

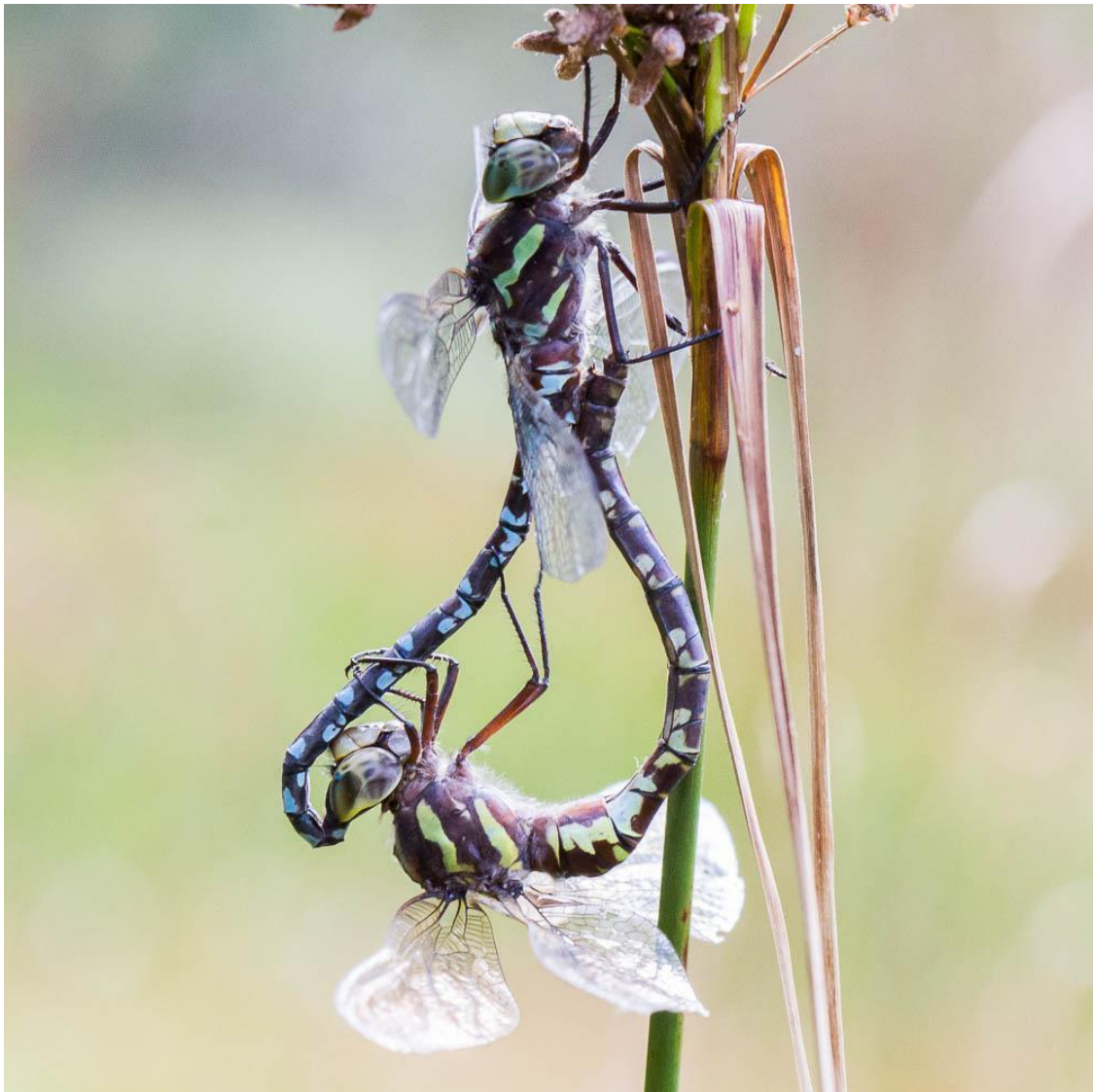
Report on the 2021 Odonata, Butterfly, and Bee Surveys at the New Hampshire National Guard Training Site, Strafford, NH

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Mating pair of Green-striped Darners (*Aeshna verticalis*) at the Training Site on 14 September 2021

31 December 2021

Executive Summary

Insect populations have been declining in New England, and conducting insect surveys at managed sites is needed to better understand insect declines, determine the presence of rare, threatened, and endangered species, and identify possible management practices to assist in conservation efforts. We surveyed the New Hampshire National Guard Training Site in Strafford, NH during 2021 for odonates, butterflies, and bees. We used standardized and opportunistic sampling over 15 survey days between May and mid-September and compared our results to a survey done in 2014. We found 48 species of odonates, which brings the Site's species list to 50. Butterfly species found in 2021 totaled 31, bringing the Site's species list to 34. Bee species found in 2021 totaled 39 species of 13 different genera. Ringed Boghaunters were previously known to occur at the Site from the 2014 survey and are listed on NH's list of threatened and endangered species. We found one individual Ringed Boghaunter on 5/24 indicating the species is still present, but we were unable to document breeding despite targeted efforts throughout May. Given that wetlands and the surrounding forest are important habitat components for Ringed Boghaunters, we recommend continued conservation of the Site's wetlands, their hydrologic regime, and the surrounding uplands. More frequent and intensive monitoring in May and surveys of all adjacent wetlands in future years will be needed to determine Ringed Boghaunter breeding locations and population size. For butterflies and bees, no state-threatened species were found. However, similar to 2014, we did document Monarchs using the Site, and this species has seen dramatic declines over the last few decades. We found Monarchs predominately in open meadow habitats and not in more forested areas. For Monarch conservation, mowing meadows should not occur in August or September when Monarch eggs, larvae, and adults are more likely to be present. Mowing in mid-July can produce regrowth of Milkweed, providing desirable tender plants for Monarch caterpillars. Supplemental planting of native flowering plants in meadows could provide essential nectar, pollen, and habitat resources to bees and other pollinators.

Introduction

Insect and pollinator populations, including bees (Hymenoptera: Anthophila), butterflies (Lepidoptera: Papilionoidea), and dragonflies and damselflies (Odonata), have been declining both worldwide and regionally in New England (Mathiasson and Rehan 2020; Wagner et al. 2021). Obtaining baseline data on insect populations at managed sites in New England, and assessing the presence of rare, threatened, and endangered (RTE) species, is important to determine changes in insect populations over time, create best management practices for these taxa, and overall attempt to better conserve and sustain insect communities and ecosystems.

Bee communities in New Hampshire have been studied previously, but primarily in drier, non-wetland sites (e.g., Milam et al. 2018; Tucker and Rehan 2019) and higher elevations (Tucker and Rehan 2017). There are approximately 200 species of wild bees in New Hampshire (Rehan 2016), including bumble bees (genus *Bombus*), honey bees (*Apis mellifera*); mining bees (genus *Andrena*), sweat bees (Halictidae), carpenter bees (*Xylocopa virginica* and *Ceratina* spp.), leaf cutter bees (genus *Megachile*), mason bees (genus *Osmia*), and blunt-horned mining bees (genus *Melitta*).

