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Inventory of Odonata (Dragonflies and Damselflies) at Sagamore Hill National Historic Site

Natural Resource Technical Report NPS/NCBN/NRTR—2010/192

ON THE COVER
Black saddlebags (*Tramea lacerata*) at Sagamore Hill National Historic Site
Photograph by Jaqueline Sones.

Inventory of Odonata (Dragonflies and Damselflies) at Sagamore Hill National Historic Site

Natural Resource Technical Report NPS/NCBN/NRTR—2010/192

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Abstract

We conducted a comprehensive baseline inventory of dragonflies and damselflies (Class Insecta, Order Odonata) at Sagamore Hill National Historic Site (SAHI) in Nassau County, New York. During 2004 and 2005 we conducted a checklist inventory at sites where odonates could potentially breed, as well as at potential migratory and foraging sites. Checklist walks are unrestricted, complete searches that provide an efficient means for initial determination of species presence. During the combined 2004 and 2005 field seasons, 22 species of odonates were documented across 7 survey sites. One state-listed species, comet darner (*Anax longipes*), was recorded at Field East Lot during 2004. This was the first recorded sighting of a comet darner in Nassau County. During 2004 and 2005, 291 individuals were sighted and 45 were collected as voucher specimens, representing 17 of the 22 species recorded. The most abundant odonate species at SAHI were common green darner (*Anax junius*), fragile forktail (*Ischnura posita*), great blue skimmer (*Libellula vibrans*), and black saddlebags (*Tramea lacerata*). Fields were the most widely used and important habitat for odonates at SAHI. In particular, Field East Lot and Field West of House supported the greatest species richness and abundance of odonates. Although we did not observe any migration events during our study, we believe that odonates likely use the fields at SAHI during migration. Overall, SAHI contains good foraging habitat and potential habitat for migrating odonates, but lacks suitable breeding habitat.

Keywords: biodiversity, damselflies, dragonflies, Sagamore Hill National Historic Site, insect, inventory, migration, odonate

Executive Summary

For the National Park Service to effectively maintain the existing dragonfly and damselfly (Class Insecta, Order Odonata) diversity of Sagamore Hill National Historic Site (SAHI) baseline knowledge of the present odonates assemblage is critical, including habitats within the park that support odonates and the abundance and viability of selected odonate species at such sites. To help meet this goal, we focused on three main objectives. The first objective was to conduct a comprehensive baseline inventory of adult odonates. The second objective was to document status, distribution, and relative abundance of rare species found within the park. The third objective was to document odonate migration events and behavior.

Potential survey sites containing breeding, feeding, and migrating habitats were identified by examining aerial photos, topographic maps, wetland maps, records of odonates provided by NPS staff, and consultation with local amateur odonatists. Each site was surveyed using the checklist technique, which entailed actively searching out odonates so that they could be caught and identified. Male and female vouchers were taken whenever possible at each site. Individuals that evaded capture but could be confidently identified in flight were recorded as sight records on field data sheets. Surveys were conducted once a month during the flight season, from May through September in 2004 and 2005.

During 2004 and 2005, 22 odonate species were recorded across 7 survey sites at SAHI. The most abundant odonate species were common green darner (*Anax junius*), fragile forktail (*Ischnura posita*), great blue skimmer (*Libellula vibrans*), and black saddlebags (*Tramea lacerata*). One state-listed species, comet darner (*Anax longipes*), was recorded at Field East Lot during 2004. This was the first recorded sighting of a comet darner in Nassau County and the only sighting of this species at the 3 National Parks in New York and New Jersey that were surveyed for odonates. Compared to the other National Parks (e.g., Fire Island National Seashore and Gateway National Recreation Area) surveyed for odonates during 2004 and 2005, SAHI contained fewer species and lower abundances of odonates. This is likely because SAHI lacks suitable breeding habitat. Nonetheless, results from this study doubled the number of known species within Nassau County.

Overall, SAHI contains good foraging habitat and potential habitat for migrating odonates, but lacks suitable breeding habitat. In general, odonates require permanent or temporary standing water to reproduce. Similarly, habitats with standing water usually support the greatest diversity and abundance of odonates. During 2004 and 2005, seasonal freshwater ponds at SAHI, such as Heron and Hog Pond, supported little breeding activity. Similarly, the salt marsh at Beach/Marsh lacked well developed salt pannes and did not support breeding odonates. We assume that most of the odonates recorded at SAHI are breeding in temporary waters in residential areas located within flying distance of the Park and are using the fields at SAHI for cover and feeding.

Fields were the most widely used and important habitat for odonates at SAHI. In general, fields support a broad assemblage of prey for odonates, provide cover from predators, provide shelter when temperatures drop at night, and provide perches where odonates can rest between feeding. At SAHI, larger fields showed greater species richness and supported greater abundances of odonates compared to smaller fields. In particular, Field East Lot and Field West of House

supported the greatest species richness and abundance of odonates. In general, researchers noted that un-mowed fields appeared to support more odonate activity than mowed fields.

Although we did not observe any migration events during our study, we believe that odonates likely use the fields at SAHI during migration, largely because SAHI is located within the odonate migration corridor and within a heavily developed landscape. In addition, many of the species we recorded in fields at SAHI are migratory, including common green darner, black saddlebag, wandering glider (*Pantala flavescens*), and spot-winged glider (*Pantala hymenaea*).

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Introduction

Although several lists of odonate (Class Insecta, Order Odonata) species have been compiled (Calvert 1895, 1897; Davis 1898, 1913; Donnelly 1992) counties in the New York metropolitan area have not been adequately sampled for odonates. Calvert (1895, 1897) was the first to publish a list of odonates known to occur in New York State. Davis (1898) wrote a preliminary list of the odonates of Staten Island. A second paper by Davis (1913) lists 117 species of odonate recorded in the vicinity of New York City and includes all previous odonate lists. The most recent summary of odonates in New York (Donnelly 1992) listed 175 species in the state with 79 species in Suffolk County, 11 species in Nassau County, and 69 species in the New York City area (19 species in Queens County, 8 species in Kings County, and 59 species in Richmond County).

