



Inventory of Odonata (Dragonflies and Damselflies) at Fire Island National Seashore

Natural Resource Technical Report NPS/NCBN/NRTR—2010/295



ON THE COVER

Common green darner (*Anax junius*) in Fire Island National Seashore.
Photograph by Jackie Sones

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Natural Resource Technical Report NPS/NCBN/NRTR—2010/295

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Contents

	Page
Figures.....	vii
Tables.....	ix
Abstract.....	xi
Executive Summary	xiii
Acknowledgments.....	xv
Introduction.....	1
Study Area	3
Survey Sites on the Mainland at the William Floyd Estate	5
<i>William Floyd Salt Marsh</i>	5
<i>William Floyd Estate - Seep</i>	5
<i>William Floyd Estate -Teal Pond</i>	6
<i>William Floyd Estate -Home Creek</i>	6
<i>William Floyd Estate Fields</i>	6
Survey Sites on Fire Island	7
<i>Kismet Pond</i>	7
<i>Sunken Forest -Wet Depressions #1-7</i>	8
<i>Sailor’s Haven Maintenance Pond</i>	9
<i>Sailor’s Haven Entrance Road</i>	9
<i>Fire Island Pines -Carrington Swamp</i>	10
<i>Fire Island Pines -Smokey Hollow Bog</i>	10
<i>Talisman Road</i>	11
<i>Watch Hill House 12</i>	12
<i>Watch Hill Marsh</i>	12

<i>Otis Pike Wilderness Area (OPWA) Bellport Beach Marsh West and Bellport Marsh East</i>	13
<i>OPWA Bellport Salt Marsh</i>	13
<i>OPWA, Bellport Swales #1-3</i>	13
Methods.....	15
Site Selection and Documentation.....	15
Potential Species Lists	15
Field Surveys	15
Voucher Specimen Processing	17
Migration Events Monitoring	17
Data Analysis.....	17
<i>Species Inventory</i>	17
<i>Investigator Effort</i>	18
Results.....	19
Species Inventory.....	19
<i>Species inventoried on the Mainland</i>	19
<i>Species inventoried on Fire Island</i>	21
Rare Species Inventoried	22
Recorded vs. Potential Species List.....	22
Categorical Abundance.....	24
Migration Events	29
Discussion	31
Mainland Sites	32
<i>Sites with high conservation value</i>	32
<i>Other sites of potential interest</i>	33
Sites on Fire Island	33

<i>Sites with high conservation value</i>	33
<i>Other sites of potential interest</i>	34
Potential Threats to Odonate Populations.....	34
Conclusion	37
Recommendations for Future Monitoring	38
Literature Cited	41

Figures

	Page
Figure 1. Overview of Odonate survey sites at Fire Island National Seashore, New York, 2004-2005	3
Figure 2. Map of Odonate survey sites at Fire Island National Seashore, New York: William Floyd Estate, 2004 and 2005.....	4
Figure 3. Map of Odonate survey sites at Fire Island National Seashore, New York: Kismet Pond, 2004 and 2005.....	7
Figure 4. Map of Odonate survey sites at Fire Island National Seashore, New York: Sunken Forest, 2004-2005.	8
Figure 5. Map of Odonate survey sites at Fire Island National Seashore, New York: Sailors Haven, 2004-2005.....	9
Figure 6. Map of Odonate survey sites at Fire Island National Seashore, New York: Fire Island Pines, 2004-2005.....	10
Figure 7. Map of Odonate survey sites at Fire Island National Seashore, New York: Talisman, 2004-2005	11
Figure 8. Map of Odonate survey sites at Fire Island National Seashore, New York: Watch Hill, 2004-2005.	12
Figure 9. Map of Odonate survey sites at Fire Island National Seashore, New York: Bellport, 2004-2005.	13
Figure 10. New species recorded by cumulative survey time (n = 3,967-min) at Fire Island National Seashore, New York, during 2004-2005.....	21