In New Hampshire, there is an existing state-wide atlas of Odonata, and thus this insect Order is relatively well-studied (Hunt 2012). At least 168 species of dragonflies and damselflies have been documented in the state. In the town of Strafford, at least 105 have been recorded, due to intensive survey effort, the presence of a wide variety of habitats located in the town, and the proximity to the coastal plain. Within the New Hampshire National Guard Training Site in Strafford, a previous study in 2014 found 37 species of odonates during approximately 8 survey days (Hunt and Jones 2014). This previous study detected two RTE Odonata species at the site - the Ebony Boghaunter and the Ringed Boghaunter. Ringed Boghaunters are especially rare in New Hampshire, and thus the presence of this species at the New Hampshire National Guard Training Site is especially of interest.

For butterflies, many researchers and amateurs have noted observations through New Hampshire (e.g., see iNaturalist.org), but no formal statewide survey has been conducted. New Hampshire Audubon did conduct a comprehensive review of butterflies observed in the state, summing up a statewide list of over 120 species (Jones 2013). At the New Hampshire National Guard Training Site in Strafford, a previous study in 2014 detected 31 species during 8 survey days (Hunt and Jones 2014). The Monarch butterfly was observed in mid-September during this study and is of particular interest due to recent population declines of this species. The declines may be, in part, attributed to breeding habitat loss and changes in disturbance regimes in the eastern US (Flockhart et al. 2015; Haan and Landis 2019).

As part of a contract between Antioch University, New Hampshire Audubon, and the New Hampshire National Guard, we conducted insect surveys in 2021 at the Guard's Training Site (hereafter Training Site or Site) located in Center Strafford, NH. The focus of the survey was to re-examine the Site since 2014 and to develop a comprehensive list of Odonata, butterflies, and bees, with specific emphasis on RTE species. We also attempted to search and delineate habitats of rare species observed. We conducted vegetation surveys along the bee transects. Lastly, we provide a list of incidental observations of other insect, wildlife, and plant species observed in 2021 (see Appendix: Table A1).

Site Description

The Training Site is approximately 104 acres with a variety of habitats. Developed areas and mowed lawns are present in the southwestern section of the site (Figure 1; from our transect 7 to Rt. 126) and did not contain much wildlife or insect habitat. Grassland and some shrubland habitat exist in the next section of the Site moving north (between transects 7, 1, and 6), comprising about 29 acres. The grassland fields are mowed annually. To the best of our knowledge mowing occurred in patches from about mid-June to September in 2021. Lastly, a mixture of closed-canopy forest (48 acres) and wetland (16 acres) habitat comprises the northeastern section of the site, although some canopy openings occur by the range and along the dirt road. Wetland types include a Black Gum-Red Maple swamp/peatland, a graminoid marsh (which also has some smaller areas of peatland habitat with *Sphagnum* moss), and Highbush Blueberry-dominated wetlands (Neid 2004).

Methods

We conducted 11 odonate surveys throughout the spring and summer of 2021. Four odonate surveys during May, focused on detection/breeding/habitat of boghaunters, were conducted by Pamela Hunt from NH Audubon. An additional 7 surveys were conducted by Kyle Bradford approximately bi-weekly from June to the middle of September (Table 1). We did systematic, meandering surveys conducted throughout 3 wetlands at the site (Figure 1), spending 20-40 minutes of active searching per wetland per visit (Bried et al. 2012). Additionally, we opportunistically surveyed the shooting range access road and the Site's meadows throughout the season. All odonates were identified to species when possible.

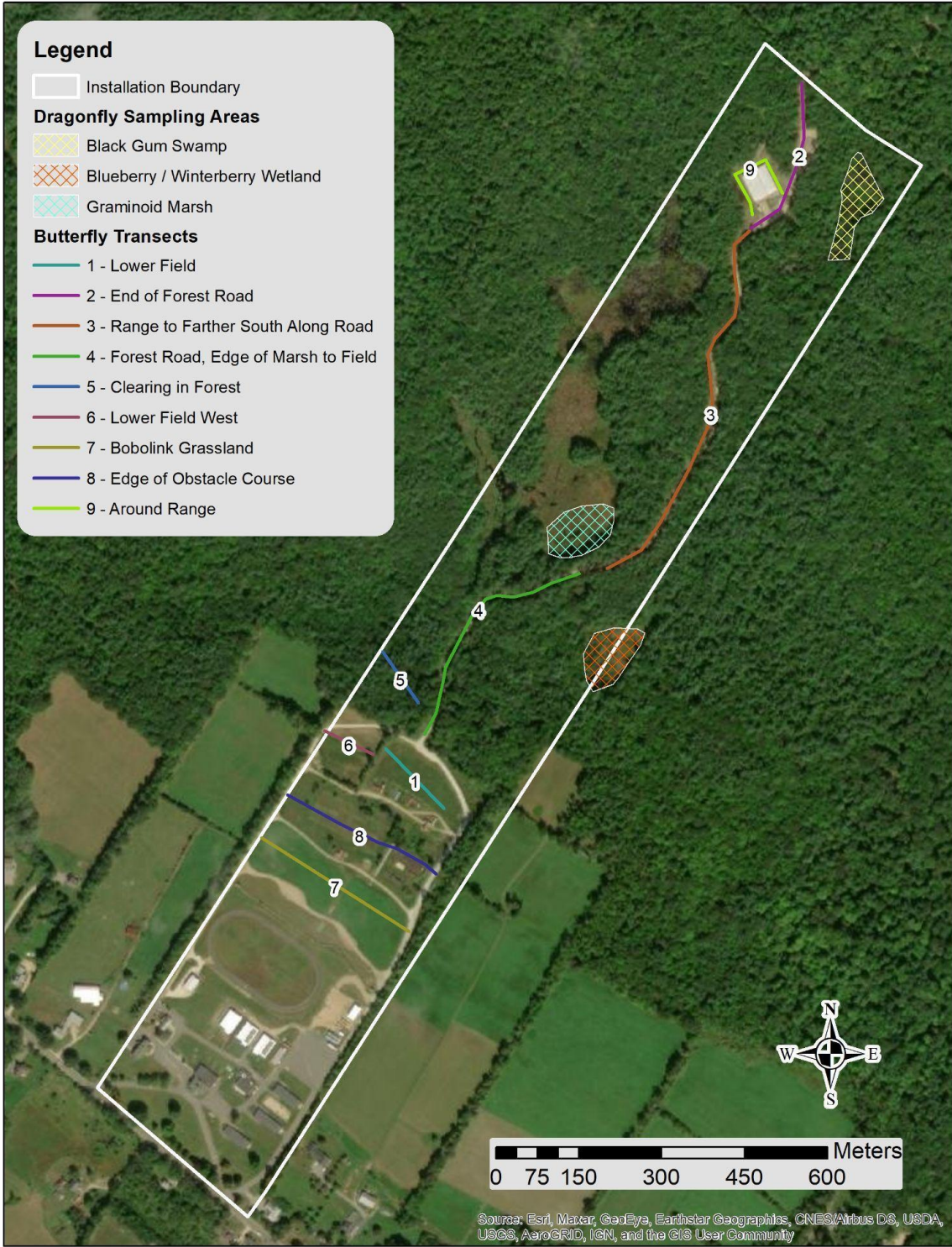


Figure 1: Map of 2021 standardized butterfly sampling transects and approximate areas for timed dragonfly surveys.