For the National Park Service and Sagamore Hill National Historic Site (SAHI) to effectively to meet their responsibilities, including maintaining the distinctive biological diversity of SAHI, it first must identify what habitats within the park support odonates, inventory sites containing these habitats for adult odonates, and document the abundance and viability of selected odonate species. Odonates are well suited to inventories because they are a relatively small group of insects, and most adults can be readily identified in the field. Odonates begin their life cycle as aquatic insects and therefore may also provide valuable information about water quality and ecological management issues

The first objective of this project was to conduct a baseline inventory of adult odonates at SAHI. The second objective was to document the occurrence of any rare species of odonates at SAHI. Twenty-seven species are state listed in New York (NYNHP 2006). Several of the 27 species carry a S1 or S2 status[1] because their populations are declining, in part due to loss and degradation of habitat. If rare odonate species are present in the park, information such as breeding status, population estimates, and habitat requirements could be used to improve management of habitat for these species.

The third objective of this project was to document odonate migration events and migration behavior. Recent technological advances have improved our ability to investigate odonate migration and behavior, greatly improving our knowledge such phenomena (Moskowitz et al. 2001, Wikelski et al. 2006). Historically, migration was thought to be a dispersal mechanism (Johnson 1960). Recent work shows that migration is not limited to dispersal and is strongly correlated with cold front passages (Russell et al. 1998, Wikelski et al. 2006). In addition, large swarms of migrants are influenced by topographic leading lines such as coastlines (Russell et al. 1998, Wikelski et al. 2006). For example, odonates appear to move along and follow the

[1] A S1 rank means the NY Natural Heritage Program has determined that there are only "...five or fewer occurrences, very few individuals...or factors making it very vulnerable in New York State" (NYNHP 2006). A S2 rank means that there are only "...6-20 occurrences, few remaining individuals...or factors making it very vulnerable in New York State" (NYNHP 2006).

coastline after a cold fronts passes (Russell et al. 1998). Due, primarily, to its location along the Atlantic seaboard, SAHI is located within the odonate migration corridor (Shannon 1935).

Study Areas

SAHI is a 33 ha (83 acres) National Park located along the Cold Spring Harbor coastline on the northern third of Cove Neck, Nassau County, New York (Figure 1). It is dominated by a mature oak-tulip-hickory forest that is fragmented by several fields ranging in size between .03 and .11 h (0.08 and 2.6 acre). SAHI is bound by a tidal marsh to the east and contains two ponds, Heron Pond and Hog Pond. This Park is heavily visited by the public, both for guided tours and for unguided strolls through the grounds. Characteristic habitats for odonates at SAHI include seasonal freshwater ponds, saltwater marshes, beach, and fields. Each habitat can be utilized in different ways by odonates, such as for reproduction, cover, foraging, or migration.

Beaches and primary dunes are migration corridors for odonates (Shannon 1935, Russell et al. 1998). Odonate migration can occur in both spring and fall, but fall migrations are most pronounced and best understood. Along the northeastern U.S. coast, fall migrations often occur between late July and mid October following the passage of cold fronts which push odonates from the north to the southwest (Russell et al. 1998). It's also believed that major topographic features, such as beaches and dunes, concentrate insects as they migrate (Moskowitz et al. 2001).

In general, coastal fresh water ponds provide the most permanent environment for odonates and typically show the greatest abundance and diversity of odonate species (McClure C. 2001). While species that use permanent freshwater ponds, in general, can take advantage of coastal ponds, some species of conservation importance such as Needham's skimmer (*Libellula needhami*) are typically associated with these habitats.

Salt marshes with well developed salt pannes typically have high invertebrate diversity and density among barrier island habitat types. Of the 4 types of pannes found in salt marshes (e.g. deep perennial, shallow perennial, temporal, and vegetative pannes) temporal pannes exclude fish and thus, have the greatest diversity of invertebrates (Wilson 2005). Salt marshes, in general, offer important foraging areas for many odonate species, especially during fall migration, and also provide breeding habitat for certain species such as seaside dragonlet (*Erythrodiplax berenice*), familiar bluet (*Enallagma civile*) and Rambur's forktail (*Ischnura ramburii*), the latter being a species of conservation interest.

For this study, survey sites were selected based on their potential to support odonate breeding habitat, their position relative to likely migration routes, and recommendations from park service personnel (see Methods for more detail). All sites were surveyed once during each visit to SAHI during 2004. During 2005 the lack of rain rendered the only breeding habitat, Heron Pond, too dry to support odonate reproduction. As a result, SAHI was surveyed only once during the 2005 field season (See Discussion).

The following paragraphs describe each survey site in detail. Note that each odonate survey site was assigned natural community classifications based on both the National Vegetation Classification Standard (NVCS)(FGDC 1997) and the New York Natural Heritage Program (NYNHP) classifications (Edinger et al. 2002) (Table 1). In this report, we discuss habitat classifications using NVCS and only refer to NYNHP classifications when habitat at a given site was not recognized by NVCS. Photographs of survey sites are contained in Figures 2-5.