Tables

	Page
Table 1. Sites surveyed for odonates at Fire Island National Seashore, Suffolk County, New York, in 2004 and 2005.	14
Table 2. Researchers that visited survey sites at Fire Island National Seashore, Suffolk County, New York, during 2003-2005.	16
Table 3. Odonate species (damselflies and dragonflies) recorded at Fire Island National Seashore, New York, in 2004 and 2005 (n = 27).	20
Table 4. Abundance of odonate species by site at Fire Island National Seashore, New York, during 2004-2005.	23
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).	24
Table 6. Categorical abundance of odonate recorded per site at Fire Island National Seashore, New York, 2004-2005.	25
Table 7. Species richness and proportion of species recorded compared to the Potential Species List (Appendix C) at Fire Island National Seashore, New York, during 2004-2005	29
Table 8. Habitat types where odonate species were recorded at Fire Island National Seashore, New York, during 2004-2005.	30

Abstract

In order to expand knowledge of odonate biodiversity and to make recommendations for management, we conducted a comprehensive baseline inventory of dragonflies and damselflies (Class Insecta, Order Odonata) at Fire Island National Seashore (FIIS), Suffolk 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. 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, 27 species of odonates were documented across 18 of the 34 sites surveyed. Two New York state listed species were observed, Rambur's forktail (*Ischnura ramburii*) and Needham's skimmer (*Libellula needhamii*). Of the 847 individuals sighted during 2004 and 2005, 92 were collected as voucher specimens, representing 25 of the 27 species recorded. The most widely distributed species included common green darner (*Anax junius*), seaside dragonlet (*Erythrodiplex berenice*), painted skimmer (*Libellula semifasciata*), and spot-winged glider (*Pantala hymenaea*). Of all sites surveyed during 2004 and 2005, Kismet Pond showed the greatest abundance ($n = 481$ individuals) and species richness (0.85) of odonates. Migration events were not observed during odonate surveys; however, a migration event was documented by one researcher at Bellport Beach at the Otis Pike Wilderness Area during 2004. Overall, FIIS contains few habitats that are appropriate for odonate reproduction; however, several sites offer good foraging and migration habitat.

Keywords: biodiversity, damselflies, dragonflies, migration, insect, inventory, odonate, Fire Island National Seashore

Executive Summary

For the National Park Service to effectively maintain the existing dragonfly and damselfly (Class Insecta, Order Odonata) diversity of Fire Island National Seashore (FIIS), 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.

Because odonates are aquatic insects, potential breeding habitat was located by examining maps associated with an amphibian and reptile inventory conducted by the Wildlife Conservation Society in 2002, aerial photos, topographic maps, wetland maps provided by NPS staff, and consultation with local amateur odonatists. Databases and museum collections were also researched for historic records.

Each site was walked using a checklist technique, which entails 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.

Twenty-seven odonate species were documented across 18 of the 34 sites surveyed at FIIS during 2004 and 2005. Two of these species are state listed in New York, Needham's skimmer (*Libellula needhami*) and Rambur's forktail (*Ischnura ramburii*). Both of these species were documented in 2004; however, only Needham's skimmer was documented in 2005. The most widely distributed species at FIIS included common green darner (*Anax junius*), seaside dragonlet (*Erythrodiplax berenice*), painted skimmer (*Libellula semifasciata*), and spot-winged glider (*Pantala hymenaea*).

In general, survey sites at FIIS contained appropriate migratory and foraging habitat, but generally lacked habitats appropriate for odonate reproduction, because few areas contained ponds, lakes, or streams with permanent water. Of all sites surveyed at FIIS, Kismet Pond showed the greatest species richness and abundance of odonates, largely due the permanent water levels observed during 2004 and 2005. Also, Needham's skimmer, a state listed species in New York that is typically associated with coastal pond habitats, was found to in large numbers at Kismet Pond.