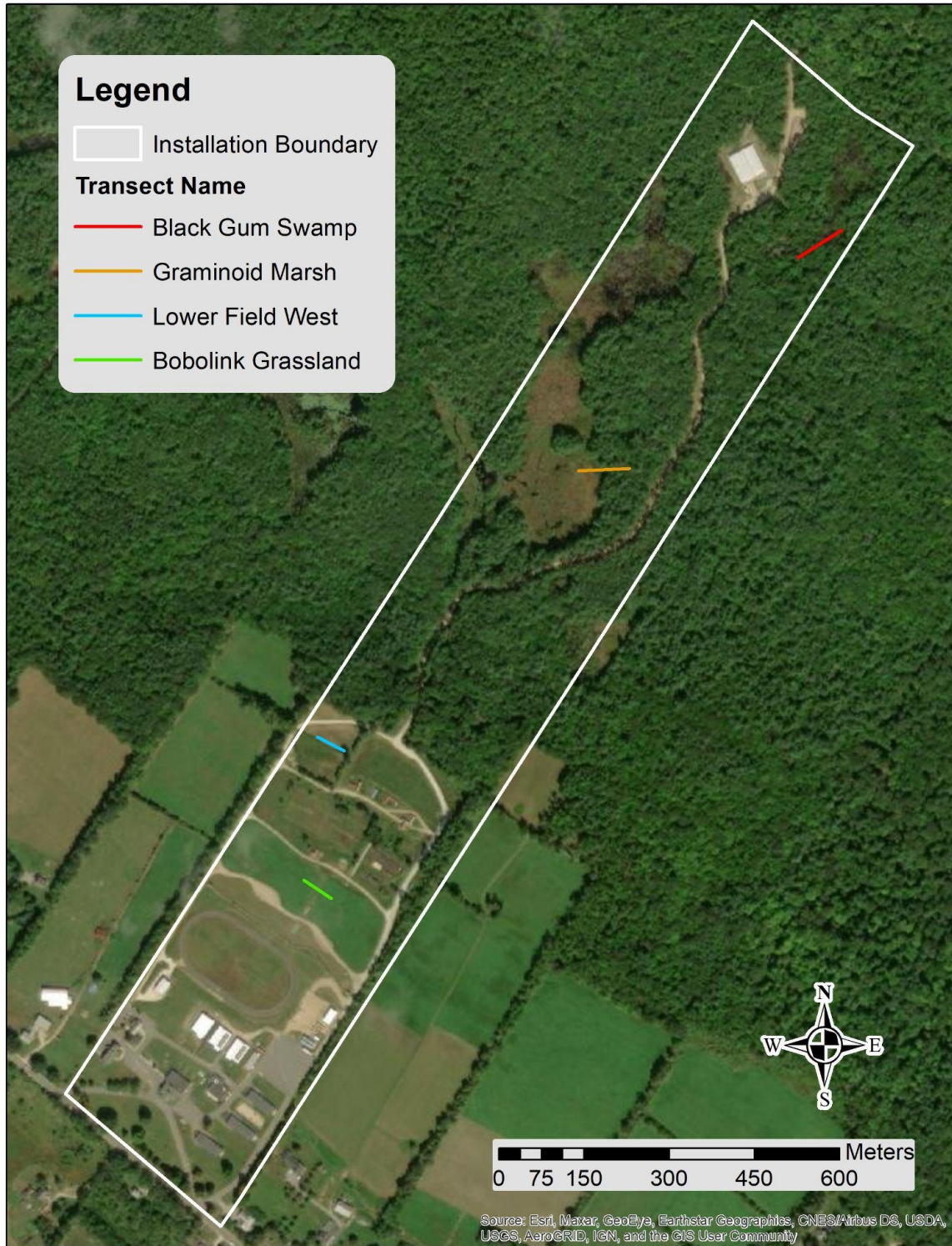


Figure 2: Map of 2021 bee bowl transects.

Table 1: Overview of insect survey days for odonates, butterflies, and bees at the site in 2021. “X” indicates taxonomic focus while “*” indicates that only incidental observations were made for that taxa on that day. Observers: MA = Mike Akresh, AB = Alaina Bandanza, KB = Kyle Bradford, PH = Pamela Hunt.

Date	Observers	Time	Odonates	Butterflies	Bees
May 6, 2021	PH	1000-1200	X	*	
May 15, 2021	PH	1130-1300	X	*	
May 19, 2021	PH	1050-1240	X	*	
May 24, 2021	MA, AB, KB, PH	1200-1640	X	X (1 transect)	X
May 25, 2021	MA, AB	1030-1230	*	X	X
June 10, 2021	KB	1045-1705	X	X	
June 24, 2021	AB, KB	0945-1610	X	X	X
July 7, 2021	KB	1015-1605	X	X	
July 22, 2021	AB, KB	0930-1615	X	X	X
July 23, 2021	AB	0930-1230			X
August 10, 2021	KB	1050-1755	X	X	
August 25, 2021	AB, KB	1102-1725	X	X	X
August 26, 2021	AB	1000-1200			X
September 14, 2021	KB	1020-1640	X	X	
October 6, 2021	AB	0900-1000			*

Seven survey days of butterflies were conducted by Kyle Bradford (with 1 day of surveys by Mike Akresh), using Pollard-style walks in all of the different habitat types (Figure 1), throughout the summer from the end of May through the middle of September (Table 1). All transects were surveyed 8 times besides transect number 9, which was surveyed 7 times. During these survey days, we also mapped out RTE butterfly habitat and use, specifically for Monarchs or other RTE butterflies observed. Surveys were approximately 2-4 hours long, as done in 2014. We identified all butterflies to species when possible. We documented additional insects, as well as other fauna and flora, encountered incidentally during our odonate and butterfly surveys. Generally, surveys were done during non-overcast days with low winds. However, we did experience some overcast skies on 8/10.

Bee sampling using bee bowls took place in 3 survey periods (May, July, and September), following other studies (e.g., Roberts et al. 2017). To survey bees present at the sites, Alaina Bandanza followed USGS Native Bee Inventory and Monitoring Lab's standard protocol, by placing colored pan trap bee bowls every 5 m along a 90 m transect (Droege et al. 2016). To assess the potential value of adjacent forest and forest edge, half of each wetland transect (Black Gum Swamp and Graminoid Marsh) was placed in the forest (Figure 2). Two reduced transects, consisting of 9 bowls each, were placed in the Lower Field West and Bobolink Grassland habitats (Figure 2). Bee bowls consisted of 4 oz. polystyrene ProPak® cups painted fluorescent yellow, blue, and white filled with soapy water (blue Dawn® dishwashing liquid) (Droege et al. 2016). For each survey period, bowls were deployed for 24 hours and then collected.

As a number of bee species, such as larger-bodied *Bombus*, are likely not captured in bee bowls (including rare species), bee bowls are often combined with manual netting to assess the complete bee diversity at a site (e.g., Popic et al. 2013). Thus, we also conducted manual bee netting, which entailed capturing bees with an insect net, and then placing the captured bees into 50 mL centrifuge tubes filled with soapy water. Net sampling effort consisted of both opportunistic (random, untimed) surveys and timed netting focused on specific flowering plants (5-minute surveys). Opportunistic netting surveys were conducted by walking around with an insect net and capturing any bees seen on any flowering vegetation. Timed surveys were conducted specifically on certain wetland plants (Highbush Blueberry, Common Arrowhead, Swamp Loosestrife) as a part of a larger NH bee study. Netting surveys were conducted when setting out and collecting bee bowls (May, July, and August), and additionally in June.