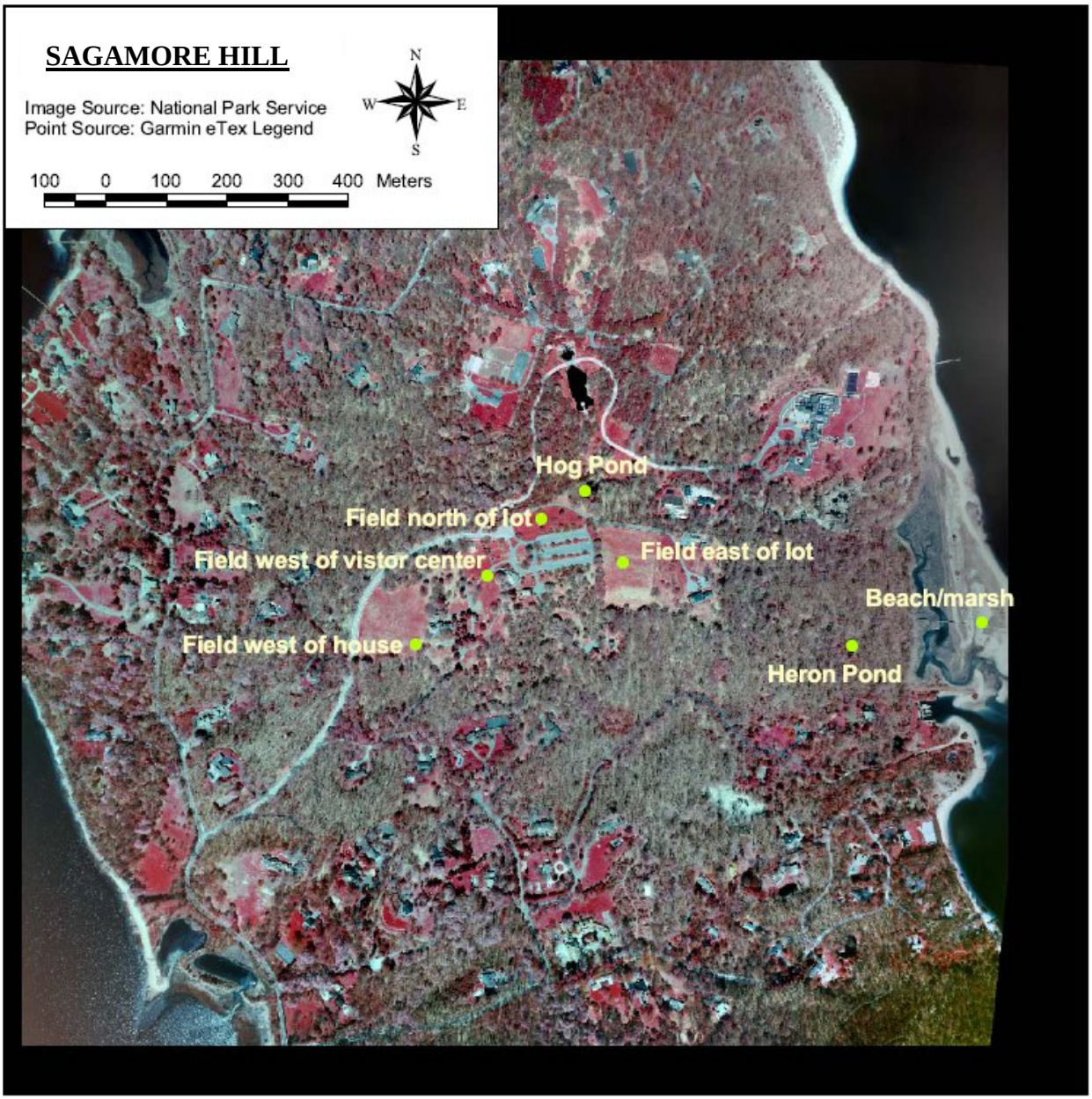

Figure 1. Odonate survey sites at Sagamore Hill National Historic Site during 2004.

Beach/marsh

On the eastern border of the park is a sandy beach, approximately 6 m (20 ft) wide, and a salt marsh (Figure 1). The salt marsh, located behind the beach, is connected to Cold Spring Harbor via a small tidal creek. Common reed (*Phragmites australis*) grows along the inland edge of the marsh. The marsh is inundated at high tide, making it unlikely odonate breeding habitat; however, the beach and marsh is potential migrating and foraging habitat.

Figure 2. Beach/marsh sites surveyed for odonates during 2004-2005 at Sagamore Hill National Historic Site, Nassau County, New York. Each sites habitat type is defined using National Vegetation Classification (NVC), if applicable, and NY Natural Heritage Program (NYNHP) classifications (in parentheses). Clockwise from top left: North Atlantic High Salt Marsh (High Salt Marsh), Northern Beachgrass Dune (Maritime Dune), and North Atlantic Low Salt Marsh (Low Salt Marsh).

Fields

Four fields were selected for surveys (Figure 1) because of their potential as foraging habitat. The fields are small, between .03 and .11 h (.08 and 2.6 acre), and are connected to each other by foot paths or surrounded by pavement. They are mowed throughout the growing season for public access and aesthetics. The fields are named in relation to visitor center: Field East of Lot, Field West of Visitor Center, Field West of House, and Field North of Lot.

Figure 3. Field sites surveyed for odonates during 2004-2005 at Sagamore Hill National Historic Site, Nassau County, New York. Each sites habitat type is defined using National Vegetation Classification (NVC), if applicable, and NY Natural Heritage Program (NYNHP) classifications (in parentheses). Clockwise from top left: Field East of Lot- Successional Old Field (Successional Old Field), Field West of Visitors Center- Successional Old Field (Successional Old Field), Field West of House- Successional Old Field (Successional Old Field), and Field North of Lot- Successional Old Field (Successional Old Field).

Heron Pond

Heron Pond is covered by a thick tulip-maple canopy, remains wet year round, and seasonally, contains standing water (Figure 1). The site is approximately 3 m (9.8 ft) in breadth (Figure 1) and is covered with a thick layer of leaf litter over deep mud. Invasive species such as multiflora rose (*Rosa multiflora*), english ivy (*Hedera helix*), and myrtle (*Myrtaceae spp.*) encroach on Heron Pond.

Figure 4. Heron Pond sites surveyed for odonates during 2004-2005 at Sagamore Hill National Historic Site, Nassau County, New York. Each sites habitat type was defined by NY Natural Heritage Program (NYNHP) classifications. Top: Vernal Pool, bottom: Shallow Emergent Marsh.

Hog Pond

Hog Pond is a seasonal pool under a thick maple canopy. As a result of the tree cover, this pool gets little sun. The size of Hog Pond varies seasonally and subject to seasonal drying. During this project it was observed to be approximately 7 m (22.96 ft) in breadth (Figure 1). There is little emergent vegetation and the surface of the pool is completely covered in a thick layer of pondweed (*Lemna minor*). This pool is adjacent to an access road for the park and has a drainage feature leading into it.