Survey sites at the William Floyd Estate primarily served as foraging habitat for odonate species. We found that the larger fields (Field F12, G7, H9) showed greater species richness and abundance of odonates. Needham's skimmer was recorded in two fields (e.g. Field F12 and H9) at the William Floyd Estate. Based on the habitat available at the William Floyd Estate, we expected to find greater diversity of foraging odonates than what was observed and suspect that the generally dry weather during 2005 may have reduced the number of foraging odonates in a these habitats. It is also possible that spraying for mosquitoes in surrounding towns also reduced food supplies for foraging odonates.

FIIS is located within the odonate migration corridor and offers important habitat for migrating odonates. In particular, several sites at the Otis Pike Wilderness Area (OPWA) possess high conservation value for odonate migration, including both Bellport Salt Marsh and Bellport Beach. Both of these areas have shown to support migration events during fall migration. Although migration events were not observed during odonate surveys, a migration event of common green darners was documented by one researcher at Bellport Beach during September of 2004. Given its location along the Atlantic coast, the Bellport Beach area is likely to also provide habitat for other species of odonate during migration, such as blue dasher (*Pachydiplax longipennis*), black saddlebags (*Tamea lacerata*), Carolina saddlebags (*Tamea carolina*), and swamp darner (*Epideschna heros*).

In general, current management practices at most survey sites appear to have either a neutral or beneficial effect on odonate populations at FIIS. For example, FIIS protects its vegetative communities by prohibiting off-road vehicle use, except in designated areas, and foot traffic, except on marked trails, roads, or boardwalks. Both of these measures, by design, protect fragile habitats (e.g. northern interdunal cranberry swale, northern bayberry dune shrubland, etc.) commonly used by odonate species. We note that the greatest threat to odonate breeding habitat and similarly, odonate populations in general, is the abundance of common reed (*Phragmites australis*) at many odonate survey sites, including Bellport Salt March, Kismet Pond, and Watch Hill Marsh. Common reed out competes native plants, changes invertebrate abundance and assemblages, affects site hydrology, and can reduce diversity of damselfly species. We recommend that in addition to continuing surveys several sites, including Kismet Pond, the Seep, and Teal Pond that common reed be monitored and if deemed necessary, managed for at Bellport Salt March, Kismet Pond, and Watch Hill Marsh.

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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 (with 19 species in Queens County, 8 species in Kings County, and 59 species in Richmond County).

For the National Park Service and Fire Island National Seashore (FIIS) to effectively to meet their responsibilities, including maintaining the distinctive biological diversity of FIIS, 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 FIIS. The second objective was to document the occurrence of any rare species of odonates at FIIS. Twenty-seven species are state listed in New York (NYNHP 2006). Several of the 27 species carry a S1 or S2 status¹ 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 coast

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).

line after a cold fronts passes (Russell et al. 1998). Due to its location along the Atlantic seaboard and given that FIIS is a barrier beach, FIIS is within the odonate migration corridor (Shannon 1935).

Study Area

Fire Island National Seashore (FIIS) is a 7,923 ha (19,587 acres) National Park located along the Atlantic coastline in Suffolk County, New York (Figure 1). It encompasses the 259 ha (640 acres) William Floyd Estate (40°46'N, 72°49'W) on Long Island and 7,664 ha (18,938 acres) of scattered parcels along the 51 km (32 mi) long barrier beach of Fire Island (40°41'N, 73°00'W). The William Floyd Estate is a historic property dominated by maritime forest that is fragmented by several fields, ranging in size from approximately 0.3 to 1.7 ha (0.7-4.2 acres) (Figure 2). The Estate is bound by a tidal creek to the north, a small temporary stream to the south, and Narrow and Moriches Bays to the east and northeast. Several small wetland and aquatic areas, including seeps, salt marshes, and ponds are scattered throughout the William Floyd Estate.