In June, we conducted standardized point-intercept vegetation surveys along the bee bowl transects to record the vegetation species composition, overstory and understory height, vegetation density between 0-3 m within 0.5 m increments, tree canopy cover, ground substrate type, leaf litter depth if present, and water depth if present. Since bees can nest in downed woody debris and standing dead wood, we also recorded the dbh (diameter at breast height) and decay

class of any woody debris >7 cm that intersected the transect line and any standing dead wood within 2 m of the transect. We also used a digital, waterproof pH probe to record pH readings at every 5 m along each transect in the wetland bee transects (Apera Instruments PH60 Waterproof Pocket Tester).

Results

Odonata

We found a total of 48 species of Odonata at the Site in 2021. Of those, 13 were newly recorded for the Site (Table 2). Combining the 2014 and 2021 lists gives a total of 50 odonate species found at the Site (includes only those identified to species level). The following 4 species were found in 2014 but not in 2021: Mottled Darner (*Aeshna clepsydra*, S4), Shadow Darner (*Aeshna umbrosa*, S5), Twin-spotted Spiketail (*Cordulegaster maculata*, S5), Clamp-tipped Emerald (*Somatochlora tenebrosa*, S4). As in 2014, no *Enallagma* (bluets) were detected in 2021. We added one additional spreadwing species to the Site's list (Sweetflag Spreadwing, *Lestes forcipatus*, S3S4), however similar to 2014 *Lestes* abundance was fairly low.

Only one species, the Ringed Boghaunter (*Williamsonia lintneri*, S2), is of particular conservation concern. One individual Ringed Boghaunter was detected at the site on 5/24 on the road, just south of the Graminoid Marsh (Figure 3). Other notable species include one female Martha's Pennant (*Celithemis martha*), which was found near butterfly transect number 1 on 7/22. This species is ranked S2S3, however, it is not as rare as it was a decade ago, and it seems to be increasing its range in NH. Ebony Boghaunters (*Williamsonia fletcheri*) were found along a path close to the Blueberry-Winterberry Wetland as well as on the road. This species was only seen on 5/24 when we counted 4 individuals. Ebony Boghaunter is ranked S3 but they are not nearly as rare as the Ringed Boghaunter.

Butterflies

Systematic butterfly surveys coupled with opportunistic encounters yielded 31 species (Table 3). We added 6 new species for the site that were not detected in 2014, bringing the Site's species list to 34 (includes only those identified to species level). Species seen in 2014 but not 2021 include: Orange Sulfur (*Colias eurytheme*, S5), Northern Oak Hairstreak (*Satyrium favonius*), American Lady (*Vanessa virginiensis*, S5), Eyed Brown (*Lethe eurydice*, S5), Silver-spotted Skipper (*Epargyreus clarus*, S4), Juvenal's Duskywing (*Erynnis juvenalis*, S4), and Peck's Skipper (*Polites peckius*, S5). No species found in 2021 are of conservation concern.

An exception may be the well-monitored Monarch (*Danaus plexippus*, S5), which has seen population declines over the last few decades.

Monarchs were observed in habitats that were substantially open, and not found in more forested areas such as along the range access road. First Monarchs observed at the site were on 7/22. A total of four Monarchs were counted during transect walks in 2021 on transect numbers 1, 7, and 8 (Figure 3). Common Milkweed (*Asclepias syriaca*), which is a Monarch host plant, was found in open fields and roadside edges (usually 1-4 plants). A patch of about 5-10 Common Milkweed plants was found along transect 8 and was mowed at least once during August. The largest patch we found included about 20 plants in the Bobolink Grassland where one Monarch caterpillar (5th instar) was seen feeding on 8/25 (Figure 3). However, this Common Milkweed patch was mowed by our next survey visit on 9/14, potentially killing the larva and any others that had not fully matured.

Bees

Over the course of the season, we caught, pinned, labeled, and identified 146 bees. We captured 101 bees in bee bowls (48 in blue-colored bowls, 21 in white bowls, and 32 in yellow bowls), and 45 while netting. We generated baseline data for the site consisting of 39 species representing 5 families and 13 different genera (Table 4). Halictidae was the most diverse and abundant family at the Site consisting of 104 individuals representing 23 species. Apidae was the second most abundant family with 22 individuals of 8 species. Within Apidae, we caught 3 species of the genus *Nomada*, which are cleptoparasites. Of the Andrenidae family, 5 *Andrena* were caught throughout the season (1 in July, 1 in June, 3 in May). For Megachilidae, we encountered 5 individuals of 4 different species. Of the Colletidae we collected, all 6 individuals were of the genus *Hylaeus*.

Lower Field West had the greatest bee diversity and abundance at the site with 69 individuals of 23 different species. Next in relative diversity and abundance was the Graminoid Marsh where we identified 32 individual bees of 20 different species. The Bobolink Grassland, road, Black Gum Swamp, and forest habitat had low diversity with only 6, 4, 2, and 3 species respectively, and relatively low abundance with 20, 7, 4, and 3 individuals respectively.