Figure 5. Hog Pond sites surveyed for odonates during 2004-2005 at Sagamore Hill National Historic Site, Nassau County, New York. Habitat type was defined as an Artificial Pond by the NY Natural Heritage Program (NYNHP) classifications.

Table 1. Coordinates and habitat types of sites surveyed for odonates during 2004-2005 at Sagamore Hill National Historic Site, Nassau County, New York. Coordinates were recorded using a handheld Garmin GPS V. Habitat types were defined using National Vegetation Classification (NVC) standards (FGDC 1997) and NY Natural Heritage Program (NYNHP) classifications (Edinger et al. 2002).

Site Name	NVC Habitat Type	NYNHP Habitat Type	UTMX	UTMY
Beach/marsh	North Atlantic High Salt Marsh; Northern Beachgrass Dune	High- and Low Salt Marsh; Maritime Dune	4527140.27	627176.19
Field east of lot	Successional Old Field	Successional Old Field	4527237.42	626585.83
Field north of lot	Successional Old Field	Successional Old Field	4527310.03	626452.37
Field west of house	Successional Old Field	Successional Old Field	4527104.43	626244.62
Field west of Visitors Center	Successional Old Field	Successional Old Field	4527216.55	626361.54
Heron Pond	-	Shallow Emergent Marsh; Vernal Pool	4527101.54	626963.08
Hog Pond	-	Artificial Pond	4527354.30	626523.53

Methods

Site Selection and Documentation

Potential breeding, feeding, and migrating sites were identified using the following approach. Aerial photos and USGS topographic maps were analyzed for landscape features that could provide odonate breeding, feeding, or migration habitat. In addition, wetland maps and records of odonates provided by NPS staff were reviewed and local amateur odonatists were consulted for their knowledge of the odonate habitats and fauna within SAHI.

Once the potential odonate sites were identified, each site was visited and its location recorded using a hand-held Garmin V GPS unit. To maximize the accuracy of GPS readings, Garmin GPS units were set to the 3D Differential mode. At sites where the canopy was too dense for the 3D mode to operate, the precision of the GPS reading was noted on NPS approved field data forms.

In the field, sites were assigned natural community classifications based on both the National Vegetation Classification Standard (NVCS)(FGDC 1997) and the New York Natural Heritage Program (NYNHP) classifications (Edinger et al. 2002) . In this report, we discuss habitat classifications using NVCS and only refer to NYNHP classifications when habitat at a given site was not recognized by NVCS (e.g. mowed lawn) (Table 1).

Potential Species Lists

A checklist of species likely to be found at SAHI (Appendix A) was generated using a four-step process. First, RINHS odonate specialists compiled a list of potential species that they would expect to find at SAHI based on their experience in habitat similar to that identified during the site selection process. Second, published lists of odonates in the Northeast (Donnelly 1999, Carpenter 1991, Walker 1953) were referenced for additional potential species based on habitat preference and distribution. Third, Park Service staff were consulted for their observations of odonates and knowledge of potential odonate habitat. Fourth, historical collections and biological repositories (e.g. American Museum of Natural History, Staten Island Museum, Smithsonian Museum of Natural History, and Yale University) were searched for any odonate species documented within Nassau County or, when possible, within the Park itself. All potential species were then compiled into a list (i.e. the Potential Species List), see Appendix A.

Field Surveys

Given that dragonflies are most active when temperatures are warm (Walker 1953, Carpenter 1991), site visits were made on sunny days when the temperature was at least 20°C. Site visits were conducted during the third week of each month, weather permitting. In 2004, sites were visited on five consecutive months (May, June, July, August, and September). During 2005, sites visited once in June. Cold and stormy weather during May 2005 did not permit sampling. No additional surveys were conducted after June 2005 as odonates specialists believed it was unlikely that any new species would be recorded and any potential breeding habitat contained little or no standing water (see Results and Discussion).

During the survey period, weather data were recorded using a Kestral 4000 (Neilson-Tellerman) once each day. However, additional data were recorded if weather conditions changed significantly during the day. Weather variables recorded at each site were: temperature (°C), wind speed and direction, relative humidity, and barometric pressure. Weather data were recorded in field notes and then transferred to NPS approved field forms.

During the 2003 study season, one researcher (JS) visited SAHI to determine site possibilities and ground truth potential habitat descriptions. During 2004 and 2005, sites were surveyed by groups of two to four researchers, including one to two odonate specialists (Table 2). All non-specialists had a working knowledge of common odonates and were trained in odonata field techniques. Field researchers netted, identified, and assisted process specimens and completed field data form. Each field data form was verified by either the project leader or the odonata specialist before leaving the field site.

Each site was surveyed for odonates using the "checklist counting technique" as described by Royer et al. (1998), which is one of the most efficient ways to initially determine species presence at a site (Royer et al. 1998). Briefly, this technique required that investigators move through a site actively looking for, identifying, and counting odonates as encountered. When odonates could be confidently identified in flight, individuals were recorded as sight records on field data sheets. When possible, a male and female voucher specimen of each species was collected from each site. Voucher specimens were caught using 1.5 m (5 ft) aerial nets. Netted specimens were placed in glassine envelopes until they could be processed. Each glassine envelope was labeled using pencil with the date, location, and genus/species information. In addition, data regarding voucher specimens were recorded on voucher cards (see Figure 6) and placed in glassine envelopes with each voucher specimen after processing.

Although most odonate species are easily identified in the field, when necessary, final determination of each species was verified using a microscope in the lab. For example, some damselflies, such as sweetflag spreadwing (*Lestes forcipatus*), southern spreadwing (*Lestes australis*), common spreadwing (*Lestes disjunctus*) cannot be distinguished from another in the field, therefore we collected several voucher specimens to determine whether a given species was in fact present at a given site.

Table 2. Researchers that visited survey sites at Sagamore Hill National Historic Site, Nassau County, New York, during 2003-2005.