The majority of FIIS, except for the William Floyd Estate, is located along a narrow barrier beach and is dominated by beach grass dune, deciduous scrub forest, dune shrubland, and salt marsh community types (Klopfer et al. 2002). Portions of the park are separated by residential communities and other conservation lands (i.e. state and county parks) (Figure 2). The Fire Island sections also contain numerous habitats typical of barrier islands and geological structures, such as ponds (natural and constructed), bogs, swamps, and odonate habitat features such as wet depressions, interdunal swales, and vegetative clearings.

North Atlantic barrier islands and similar geographical features typical of FIIS provide a distinctive mix of habitats that could potentially support odonate populations. Characteristic habitats include beach, primary and secondary dunes and associated swales, and salt marshes.

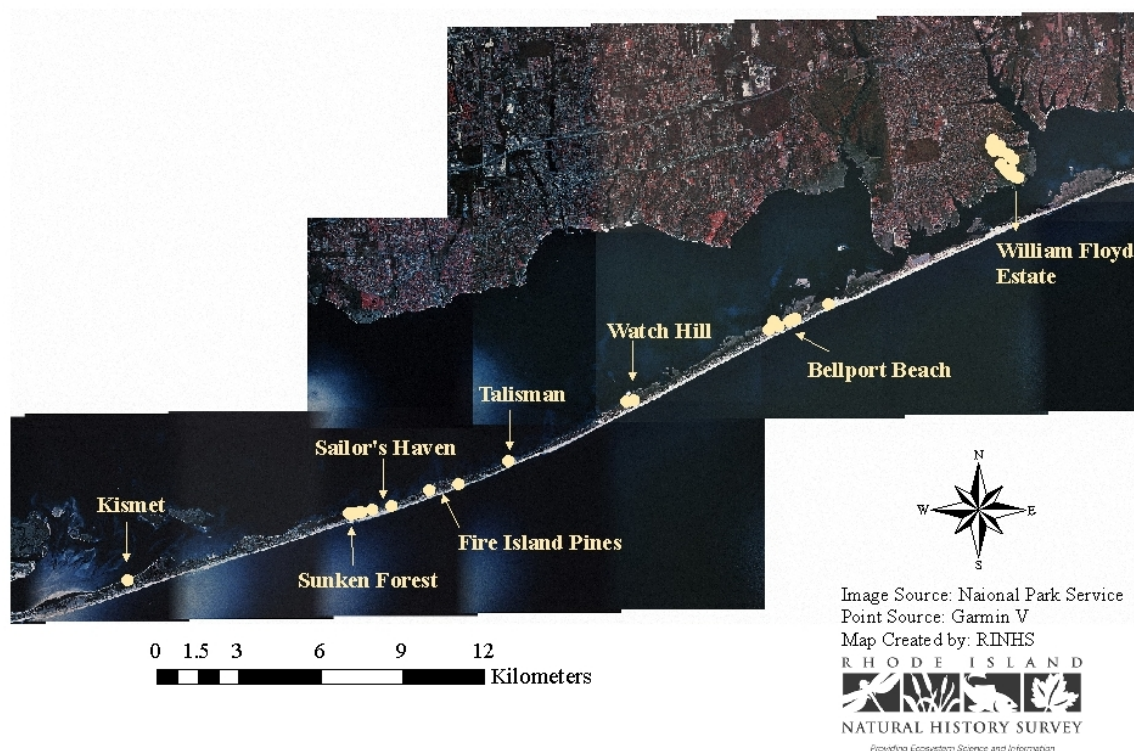


Figure 1. Overview of Odonate survey sites at Fire Island National Seashore, New York, 2004-2005



Figure 2. Map of Odonate survey sites at Fire Island National Seashore, New York: William Floyd Estate, 2004 and 2005.

Each habitat on a barrier island 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).

Interdunal swales can be important foraging and, for a limited but distinctive set of species, breeding habitat for odonates. Hydrological factors making interdunal swales distinctive habitat include watertable height, rainfall, and over wash. Water bodies in interdunal swales are characterized by fishlessness, seasonality, sandy substrate, sun and wind exposure, and vegetation such as rush (*Juncus ssp.*), bayberry (*Myrica pensylvanica*), and myrtle (*Myrtaceae spp.*), which provide good sites for oviposition, emergence, and perching. While many species benefit from high prey densities at interdunal water sources, there are species of odonate that can breed in temporary waters, their populations growing on wet years, shrinking in dry ones.