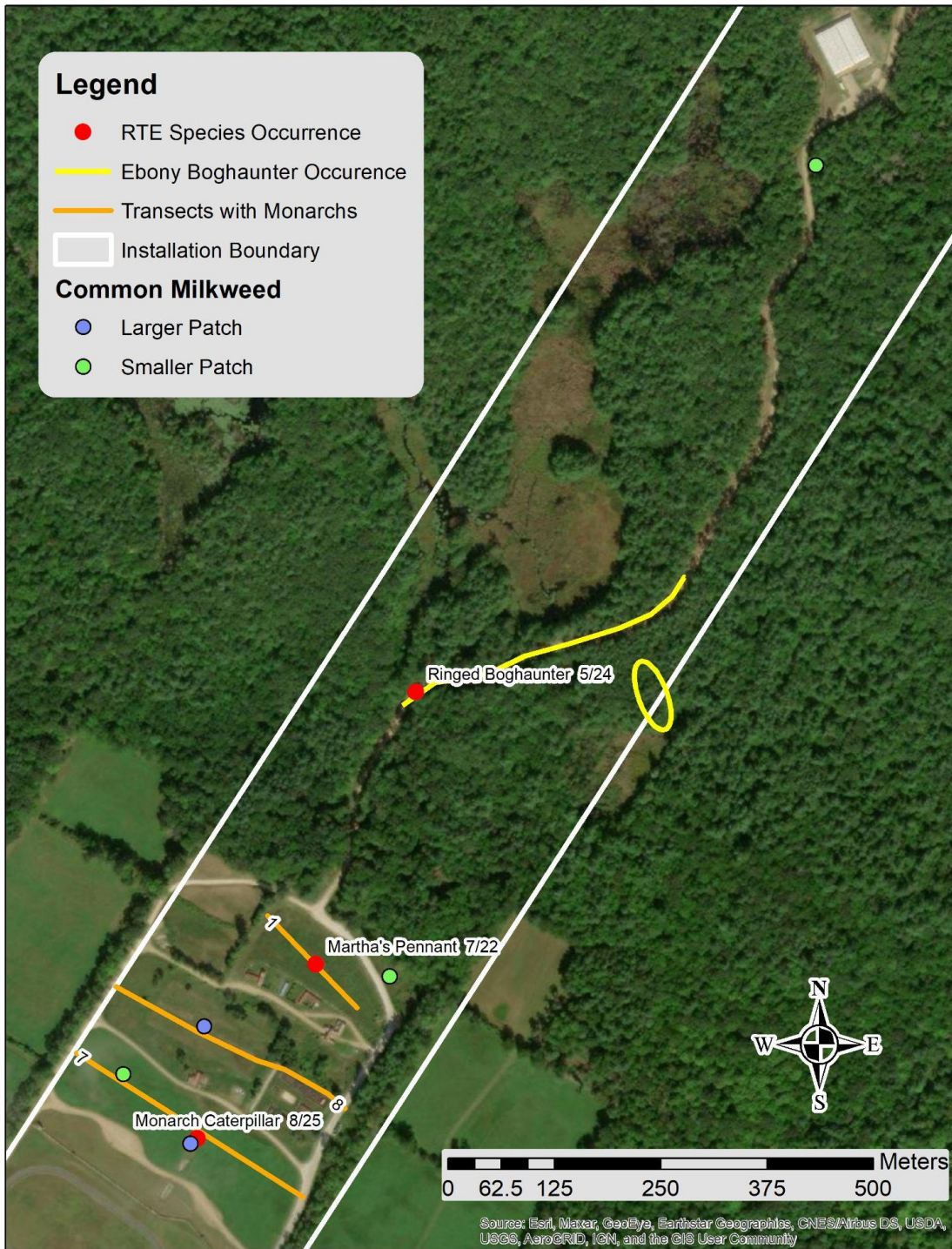


Figure 3: Locations of rare, threatened, and endangered (RTE) species and the date they were found during 2021. Ebony Boghaunters were found on 5/24 and their location is approximated. Monarchs were found at 3 out of 9 butterfly transects. See Figure 1 for all transect locations. Common Milkweed (*Asclepias syriaca*) was incidentally encountered during surveys, and locations of where plant(s) were found are mapped along with their relative abundances (“Smaller Patch” = 4 or fewer plants and “Larger Patch” = more than 4 plants).

Table 2: Dragonfly and damselfly species encountered in 2021. Abundances are listed for each survey date, as numbers when available, or with relative abundance codes. Codes are as follows: A = Abundant (multiple individuals encountered over a large portion of the site), C = Common (widespread but in lower numbers, or locally abundant), and U = Uncommon (scattered individuals, usually less than 5 total). For rarely encountered species, the sex is sometimes given as “m” or “f.” Species lists for each wetland surveyed are provided. BGS = Black Gum Swamp, BWW = Blueberry-Winterberry Wetland, and GM = Graminoid Marsh. Species listed under “Fields” and “Road” were encountered opportunistically during site visits. “Fields” refers to the Site’s upland meadows, and “Road” refers to along the forested road that accesses the shooting range. “*” after species’ common name indicates a species that was not seen during the 2014 survey (Hunt and Jones 2014).

Species		State Rank	5/6	5/15	5/19	5/24	6/10	6/24	7/7	7/22	8/10	8/25	9/14	BGS	BWW	GM	Fields	Road
Canada Darner	<i>Aeshna canadensis</i>	S5								U		U	U			X		
Lance-tipped Darner*	<i>Aeshna constricta</i>	S3								1/U							X	
Black-tipped Darner	<i>Aeshna tuberculifera</i>	S5									1/U	U			X		X	
Green-striped Darner	<i>Aeshna verticalis</i>	S4S5								C	A	A	C		X	X		
Common Green Darner	<i>Anax junius</i>	S5							C	1/U	U	U	1/U				X	
Harlequin Darner*	<i>Gomphaeschna furcillata</i>	S3S4				3/U	5/C							X				
American Emerald	<i>Cordulia shurtleffii</i>	S5																X 5/25
Racket-tailed Emerald	<i>Dorocordulia libera</i>	S5					1/U	3/U						X			X	
Beaverpond Baskettail	<i>Epitheca canis</i>	S5				1/U										X		
Baskettail sp.	<i>Epitheca</i> sp.				1/U	1/U												X
Brush-tipped Emerald*	<i>Somatochlora walshii</i>	S3S4										1/U			X			
Ebony Boghaunter	<i>Williamsonia fletcheri</i>	S3				4/U									X			X
Ringed Boghaunter	<i>Williamsonia lintneri</i>	S2				1/U												X
Lancet Clubtail	<i>Phanogomphus exilis</i>	S5				U												X
Dusky Clubtail*	<i>Phanogomphus spicatus</i>	S5			2/U	1/U												X

Calico Pennant	<i>Celithemis elisa</i>	S5					U	U	C	C	1/U					X	X	X
Halloween Pennant*	<i>Celithemis eponina</i>	S5								2/U						X		
Martha's Pennant*	<i>Celithemis martha</i>	S2S3								1f/U							X	
Eastern Pondhawk	<i>Erythemis simplicicollis</i>	S5					A	A	A	A	C	U		X	X	X	X	X
White Corporal	<i>Ladona exusta</i>	S3			2/U	2/U												X
Chalk-fronted Corporal	<i>Ladona julia</i>	S5				C	U							X	X			X
Frosted Whiteface*	<i>Leucorrhinia frigida</i>	S5					C	U								X		
Crimson-ringed Whiteface	<i>Leucorrhinia glacialis</i>	S4S5				1/U										X		
Hudsonian Whiteface	<i>Leucorrhinia hudsonica</i>	S5		U		A								X	X			X
Dot-tailed Whiteface	<i>Leucorrhinia intacta</i>	S5				C	C	C	1/U					X	X	X	X	
Belted Whiteface	<i>Leucorrhinia proxima</i>	S4S5					C	C	C					X	X			
Spangled Skimmer	<i>Libellula cyanea</i>	S5				1/U	A	C	A	C	1/U			X	X	X	X	
Slaty Skimmer	<i>Libellula incesta</i>	S5						A	A	A	1/U	1/U		X	X			X
Widow Skimmer*	<i>Libellula luctuosa</i>	S5						1f/U	3/U	1f/U		1/U					X	X
Twelve-spotted Skimmer*	<i>Libellula pulchella</i>	S5								1/U								X
Four-spotted Skimmer	<i>Libellula quadrimaculata</i>	S5				C	A	C						X	X			X
Painted Skimmer*	<i>Libellula semifasciata</i>	S3				1/U	U							X	X			
Blue Dasher	<i>Pachydiplax longipennis</i>	S5						2/U	A	A	C			X	X	X	X	
Eastern Amberwing*	<i>Perithemis tenera</i>	S5								U	1m/U						X	

Common Whitetail	<i>Plathemis lydia</i>	S5					1/U	1/U	U			1f/ U				X	X	X
Cherry-faced Meadowhawk	<i>Sympetrum internum</i>	S5						2/U	A	A	A	A	C	X	X	X	X	X
Autumn Meadowhawk	<i>Sympetrum vicinum</i>	S5									C	A	A	X	X	X	X	X
Stream Cruiser*	<i>Didymops transversa</i>	S5				1/U												X
Aurora Damsel	<i>Chromagrion conditum</i>	S5		1/U	U	A	A								X			X
Fragile Forktail	<i>Ischnura posita</i>	S5				A	C	C	1/ U	1/U	C	U		X	X	X		X
Eastern Forktail	<i>Ischnura verticalis</i>	S5			U	C	1/U		C	1/U	C	U			X	X		X
Sphagnum Sprite	<i>Nehalennia gracilis</i>	S4S5					A	A	A	C	1/U			X	X	X		
Sedge Sprite	<i>Nehalennia irene</i>	S5						C						X				
Spotted Spreadwing	<i>Lestes congener</i>	S5							1f/ U						X			
Sweetflag Spreadwing*	<i>Lestes forcipatus</i>	S3S4								1m/ U	U				X			
Slender Spreadwing	<i>Lestes rectangularis</i>	S5						1f/U			1m/ U	1m/ U	U	X	X			
Spreadwing sp.	<i>Lestes sp.</i>							3/U	1/ U	3/U	1/U				X	X		X
Swamp Spreadwing	<i>Lestes vigilax</i>	S5						1m/ U								X		
TOTALS	48		0	2	5	19	16	19	16	20	17	14	6	9	24	25	15	26