	2003	2004					2005				
	June	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.
Researcher initials*	JS	JS, NB	JS, NB	JS, MV, NB, SJ	JS, NB, SJ	JS, NB	-	ET, NB	-	-	-

* ET: Emily Troiano, JS: Jaqueline Sones, MV: Michael Veit, NB: Nina Briggs, SJ: Sarah Jennings

Voucher Specimen Processing

Specimens were processed and stored following standard procedures described by Dunkle (1990). Briefly, each specimen was placed in a glassine envelope and submerged in acetone for ~ 3 min. Specimens were then removed from the acetone and arraigned for storage with the body facing left, eyes facing up, wings placed over the back, and the legs and abdomen straightened (Dunkle 1990, Brunelle 1994). Each specimen was then put in a glassine envelope and returned to the acetone to remove lipids and water and preserve color. Larger specimens were processed in acetone for approximately 24 hours; smaller specimens were processed for 12 hours. After being removed from the second acetone treatment, specimens were dried under a light and stored in airtight containers until they could be put in insect cases in the lab.

Voucher Field #:	**Date:**
ParkCode:	Time:
Park Unit:	Collected by:
SiteID:	Determined by:
Town:	Species:
County:	Male/Female
State:	Age:
Location Notes:	Behavior:
	GraphicID#:

Figure 6. Example of voucher card template used for all voucher specimens collected during the 2004-2005 odonate survey of Sagamore Hill National Historic Site, Nassau County, New York.

Migration Events Monitoring

Odonate migration events are largely influenced by weather patterns, such as passing cold fronts that occur between late July and mid-October (Russell et al. 1998). The peak of odonate migration usually occurs during September (Russell et al. 1998) and therefore, sampling dates were predetermined, in part, to assure that at least one survey was conducted during a possible peak-migration period (e.g. survey conducted during the third week of the September 2004). During all field surveys, but especially those conducted during September, investigators monitored for possible migration events. For this study, a migration event was defined as a swarm or large group of dragonflies or damselflies moving together in same direction. Migration events have been documented using different approaches across the region; however, results are comparable providing that that estimates contain the number of individuals moving through a specific area (e.g. 1 m^2) during an interval of time (Russell et al. 1998). Therefore, in this study researchers chose to document and quantify a migration event by counting individual odonates as they fly overhead (e.g. 1 m^2) using 10-min intervals, for the duration of the migration event. After a migration event had ceased, the total number of each species was quantified.

Data Analysis

Species Inventory

To quantify the status, distribution, and abundance of odonate species found within the park, data collected during field surveys were entered into an Access database and queries were run to determine the abundance and distribution of each odonate species at SAHI. Outputs of each query were summarized using Excel. Biological diversity of odonate species at SAHI was quantified for each survey site using a measure of species richness. Species richness is defined as the total number of species present in a given area.

Investigator Effort

To provide a measure of investigator effort we calculated the raw and adjusted survey effort for each site (Appendix B). Raw effort was defined as the total number of survey hours conducted by all investigators at each site. Adjusted effort was calculated by weighting the raw effort of a given researcher by their level of experience. For example, survey time committed by odonate specialists (e.g. J.S., M.V., N.B.) served as the standard by which others were weighted. Thus, the time taken by odonate specialists to conduct surveys was multiplied by a factor of 1.0. Survey time conducted by other researchers was multiplied by either 0.75 (E.T.) or 0.5 (S.J.) based on the capacity of each researcher to conduct surveys and process specimens independently. These measures of Investigator Effort may be applicable to future odonate surveys and could be used to determine the repeatability of the results presented in this report.

Results

Species Inventory

During 2004 and 2005, 22 odonate species were identified across 7 survey sites at SAHI (Table 3). Twenty-one species were recorded and identified during 2004 *(n* = 1,167 survey minutes; Appendix B) and 1 additional species was detected during 2005 *(n* = 220 survey minutes; Appendix B (Table 4, Figure 7). Of the 22 species recorded at SAHI, 17 species were dragonflies and 5 were damselflies (Table 4). During 2004 and 2005, 45 voucher specimens were collected representing 17 of the 22 species documented at SAHI (Table 3). Given that only 11 odonate species had previously been recorded in Nassau County (Donnelly 1999), results from this study have doubled the number of known species within the county.

Of the 3 National Parks in New York and New Jersey surveyed for odonates during 2004 and 2005 (e.g., Fire Island National Seashore [FIIS], Gateway National Recreation Area [GATE], and SAHI), SAHI showed the lowest species richness and number of sites with odonate species (Table 5). At SAHI, Field East Lot showed the greatest species richness *(n* = 13), followed by Field West of House *(n* = 10) (Table 6). The most abundant odonate species at SAHI were common green darner (*Anax junius*) *(n* = 99), fragile forktail (*Ischnura posita*) *(n* = 27), great blue skimmer (*Libellula vibrans*) *(n* = 24), and black saddlebags (*Tramea lacerata*) *(n* = 23) (Table 3).

