supporting Information” *PLoS ONE* 7(5): e37235.

Cameron, S. A., J.D. Lozier, J.P Strange, J.B. Koch, N. Cordes, L. F. Solter, and T. L. Griswold. 2011. “Patterns of Widespread Decline in North American Bumble Bees.” *PNAS* 108(2): 662-667.

Cane, J. H., R. L. Minckley, and L. J. Kervin. 2000. “Sampling Bees (Hymenoptera: Apiformes) for Pollinator Community Studies: Pitfalls of Pan-trapping.” *Journal of the Kansas Entomological Society* 73: 225–231.

Droege, S., J. D. Engler, E. Sellers, and L. E. O’Brien. 2016. *US National Protocol Framework for the Inventory and Monitoring of Bees.* Fort Collins: U.S. Fish and Wildlife Service.

Garibaldi, L.A., L.G. Carvalheiro, S.D. Leonhardt, M.A. Aizen, B.R. Blaauw, R. Isaacs, M. Kuhlmann, D. Kleijn, A. M. M. Klein, C. Kremen, L. Morandin, J. Scheper, and R. Winfree. 2014. “From Research to Action: Enhancing Crop Yield Through Wild Pollinators.” *Frontiers in Ecology and the Environment* 12: 439-447.

Grozinger, C. M. and J. D. Evans. 2015. “Editorial Overview: Social insects: from the Lab to the Landscape – Translational Approaches to Pollinator Health.” *Current Opinions in Insect Science* 10: vii-ix.

Haan, N.L. and D.A. Landis. 2019. “Grassland Disturbance Increases Monarch Oviposition and Decreases Arthropod Predator Abundance.” *Biological Conservation* 233: 185- 192.

Knight, S.M., D.R. Norris, R. Derbyshire, and D.T.T. Flockhart. 2019. “Strategic Mowing of Roadside Milkweeds Increases Monarch Butterfly Oviposition.” *Global Ecology and Conservation* 19. e00676.

NatureServe. 2019. "NatureServe Explorer: An Online Encyclopedia of Life." Version 7.1. Arlington: NatureServe. Accessed November 19, 2019. http://explorer.natureserve.org. Accessed November 19, 2019.

NRC. 2007. *Status of pollinators in North America.* Page 326. Washington, DC: The National Academies Press.

Pearse, I.S., M. McMunn, and L.H. Yang. 2019. "Seasonal Assembly of Arthropod Communities on Milkweeds Experiencing Simulated Herbivory." *Arthropod-Plant Interactions* 13: 99-108.

Roulston, T. H., S. A. Smith, and A. L. Brewster. 2007. "A Comparison of Pan Trap and Intensive Net Sampling Techniques for Documenting a Bee (Hymenoptera: Apiformes) Fauna." *Journal of the Kansas Entomological Society* 80:179-181.

Wilson, J. S, T. Griswold, and O. J. Messinger. 2008. "Sampling Bee Communities (Hymenoptera: Apiformes) in Desert Landscape: Are Pan Traps Sufficient?" *Journal of the Kansas Entomological Society* 81: 288-300.