Table 3: Butterfly species encountered at the site in 2021. Numbers are total abundances from timed transect walks (Figure 1). “X” indicates the species was only encountered incidentally on that day. Species totals for each survey date include both timed transects and opportunistic data. Red-spotted Purple and White Admiral are split as subspecies in the table but are otherwise counted as a single species. “*” after species’ common name indicates a species that was not seen during the 2014 survey (Hunt and Jones 2014).

Species		State Rank	5/6	5/15	5/19	5/24	5/25	6/10	6/24	7/7	7/22	8/10	8/25	9/14
Least Skipper	<i>Ancyloxypha numitor</i>	S5							1				2	
Arctic Skipper*	<i>Carterocephalus mandan</i>	S5					1							
Duskywing sp.	<i>Erynnis</i> sp.								1					
Dun Skipper*	<i>Euphyes vestris</i>	SNR								X	X			
Hobomok*	<i>Lon hobomok</i>	S5						1	X					
Long Dash	<i>Polites mystic</i>	S5						1						
Tawny-edged Skipper	<i>Polites themistocles</i>	S4							2					
European Skipper	<i>Thymelicus lineola</i>	SNA						1	1	X				
Skipper sp.	Hesperiidae													
Eastern Pine Elfin	<i>Collophrys niphon</i>	S5		X	X	X	X		X					
Spring Azure	<i>Celastrina ladon</i>	S5			X	X	X							
Summer Azure	<i>Celastrina neglecta</i>	SNR												X
Eastern Tailed-blue	<i>Cupido comyntas</i>	S5							X		X		2	
American Copper	<i>Lycaena phlaeas</i>	S5				2	2	X		2	2		3	X
Banded Hairstreak*	<i>Satyrium calanus</i>	S4									X			
Hairstreak sp.	Lycaenidae								X					

Silver-bordered Fritillary*	<i>Boloria selene</i>	S5					X	1						
Common Wood Nymph	<i>Cercyonis pegala</i>	S5							X	X	1			
Common Ringlet	<i>Coenonympha californica</i>	S5				1	1	14	X		X	23	5	
Monarch	<i>Danaus plexippus</i>	S5									1		1	2
Red-spotted Purple	<i>Limenitis arthemis</i> ssp. <i>astyanax</i>	S5						X						
White Admiral	<i>Limenitis arthemis</i> ssp. <i>arthemis</i>	S5						X						
Mourning Cloak*	<i>Nymphalis antiopa</i>	S5		X						X	1			
Pearl Crescent	<i>Phyciodes tharos</i>	S4?				1	3				2	2		X
Comma sp.	<i>Polygonia</i> sp.								X					
Great Spangled Fritillary	<i>Argynnis cybele</i>	S5							3	3	X		2	
Red Admiral	<i>Vanessa atalanta</i>	S5								1				
Lady sp.	<i>Vanessa</i> sp.									X				
Canadian Tiger Swallowtail	<i>Pterourus canadensis</i>	S5			X	X	1	1						
Black Swallowtail	<i>Papilio polyxenes</i>	SNR					1				X			
Clouded Sulphur	<i>Colias philodice</i>	S5				X	1	1	X	2	1	1	9	5
Cabbage White	<i>Pieris rapae</i>	SNA					1	3		X		1	2	4
Species Totals	31		0	2	3	7	11	10	13	10	12	4	8	6

Table 4: Bees surveyed at the site in 2021. “Road” indicates species that were opportunistically netted in a patch of Jewelweed (*Impatiens capensis*) along the road to the shooting range. “Forest” indicates bees found in the wooded, closed-canopy portions of the wetland transects. BGS = Black Gum Swamp, GM = Graminoid Marsh, BOBO = Bobolink Grassland, and LFW = Lower Field West. “*” for LFW listings indicates the species was also opportunistically netted for South of LFW in the adjacent field to the west of the obstacle course. “**” indicates bees that cannot be reliably identified with existing keys.

Species		5/24	5/25	6/24	7/22	7/23	8/25	8/26	BGS	GM	BOBO	LFW	Road	Forest	Total bees
Bicolored Striped Sweat Bee	<i>Agapostemon virescens</i>	1	3			2	2	1		X	X	X*	X		9
	<i>Andrena rufosignata</i>	3								X					3
	<i>Andrena</i> sp.			1	1					X	X				2
Western Honey Bee	<i>Apis mellifera</i>				1	2				X	X	X*			3
Golden Green Sweat Bee	<i>Augochlorella aurata</i>		10		3	21		3			X	X			37
Pure Gold-green Sweat Bee	<i>Augochlora pura</i>						1						X		1
Brown-belted Bumblebee	<i>Bombus griseocollis</i>	1			2	1				X		X*			4
Common Eastern Bumblebee	<i>Bombus impatiens</i>				1		2			X			X		3
Sanderson Bumblebee	<i>Bombus sandersoni</i>				1					X					1
Doubled Ceratina	<i>Ceratina dupla</i>		6		2							X*			8
Confused Sweat Bee	<i>Halictus confusus</i>					1	1				X	X			2

Ligated Furrow Bee	<i>Halictus ligatus</i>	6			8						X*			14
Orange-legged Furrow Bee	<i>Halictus rubicundus</i>				1				X					1
	<i>Hoplitis producta</i>		1								X			1
Modest Masked Bee	<i>Hylaeus modestus</i>		1		1				X		X			2
	<i>Hylaeus (modestus group) females**</i>				2	2			X		X			4
Admirable Sweat Bee	<i>Lasioglossum admirandum</i>					1		1			X	X		2
Deep-blue Sweat Bee	<i>Lasioglossum coeruleum</i>					2				X				2
Leathery Sweat Bee	<i>Lasioglossum coriaceum</i>	1								X				1
	<i>Lasioglossum cressoni</i>					3		2		X		X		5
	<i>Lasioglossum (Dialictus species)</i>	1			1					X				2
	<i>Lasioglossum leucocomus</i>					1		1				X		2
White-banded Sweat Bee	<i>Lasioglossum leucozonium</i>					1						X		1
Lotus Sweat Bee	<i>Lasioglossum nelumbonis</i>		1			1				X		X		2
Black-and-green Metallic Sweat Bee	<i>Lasioglossum nigroviride</i>				1							X		1
	<i>Lasioglossum nr. paradmirandum</i>					1							X	1