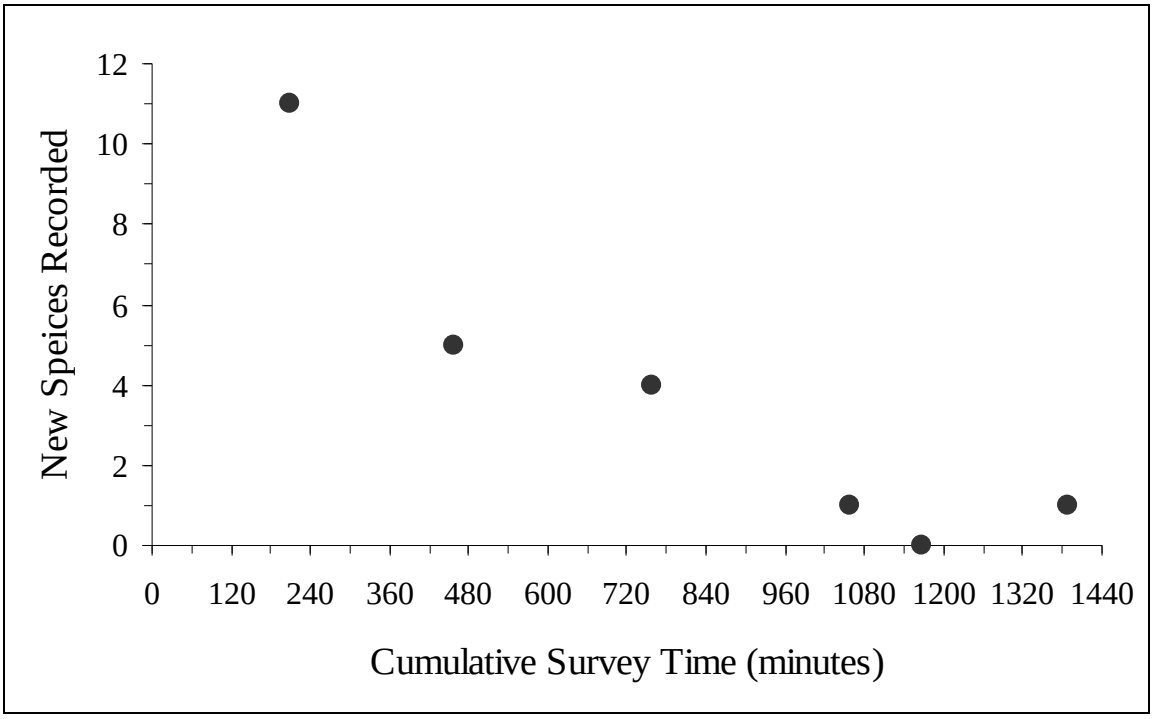

Figure 7. New species recorded by cumulative survey time (min) at Sagamore Hill National Historic Site, New York, 2004-2005 (*n* = 1,387 min total). Cumulative survey time was calculated using Raw Effort (see Appendix B and Methods).

Table 3. Abundance of odonate species by site at the Sagamore Hill National Historic Site, Nassau County, New York, during 2004-2005. Abundance is presented as sight records followed by voucher specimens in parenthesis. Common names of species are presented in Table 4.

Species Name	Beach Marsh	Field East Lot	Field North Lot	Field West of House	Field West of VC	Heron Pond	Hog Pond	Total
Anax junius	10	41	1 (1)	45 (2)	2 (1)			99 (4)
Anax longipes [a]		1						1
Celithemis eponina		1 (1)		11 (2)				12 (3)
Enallagma civile		3 (2)	1 (1)	1 (1)	2 (2)			7 (6)
Epiaeschna heros		1		2				3
Epitheca cynosura		1				1		2
Erythemis simplicicollis			2 (1)					2 (1)
Erythrodiplax berenice	1 (1)							1 (1)
Ischnura hastata		1 (1)			1 (1)			2 (2)
Ischnura posita						11 (1)	16 (2)	27 (3)
Ischnura verticalis							25	25
Lestes rectangularis						4 (4)		4 (4)
Libellula luctuosa				1 (1)				1 (1)
Libellula lydia						1		1
Libellula pulchella	1	1				4 (1)		6 (1)
Libellula semifasciata		2 (1)	1 (1)		1			4 (2)
Libellula vibrans						22 (2)	2	24 (2)
Pachydiplax longipennis	4 (1)	1		1 (1)		1		7 (2)
Pantala flavescens	2 (2)	2 (1)	1	4	2			11 (3)
Pantala hymenaea	5	3 (2)	2	4				14 (2)
Sympetrum internum				2 (2)		12 (5)	1	15 (7)
Tramea lacerata	6	9		8 (1)				23 (1)
Total	29 (4)	67 (8)	8 (4)	79 (10)	8 (4)	56 (13)	44 (2)	291 (45)

[a] State listed in NY

Table 4. Odonate species recorded by year at Sagamore Hill National Historic Site, Nassau County, New York, during 2004-2005.

		Recorded	
Common Name	ScientificName	2004	2005
- Damselflies -			
Familiar bluet	*Enallagma civile*	X	X
Citrine forktail	*Ischnura hastata*	X	
Fragile forktail	*Ischnura posita*	X	X
Eastern forktail	*Ischnura verticalis*		X
Slender spreadwing	*Lestes rectangularis*	X	
- Dragonflies -			
Common green darner	*Anax junius*	X	X
Comet darner [a]	*Anax longipes* [a]	X	
Halloween pennant	*Celithemis eponina*	X	
Swamp darner	*Epiaeschna heros*	X	
Common baskettail	*Epitheca cynosura*	X	
Eastern pondhawk	*Erythemis simplicicollis*	X	
Seaside dragonlet	*Erythrodiplax berenice*	X	
Widow skimmer	*Libellula luctuosa*	X	
Common whitetail	*Libellula lydia*	X	
Twelve-spotted skimmer	*Libellula pulchella*	X	X
Painted skimmer	*Libellula semifasciata*	X	X
Great blue skimmer	*Libellula vibrans*	X	X
Blue dasher	*Pachydiplax longipennis*	X	X
Wandering glider	*Pantala flavescens*	X	
Spot-winged glider	*Pantala hymenaea*	X	
Cherry-faced meadowhawk	*Sympetrum internum*	X	
Black saddlebags	*Tramea lacerata*	X	X
Totals			

[a] State listed in NY

State-listed species

During 2004, we recorded 1 state-listed species, comet darner (*Anax longipes*) (Table 4). This species was foraging when recorded at Field East Lot on 21 June 2004. This was the only sighting of this species at the 3 National Parks in New York and New Jersey surveyed for odonates during 2004 and 2005 (Table 5). In addition, this was the first recorded sighting of a comet darner in Nassau County (Donnelly 1999).

Migration Events

Migration events were not observed at odonate survey sites at SAHI during 2004 and 2005.