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APPENDIX A FLORAL RESOURCES

Date	Common Name	Genus	Species	Abundance
Late Spring	Common milkweed	*Asclepias*	*syriaca*	5
Late Spring	Butterfly milkweed	*Asclepias*	*tuberosa*	3
Late Spring	Canada thistle	*Cirsium*	*arvense*	3
Late Spring	Black-eyed Susan	*Rudbeckia*	*hirta*	3
Late Spring	Daisy fleabane	*Erigeron*	*annuus*	3
Late Spring	Yarrow	*Achillea*	*millefolium*	3
Late Spring	Hemp dogbane	*Apocynum*	*cannabinum*	3
Late Spring	White clover	*Trifolium*	*repens*	3
Late Spring	Red clover	*Trifolium*	*pratense*	3
Late Spring	Chicory	*Cichorium*	*intybus*	3
Late Spring	Blackberry	*Rubus*	*allegheniensis*	3
Late Spring	Yellow sweet clover	*Melilotus*	*officinalis*	3
Late Spring	Crown vetch	*Securigera*	*varia*	2
Late Spring	Spiderwort	*Tradescantia*	*virginiana*	2
Late Spring	Lance leaved coreopsis	*Coreopsis*	*lanceolata*	2
Late Spring	Black medic	*Medicago*	*lupulina*	2
Late Spring	Bladder campion	*Silene*	*latifolia*	2
Late Spring	Venus’ looking glass	*Triodanis*	*perfoliata*	2
Late Spring	Elderberry	*Sambucus*	*nigra or racemosa*	2
Late Spring	Purple coneflower	*Echinacea*	*purpurea*	2
Summer	Common milkweed	*Asclepias*	*syriaca*	4
Summer	Thistle spp.	*Cirsium*	spp.	3
Summer	White clover	*Trifolium*	*repens*	2
Summer	Common yarrow	*Achillea*	*millefolium*	2
Summer	Horse nettle	*Solanum*	*carolinense*	2
Summer	Common evening primrose	*Oenothera*	*biennis*	2
Summer	Pickerelweed	*Pontederia*	*cordata*	2
Fall	Eastern baccharis	*Baccharis*	*halimifolia*	4
Fall	Goldenrod	*Solidago*	spp.	3
Fall	Thistle spp.	*Cirsium*	spp.	3
Fall	Goldenrod	*Solidago*	spp.	3
Fall	Thistle spp.	*Cirsium*	spp.	3
Fall	Goldenrod	*Solidago*	spp.	2
Fall	Thistle spp.	*Cirsium*	spp.	2
Fall	Goldenrod	*Solidago*	spp.	2
Fall	Thistle spp.	*Cirsium*	spp.	2
Fall	Eastern baccharis	*Baccharis*	*halimifolia*	2
Fall	Goldenrod	*Solidago*	spp.	2

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APPENDIX B BUTTERFLY PHOTOGRAPHS

Species Identified as "Common"

Cabbage White (*Pieris rapae*)

Dorsal View

Ventral View

Common Buckeye (*Junonia coenia*)

Dorsal View

Ventral View

Eastern Tailed Blue (*Cupido comyntas*)

Dorsal View

Ventral View

Eastern Tiger Swallowtail (*Papilio glaucus*)

Dorsal View

Ventral View

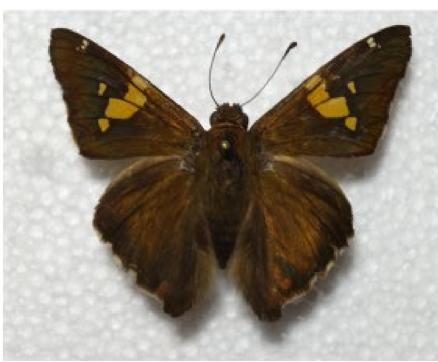
Dorsal View

Ventral View

Zabulon Skipper (*Poanes zabulon*)

(Left: Male, Right: Female)

Silver-Spotted Skipper (*Epargyreus clarus*)



Dorsal View

Ventral View

Pearl Crescent (*Phyciodes tharos*)

Dorsal View

Ventral View

Fiery Skipper (*Hylephila phyleus*)

Dorsal View

Ventral View

Orange Sulfur (*Colias eurytheme*)

Dorsal View

Ventral View

1

Spicebush Swallowtail (*Papilio troilus*)

Dorsal View

Ventral View

2

Other Species of Note

Sleepy Orange (*Abaeis nicippe*)

Dorsal View

Ventral View

Black Swallowtail (*Papilio polyxenes*)

Dorsal View

Ventral View

Cloudless Sulfur (*Phoebis sennae*)

Dorsal View

Ventral View

1

Red-Spotted Purple (*Limenitis arthemis*)

Dorsal View

Ventral View

2

Red Admiral (*Vanessa atalanta*)

Dorsal View

Ventral View

Painted Lady (*Vanessa cardui*)