	<i>Lasioglossum oblongum</i>	1	1			3	1		X	X		X			6	
	<i>Lasioglossum oceanicum</i>		2			3						X			5	
	<i>Lasioglossum pectorale</i>				2							X*			2	
	<i>Lasioglossum quebecense</i>							1						X	1	
	<i>Lasioglossum subviridatum</i>					1		2	X					X	3	
	<i>Lasioglossum tegulare</i>				1							X			1	
Experienced Sweat Bee	<i>Lasioglossum versatum</i>		4			3				X		X			7	
Frigid Leafcutter Bee	<i>Megachile frigida</i>						2						X		2	
	<i>Nomada bethunei</i>		1									X			1	
	<i>Nomada maculata</i>		1							X					1	
Gracile Nomad Bee	<i>Nomada gracilis</i>		1									X			1	
	<i>Osmia inspergens</i>	1								X					1	
Maine Blueberry Bee	<i>Osmia atriventris</i>					1				X					1	
Totals		39	15	32	1	28	50	9	11	2	20	6	23	4	3	146

Conclusions and Recommendations

The odonate diversity at the Site is within the typical range for similar sites with limited flowing water (45-50 species). The increase in species not previously seen in 2014 may have been, in part, due to increased survey effort including more opportunistic surveying in open fields and the road. New species for the Site such as Lance-tipped Darner, Eastern Amberwing, Martha's Pennant, Stream Cruiser, Dusky Clubtail, Widow Skimmer, and Twelve-spotted Skimmer, were all found in low numbers and only on the road or in meadows. Stream Cruisers need flowing water, while Martha's Pennant and Eastern Amberwing need more open ponds instead of the grassy and peaty wetlands that are at the Site. It may be the case that these species are breeding off-site and are utilizing the meadows for feeding. Lance-tipped Darner, Dusky Clubtail, Widow Skimmer, and Twelve-spotted Skimmer seem to just be rare at the Site.

For both odonates and butterflies, there were some species observed in 2014, but not seen again in 2021. Due to survey detection, insect population fluctuations, and potentially some individuals detected during dispersal, one would never expect to get a complete faunal list in a given year. Odonate species like Twin-spotted Spiketail and Clamp-tipped Emerald occur in low densities and can thus be easily missed. Shadow Darner is unusual for not being found in 2021. All of the butterfly species not seen in 2021, besides the Juvenal's Duskywing, were observed in low numbers in 2014. We did detect an unidentified duskywing species this year, which may have been a Juvenal's Duskywing.

The most important result for odonates in 2021 was that Ringed Boghaunters are still occupying the Site, though it is unclear why there was such limited activity compared to 2014. Other surveys in NH during 2021 first reported Ringed Boghaunters on 4/30 in Fremont and were common at the same site on 5/7. Additional records of flying adults were on 5/12 (Hooksett), 5/13 (Kingston, Amherst, Barrington), and 5/21 (Fremont). Exuviae were found in Litchfield and Amherst (5/11 and 5/13, respectively). It would thus seem there was a pulse of activity in mid-May, so it is unclear why we did not find any at Strafford during this same time frame. The sighting in Barrington was the only other one in Strafford County in 2021, and in Durham, Ringed Boghaunters were not found this year during repeated surveys of a site that previously had this species. We still do not have a good idea of how to detect Ringed Boghaunters, and this is compounded by low and/or variable densities, making it difficult to understand this species' occupancy and abundance at specific sites. Clearly, the species still occurs at the Training Site, but we still do not know where it is breeding.

Our study was the first to examine bee diversity and abundance at the Site; bee diversity and abundance were lower across the Site than one might expect based on our survey effort (Milam pers comm). Discussion among scientists in the "beemonitoring" listserv group also

found lower than average observations of bees nationwide during the 2021 season, as was the consensus of regional Melittologists (Milam pers comm). The combination of a cold spring, hot summer, and record-breaking heat and precipitation in July likely contributed to the relatively low number of bees sampled this field season. In addition, bees exhibit high inter- and intra-annual variation in abundance and diversity, therefore repeat-year sampling is desirable to document bee communities at specific sites. The Hunt and Jones (2014) survey incidentally noted two species observed at the site, Tricolored Bumblebee (*Bombus ternarius*), and Common Eastern Bumblebee (*B. impatiens*). We did not see or capture *Bombus ternarius* in 2021.

Despite our low capture rates, we detected some interesting species, and our study will provide a baseline for bee species diversity and community composition at the Site for future years. None of the species seen in 2021 were state-listed threatened, endangered, or of special concern, but only 3 bee species are currently listed in NH. *Nomada bethunei* is listed as uncommon on DiscoverLife (2021) and has not been collected often in NH; although if one samples on blueberries, this species is not unexpected (Milam pers com). Two of the bee species caught are naturalized exotic species (*Apis mellifera* and *Lasioglossum leucozonium*; Zayed et al. 2007).

Future studies of bees within the Graminoid Marsh warrant increased netting effort on Highbush Blueberry and Lowbush Blueberry (*Vaccinium* spp.), as they are known to host seven specialist bee species in New Hampshire (Fowler and Droege 2020). Additionally, Maleberry (*Lyonia ligustrina*), which was noted in the Black Gum Swamp, is the host for *Melitta melittoides* and *Colletes productus*, species that are uncommon in most collections. Future surveys would benefit from targeted netting on *Lyonia ligustrina*, which is a known host of 3 rare specialist bees (Fowler and Droege 2020). Additional targeted netting within the Blueberry-Winterberry wetland is recommended as Winterberry (*Ilex verticillata*) is a host of 3 rare specialist bees (Fowler and Droege 2020).

Our recommendation going forward is continued protection of the Site's wetlands and surrounding upland forest as well as limiting access to wetlands. Maintaining wetland hydrologic regime, and limiting potential pollution and runoff may be important in conserving Ringed Boghaunters, other odonates, and bees that occupy the site. More frequent and intensive surveys for Ringed Boghaunters, such as daily surveys in May conducted every few years, may be necessary to document breeding and better understand population numbers at the Site. Additionally, surveying all adjacent wetlands in future years may be needed. Increased sampling for bees on plants known to support specialist bees is advised, in addition to multiyear sampling effort to account for high annual variation in bee communities.

In 2014 and 2021 Ringed Boghaunters were only found on the road that accesses the shooting range, we continue to recommend lowered speeds on the road during the species' flight season (May through early June) to reduce potential vehicle-related casualties. Lower speeds and driver awareness, throughout the season, will also benefit other species that utilize the road such as herpetofauna. We found one dead Garter Snake and one dead Ribbon Snake on the road during our surveys. A vehicle-related casualty seemed likely for the Garter Snake, however, we are less certain whether the Ribbon Snake had died of vehicle mortality or from other causes (e.g., heat).

The current mowing regime of the grasslands is likely the biggest concern for bees and butterflies, especially Monarchs at the Site. To reduce unnecessary mortality and help in Monarch conservation, we recommend some best management practices. Generally, mowing in August or September would be detrimental to Monarchs, because that would kill eggs, larvae, and pupae on Common Milkweed. Mowing in May or June is also generally not recommended due to breeding birds. There is some evidence that mowing in mid-July can spur Common Milkweed regrowth and support increases in Monarch reproduction (Fischer et al. 2015; Haan and Landis 2019). However, mowing in July may not allow enough time for Bobolink or other avian young to mature and disperse to adjacent areas. Also, there may be variation in Monarch's phenology year to year. An alternative to mowing in July would be to mow after October 1 when it is likely that all potential larvae have had enough time to mature, and Bobolink young are old enough to disperse to adjacent areas. If choosing to mow during the fall, or any other time of the year, it may be useful to leave patches of un-mown refugia where insects can disperse to. Some meadow patches, or at least some edge, could be left un-mown for an entire year to provide additional insect refugia. Besides mowing, planting Common Milkweed and dispersing seeds in meadows could increase the Site's capacity for Monarch breeding. Planting other flowering, native plants in meadows could provide additional nectar resources for Monarchs, bees, and other pollinators.