Table 5. Summary of odonate species recorded during 2004-2005 at Fire Island National Seashore (FIIS), Gateway National Recreation Area (GATE), and Sagamore Hill National Historic Site (SAHI)

		Number of Sites Where		Number of		
Location	Species Richness	Species were Recorded	Rare Species were Recorded	Rare Species Recorded	Species with Voucher Specimens	Voucher Specimens Collected
FIIS	27	18	5	2	25	92
GATE	37	38	12	2	36	353
SAHI	22	7	1	1	17	45
Total	--	63	18	3	--	490

Table 6. Species richness and proportion of species recorded compared to the Potential Species List (Appendix A) at Sagamore Hill National Historic Site, Nassau County, New York, during 2003-2005.

		Proportion of	
Site Name	Species Richness	Total species recorded	Potential Species List recorded
Beach Marsh	7	0.32	0.13
Field East Lot	13	0.59	0.25
Field North Lot	6	0.27	0.11
Field West of House	10	0.45	0.19
Field West of VC	5	0.23	0.09
Heron Pond	8	0.36	0.15
Hog Pond	4	0.18	0.08
Totals	22	1.00	0.42

Discussion

Species Inventory

During 2004 and 2005, we documented 22 species of odonates at SAHI. The majority (95%) of these species were first recorded during the 2004 field season (*n* = 21 species) and only 1 additional new species was recorded during 2005 (Table 4). We note that during 2005 we conducted only 1 survey at SAHI (21 June 2005). During this survey, researchers observed little foraging activity by odonates and found that both seasonal freshwater ponds and the saltwater marsh lacked viable breeding habitat for odonates. The overall trend in new species detected (Figure 7), combined with observations of odonate habitat and behavior suggested that substantial survey effort would have been required to document one additional new species at SAHI. Therefore, no further odonate surveys were conducted after 21 June 2006 at SAHI.

The results of this study have doubled the number known species within Nassau County (Donnelly 1999). Since all but one of the species (e.g., comet darner) recorded during this study have previously been detected in surrounding counties (Suffolk and Queens County), their previous absence from the Nassau County lists is likely due to lack survey effort within Nassau County. Nonetheless, it is obvious that compared to previous sites surveyed for odonates in Nassau County, fields at SAHI support a considerable number of odonate species.

Overall, SAHI contains good foraging habitat, but lacks suitable breeding habitat for odonates. In general, most odonate species require permanent water to complete their life cycle; although, some species are capable of reproducing in temporary waters (Walker 1953). During 2004 and 2005, season freshwater ponds at SAHI, such as Heron and Hog Pond, supported little breeding activity. For example, Heron Pond contained standing water for most of 2004, yet we observed oviposition by 2 cherry faced meadowhawks (*Sympetrum internum*) and 1 great blue skimmer. In addition, we did not observe any breeding at Hog Pond, likely because the thick layer of pond weed excluded odonates from breeding. The salt marsh at Beach/Marsh also did not support breeding odonates. We suspect that seaside draonglets are not breeding in the marsh, primarily, because the marsh lacked well developed salt pannes and was either inundated with water or dry when surveyed. Overall, we believe that most of the odonates recorded at SAHI are breeding in man-made pools (i.e., temporary waters) in residential areas located within flying distance of the Park and are using the fields at SAHI for cover and feeding.

Fields were the most widely used and important habitat for odonates at SAHI (Table 3, 6). In general, fields support a broad assemblage of prey for odonates, provide cover from predators, provide shelter when temperatures drop at night, and provide perches where odonates can rest between feeding. At SAHI, larger fields showed greater species richness and supported greater abundances of odonates compared to smaller fields (Table 3, 6). For example, Field East Lot, which is the largest field, showed the greatest species richness and abundance of odonates at SAHI (Table 3, 6). We note that the only known sighting of a comet darner in Nassau County was from Field East Lot during 2004. Comet darners are usually associated with coastal ponds (Carpenter, 1991), which are not present at SAHI, and therefore this individual was likely using the field for feeding and/or cover. The Field West of House also showed great species richness and abundance of odonates (Table 3, 6). Similar to Field East Lot, Field West of House is one of the larger fields at SAHI. We suspect that many of the odonate species that breed within flying distance of the Park use the fields at SAHI for cover and foraging habitat. Therefore, fields at

SAHI may offer one of the best locations within Nassau County for sampling odonate species, as well as prime foraging habitat for adult odonates.

During 2004 researchers noted that un-mowed fields appeared to support more odonate activity than mowed fields. For example, surveys conducted at Field East Lot prior to mowing (May 2004) recorded 3-times the number of odonate species compared to after mowing (June 2004). Similarly, the record of a comet darner in Nassau County was taken in this Field prior to mowing. In addition, researchers noted that many odonate species appeared to be using tall grass as cover, including common green darners, citrine forktails (*Ischnura hastata*), and familiar bluets. Researchers also observed Halloween pennant dragonflies (*Celithemis eponina*) perched on tall grasses between feeding flights. In contrast, after fields were mowed grasses were not tall enough to be used as cover or perches. Overall, researchers believed that mowing of fields negatively influenced odonate abundance and diversity.

Migration events

Although we did not observe any migration events during our study, we do not infer that migrating odonates do not use habitat at SAHI. In fact, given that SAHI is located within the migration corridor (Shannon 1935) and within a heavily developed landscape, it's likely that odonates use the fields at SAHI during migration. We note that many of the species we recorded in fields at SAHI are migratory, including common green darner, black saddlebag, wandering glider (*Pantala flavescens*), and spot-winged glider (*Pantala hymenaea*).

Conclusion

During 2004 and 2005, 22 odonate species were recorded across 7 survey sites at SAHI. The most abundant odonate species were common green darner, fragile forktail, great blue skimmer, and black saddlebags. One state-listed species, comet darner, was recorded at Field East Lot during 2004. This was the first recorded sighting of a comet darner in Nassau County and the only sighting of this species at the 3 National Parks in New York and New Jersey that were surveyed for odonates. Compared to the other National Parks (e.g., Fire Island National Seashore and Gateway National Recreation Area) surveyed for odonates during 2004 and 2005, SAHI contained fewer species and lower abundances of odonates. This is likely because SAHI lacks suitable breeding habitat. Nonetheless, results from this study doubled the number of known species within the Nassau County (Donnelly 1999).