Typical such species include wandering glider (*Pantala flavescens*), spot-winged glider (*Pantala hymenaea*), common green darner (*Anax junius*) and swamp darner (*Epiaschna heros*).

In general, within barrier island systems 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 such habitat on barrier structures, some species of conservation importance such as Needham's skimmer (*Libellula needhami*) are typically associated with these coastal ponds.

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 panes) 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 contain odonate habitat typical of barrier islands that could support breeding, foraging, and migration events for odonate species. Thirty-four sites were surveyed during 2004 and 2005, including 13 sites on the William Floyd Estate and 21 sites on Fire Island. The William Floyd Estate contains relatively few potential breeding sites. Nonetheless, there is substantial potential foraging habitat for adult odonates in the form of a patchwork of fields separated by forest. Many individual fields were surveyed and counted as separate sites.

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) (Appendix A). 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 Appendix B.

Survey Sites on the Mainland at the William Floyd Estate

William Floyd Salt Marsh

The salt marsh site is located at the southern end of the William Floyd Estate, and consists of North Atlantic low salt marsh, North Atlantic high salt marsh, and salt pannes/pools (FGDC 1997) (Figure 2). Portions of the salt marsh have been ditched for drainage, however sections are in the process of being restored (Stavdal, personal communication).

William Floyd Estate - Seep

This site is a damp area smaller than 0.002 ha (20 m²) near the edge of a Successional Old Field (Figure 2). It was identified in 2004 and no odonate activity was observed at that time. It was not resurveyed in 2005 because of its inaccessibility. Although there were no odonate observations made here during this project, the site is listed because it is possible odonate habitat of unknown, though likely limited potential. The site is open, not in full forest cover, although mature

hardwood forest virtually surrounds it. Vegetation makes close access to the site extremely difficult. The dominant plant at the edge of the site is rush.

William Floyd Estate -Teal Pond

Teal Pond is a small, 0.009 ha (0.02 acre) eastern reed (*Phragmites australis*) marsh (FGDC 1997) (Figure 2). Eastern reed, also called common reed has become established in a dense border around the pond. We assume that the haplotype of common reed present at is the non-native, invasive type. Access to the pond itself is difficult due to bull briar (*Smilax rotundifolia*).

William Floyd Estate -Home Creek

This site is situated near the headwaters for Home Creek, a brackish, tidally influenced stream that drains along the northern edge of the William Floyd Estate and empties into Moriches Bay (Figure 2). In the area surveyed, Home Creek is approximately 3 m (9.5 ft) wide. The bank has low shrubs and trees on the east/northeast side and a dense band of common reed on the west side. At the time of survey, the depth of the creek was approximately 0.6 m (24 in) and there appeared to be little water movement. We believe that fresh water flow in this stream is likely minimal and seasonal. Also, given that this site is near the head of the stream, tidal flushing is also likely minimal. The west side of Home creek is privately owned and lined with boat docks.

William Floyd Estate Fields

Nine of the fields that are being maintained at the Estate were selected for surveys (Figure 2). Most of these small fields are between 1 and 2 ha (2.4 and 4.9 acres) and are separated from each other by a matrix forest that dominates the vegetative cover at the Estate. All fields are regularly mowed to retain their historic and aesthetic values and are not used for active agriculture.

Survey Sites on Fire Island

Kismet Pond

Kismet Pond is a eutrophic, 0.8 ha (2 acre) pond, fringed on the east by a wet sedge meadow and on the north by an eastern reed marsh (FGDC 1997), the latter containing a dense stand of common reed (Figure 3). It is a naturally occurring pond that was widened with a bulldozer in the 1970's (Bilecki, personal communication). There is little emergent vegetation at the pond's edge, except for some pondweed (*Potamogeton spp*) in the water. The pond is 0.76 m (30 in) deep in the center and little fluctuation in water level was observed during the 2004 and 2005 field seasons. The substrate of the pond is an organic layer which overlays a sandy bottom.