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Appendix

Table A1: Incidentally encountered flora and fauna at the Site during 2021. “*” indicates invasive species.

Birds	Species	
	Red-winged Blackbird	<i>Agelaius phoeniceus</i>
Wood Duck	<i>Aix sponsa</i>	
Ruby-throated Hummingbird	<i>Archilochus colubris</i>	
Great Blue Heron	<i>Ardea herodias</i>	
Tufted Titmouse	<i>Baeolophus bicolor</i>	
Ruffed Grouse	<i>Bonasa umbellus</i>	
Red-shouldered Hawk	<i>Buteo lineatus</i>	
Broad-winged Hawk	<i>Buteo platypterus</i>	
Northern Cardinal	<i>Cardinalis cardinalis</i>	
Turkey Vulture	<i>Cathartes aura</i>	
Veery	<i>Catharus fuscescens</i>	
Hermit Thrush	<i>Catharus guttatus</i>	
Brown Creeper	<i>Certhia americana</i>	
Northern Flicker (Yellow-shafted)	<i>Colaptes auratus auratus/luteus</i>	
Eastern Wood-pewee	<i>Contopus virens</i>	
American Crow	<i>Corvus brachyrhynchos</i>	
Common Raven	<i>Corvus corax</i>	
Blue Jay	<i>Cyanocitta cristata</i>	
Bobolink	<i>Dolichonyx oryzivorus</i>	
Hairy Woodpecker	<i>Dryobates villosus</i>	
Common Yellowthroat	<i>Geothlypis trichas</i>	
Purple Finch	<i>Haemorhous purpureus</i>	

Wood Thrush	<i>Hylocichla mustelina</i>
Red-bellied Woodpecker	<i>Melanerpes carolinus</i>
Wild Turkey	<i>Meleagris gallopavo</i>
Swamp Sparrow	<i>Melospiza georgiana</i>
Song Sparrow	<i>Melospiza melodia</i>
Northern Mockingbird	<i>Mimus polyglottos</i>
Black-and-white Warbler	<i>Mniotilta varia</i>
Brown-headed Cowbird	<i>Molothrus ater</i>
Great Crested Flycatcher	<i>Myiarchus crinitus</i>
House Sparrow	<i>Passer domesticus</i>
Indigo Bunting	<i>Passerina cyanea</i>
Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>
Yellow-bellied Sapsucker	<i>phyrapicus varius</i>
Scarlet Tanager	<i>Piranga olivacea</i>
Black-capped Chickadee	<i>Poecile atricapillus</i>
Eastern Phoebe	<i>Sayornis phoebe</i>
Ovenbird	<i>Seiurus aurocapilla</i>
Black-throated Blue Warbler	<i>Setophaga caerulescens</i>
Yellow-rumped Warbler (Myrtle)	<i>Setophaga coronata coronata</i>
Blackburnian Warbler	<i>Setophaga fusca</i>
Pine Warbler	<i>Setophaga pinus</i>
Red-breasted Nuthatch	<i>Sitta canadensis</i>
White-breasted Nuthatch	<i>Sitta carolinensis</i>
Yellow-bellied Sapsucker	<i>Sphyrapicus varius</i>
American Goldfinch	<i>Spinus tristis</i>
Chipping Sparrow	<i>Spizella passerina</i>

	European Starling*	<i>Sturnus vulgaris</i>
	Tree Swallow	<i>Tachycineta bicolor</i>
	American Robin	<i>Turdus migratorius</i>
	Red-eyed Vireo	<i>Vireo olivaceus</i>
	Blue-headed Vireo	<i>Vireo solitarius</i>
	Mourning Dove	<i>Zenaida macroura</i>
Herpetofauna	Gray Treefrog	<i>Hyla versicolor</i>
	Pickrel Frog	<i>Lithobates palustris</i>
	Eastern Newt	<i>Notophthalmus viridescens</i>
	Spring Peeper	<i>Pseudacris crucifer</i>
	Ribbon Snake	<i>Thamnophis saurita</i>
	Common Garter Snake	<i>Thamnophis sirtalis</i>
Invertebrates	A Soldier Beetle	<i>Cantharis rufa</i>
	Six-Spotted Tiger Beetle	<i>Cicindela sexguttata</i>
	Japanese Beetle*	<i>Popillia japonica</i>
	Red Milkweed Beetle	<i>Tetraopes tetraphthalmus</i>
	Banded Longhorn Beetle	<i>Typocerus velutinus</i>
	A thread-waisted sand wasp	<i>Ammophila</i> sp.
	A Sand Wasp	<i>Bicyrtes ventralis</i>
	Eastern Carpenter Ant	<i>Camponotus pennsylvanicus</i>
	New York Carpenter Ant	<i>Camponotus novaeboracensis</i>
	Uncertain Ant	<i>Formica incerta</i>
	Complete Ant	<i>Formica integra</i>
	New World Black Ant	<i>Formica neogagates</i>
	Incomplete Ant	<i>Formica subintegra</i>
	Somewhat Silky Ant	<i>Formica subsericea</i>
	Labor Day Ant	<i>Lasius neoniger</i>

	American Ant	<i>Myrmica americana</i>
	Odorous House Ant	<i>Tapinoma sessile</i>
	Pavement Ant*	<i>Tetramorium immigrans</i>
	Hummingbird Clearwing	<i>Hemaris thysbe</i>
	New England Buck Moth	<i>Hemileuca lucina</i>
	A geometer moth	<i>Iridopsis</i> sp.
	A Tortricid Leafroller Moth	<i>Olethreutes</i> sp.
	Snowy Urola Moth	<i>Urola nivalis</i>
	Green-striped Grasshopper	<i>Chortophaga viridifasciata</i>
Plants	Jack-in-the-Pulpit	<i>Arisaema triphyllum</i>
	Common Milkweed	<i>Asclepias syriaca</i>
	Wild Calla	<i>Calla palustris</i>
	Oriental Bittersweet*	<i>Celastrus orbiculatus</i>
	Sweet-fern	<i>Comptonia peregrina</i>
	Threeleaf Goldthread	<i>Coptis trifolia</i>
	Canadian Bunchberry	<i>Cornus canadensis</i>
	Pink Lady's Slipper	<i>Cypripedium acaule</i>
	Swamp Loosestrife	<i>Decodon verticillatus</i>
	Northern Spicebush	<i>Lindera benzoin</i>
	Bird's-foot Trefoil	<i>Lotus corniculatus</i>
	Maleberry	<i>Lyonia ligustrina</i>
	Starflower	<i>Lysimachia borealis</i>
	Indian Cucumber Root	<i>Medeola virginiana</i>
	Pitch Pine	<i>Pinus rigida</i>
	White Oak	<i>Quercus alba</i>
Broadleaf Arrowhead	<i>Sagittaria latifolia</i>	
Little Bluestem	<i>Schizachyrium scoparium</i>	

	Poison-ivy	<i>Toxicodendron radicans</i>
	Painted Trillium	<i>Trillium undulatum</i>
	Tufted Vetch	<i>Vicia cracca</i>