Dorsal View

Ventral View

American Lady (*Vanessa virginiensis*)

Dorsal View

Ventral View

Dorsal View

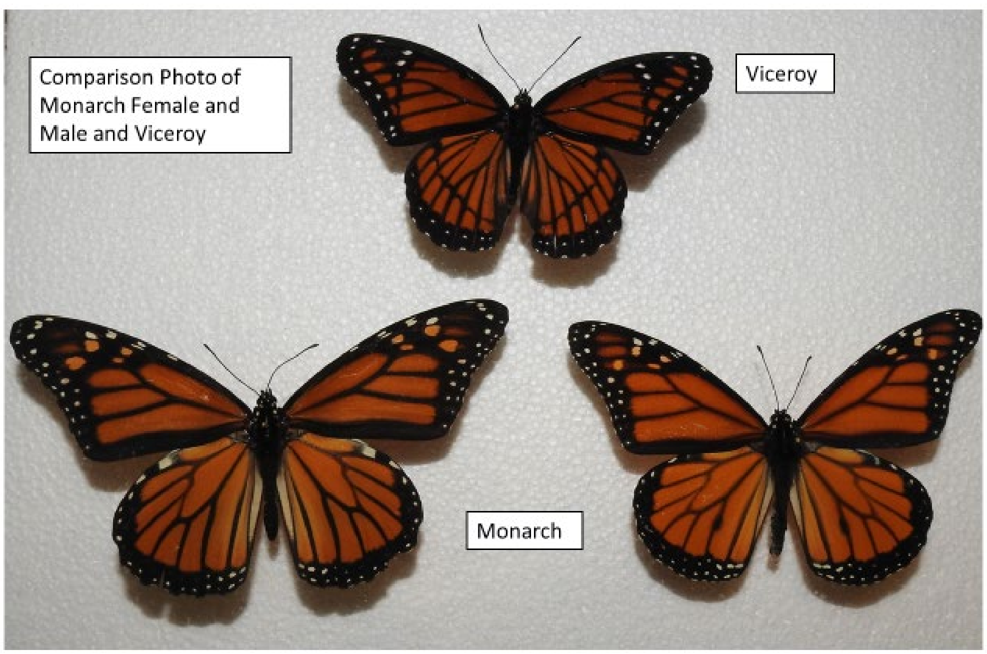
Ventral View

Monarch (*Danaus plexippus*)
(Left: Female, Right: Male)

Viceroy (*Limenitis archippus*)

Dorsal View

Ventral View



APPENDIX C BEE PHOTOGRAPHS

Genus: *Agapostemon* (*Agapostemon virescens*)


Dorsal View


Side View

Genus: *Andrena*


Dorsal View


Side View

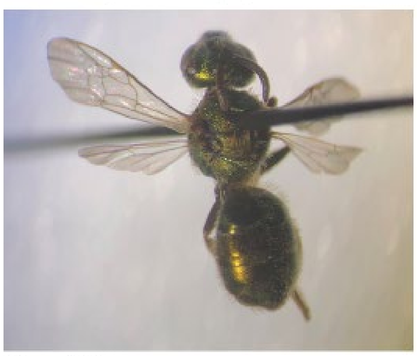
Genus: *Augochlora* (*Augochlora pura*)

Dorsal View

Side View

1

Genus: *Augochlorella* (*Augochlorella aurata*)



Dorsal View

Side View

2

Genus: *Bombus* (*Bombus bimaculatus*)

Dorsal View

Side View

Genus: *Ceratina*

Dorsal View

Side View

Genus: *Coelioxys*

Dorsal View

Side View

Genus: *Halictus*

Dorsal View

Side View

Genus: *Lasioglossum*

Dorsal View

Side View

1

Genus: *Megachile*

Dorsal View

Side View

2

Genus: Ptilothrix (*Ptilothrix bombiformis*)


Dorsal View


Side View

Genus: *Xylocopa* (*Xylocopa virginica)*


Dorsal View


Side View