Overall, SAHI contains good foraging habitat and potential habitat for migrating odonates, but lacks suitable breeding habitat. Recall that odonates require either permanent or temporary standing water to reproduce (Walker 1953). In general, habitats with standing water show the greatest species richness and diversity of odonate species. During 2004 and 2005, seasonal freshwater ponds at SAHI, such as Heron and Hog Pond, supported little breeding activity. Similarly, the salt marsh at Beach/Marsh lacked well developed salt pannes and did not support breeding odonates. We assume that most of the odonates recorded at SAHI are breeding in temporary waters in residential areas located within flying distance of the Park and are using the fields at SAHI for cover and feeding.

Fields were the most widely used and important habitat for odonates at SAHI. In general, fields support a broad assemblage of prey for odonates, provide cover from predators, provide shelter when temperatures drop at night, and provide perches where odonates can rest between feeding. At SAHI, larger fields showed greater species richness and supported greater abundances of odonates compared to smaller fields. In particular, Field East Lot and Field West of House supported the greatest species richness and abundance of odonates. In general, researchers noted that un-mowed fields appeared to support more odonate activity than mowed fields.

Although we did not observe any migration events during our study, we believe that odonates likely use the fields at SAHI during migration, largely because SAHI is located within the odonate migration corridor (Shannon 1935) and within a heavily developed landscape. In addition, we note that many of the species we recorded in fields at SAHI are migratory, including common green darner, black saddlebag, wandering glider, and spot-winged glider.

Recommendations for Future Monitoring

Given the high measures of odonate diversity at both Field East Lot and Field West of House, we suggest the following recommendation for future monitoring.

1. We recommend that odonate surveys be conducted for 1-2 hours at Field East Lot and Field West of House prior to the mowing of these fields, when that grasses are > 1m in height from late-May to mid-September.

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Appendix A.
Potentially occuring odonate species (i.e. Potential Species List) at Sagamore Hill National Historic Site, Nassau County, New York.

Potential Species List was based on expert opinion, published lists of odonates in the Northeast (Donnelly 1999, Carpenter 1991, Walker 1953), observations of NPS staff, and historical collections and biological repositories (see Methods for details).

Common Name	Scientific Name
- Damselflies -	
Eastern red damsel	*Amphiagrion saucium*
Great spreadwing	*Archilestes grandis*
Aurora damsel	*Chromagrion conditum*
Azure bluet	*Enallagma aspersum*
Familiar bluet	*Enallagma civile*
Big bluet	*Enallagma durum*
Orange bluet	*Enallagma signatum*
Vesper bluet	*Enallagma vesperum*
Citrine forktail	*Ischnura hastata*
Fragile forktail	*Ischnura posita*
Rambur's forktail *	*Ischnura ramburii* *
Eastern forktail	*Ischnura verticalis*
Southern spreadwing	*Lestes australis*
Spotted spreadwing	*Lestes congener*
Common spreadwing	*Lestes disjunctus*
Amber-winged spreadwing	*Lestes eurinus*
Sweetflag spreadwing	*Lestes forcipatus*
Elegant spreadwing	*Lestes inaequalis*
Slender spreadwing	*Lestes rectangularis*
Swamp spreadwing	*Lestes vigilax*
Sphagnum sprite	*Nehalennia gracilis*
Sedge sprite	*Nehalennia irene*
- Dragonflies -	
Common green darner	*Anax junius*
Calico pennant	*Celithemis elisa*
Halloween pennant	*Celithemis eponina*
Banded pennant	*Celithemis fasciata*
Martha's pennant	*Celithemis martha*
Petite emerald	*Dorocordulia lepida*
Swamp darner	*Epiaeshna heros*

Appendix A. Potentially occuring odonate species (i.e. Potential Species List) (continued).

Common Name	**Scientific Name**
- Dragonflies - (continued)	
Common baskettail	*Epitheca cynosura*
Mantled baskettail *	*Epitheca semiaquea* *
Eastern pondhawk	*Erythemis simplicicollis*
Seaside dragonlet	*Erythrodiplax berenice*
Lancet clubtail	*Gomphus exilis*
Bar-winged skimmer	*Libellula axelina*
Spangled skimmer	*Libellula cyanea*
White corporal	*Libellula exusta*
Slaty skimmer	*Libellula incesta*
Widow skimmer	*Libellula luctuosa*
Common whitetail	*Libellula lydia*
Needham's skimmer *	*Libellula needhami* *
Twelve-spotted skimmer	*Libellula pulchella*
Painted skimmer	*Libellula semifasciata*
Great blue skimmer	*Libellula vibrans*
Blue dasher	*Pachydiplax longipennis*
Wandering glider	*Pantala flavescens*
Spot-winged glider	*Pantala hymenaea*
Eastern amberwing	*Perithemis tenera*
Cherry-faced meadowhawk	*Sympetrum internum*
Ruby meadowhawk	*Sympetrum rubicundulum*
Carolina saddlebags	*Tramea carolina*
Black saddlebags	*Tramea lacerate*

* Species listed as imperiled in New York (NYNHP 2006)

Appendix B.
Investigator Effort (min) during odonate surveys conducted at Sagamore Hill National Historic Site, New York, 2004-2005.

Raw effort is the total number of survey minutes conducted by all investigators at each site. Adjusted effort was calculated by weighting the raw effort of a given researcher by their level of experience (see Methods for details).

	2004 Effort		2005 Effort		Total Effort	
Site Name	Raw	Adjusted	Raw	Adjusted	Raw	Adjusted
Beach Marsh	159	144	40	35	199	179
Field East Lot	284	264	50	44	334	308
Field North Lot	65	60	20	18	85	77
Field West of House	295	270	40	35	335	305
Field West of VC	104	96	20	18	124	114
Heron Pond	170	160	30	26	200	186
Hog Pond	90	85	20	18	110	102
Total	1,167	1,079	220	193	1,387	1,272

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