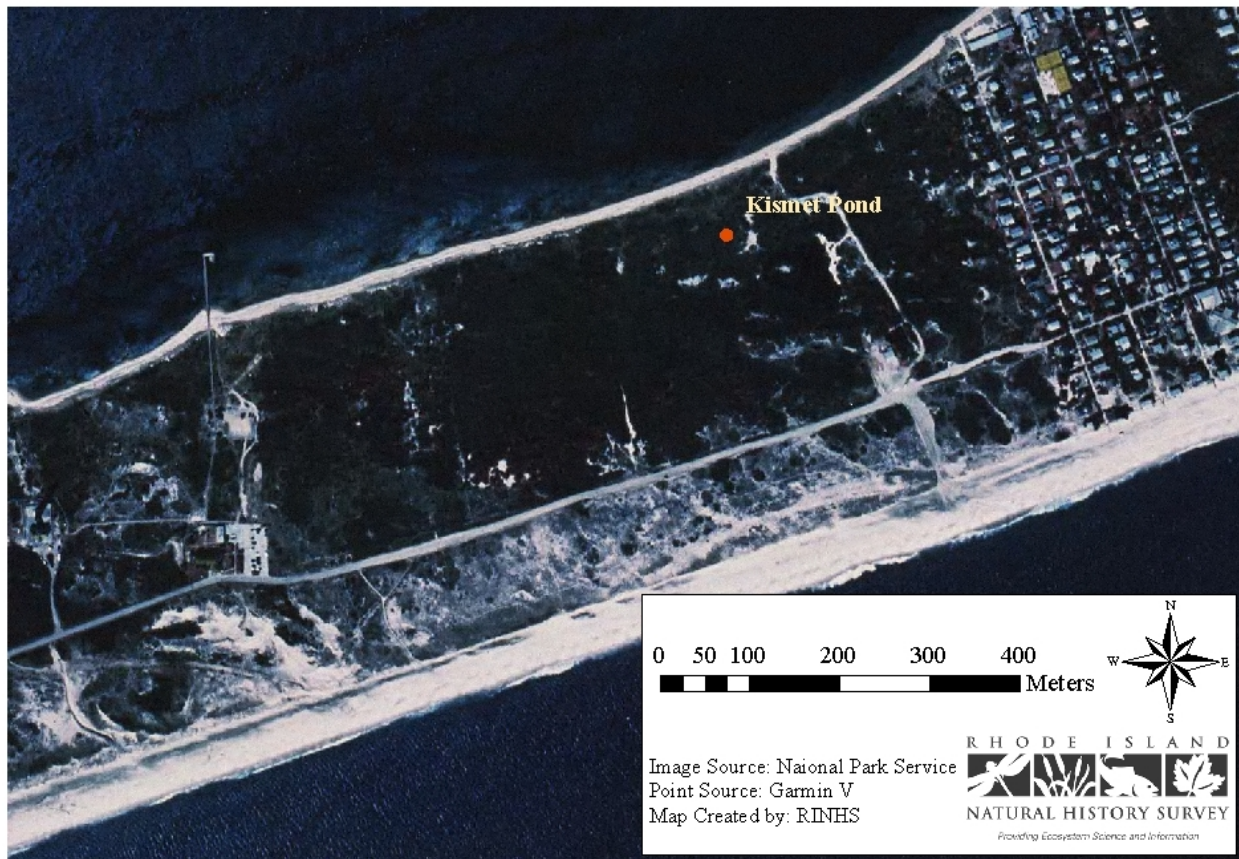


Figure 3. Map of Odonate survey sites at Fire Island National Seashore, New York: Kismet Pond, 2004 and 2005.

Sunken Forest -Wet Depressions #1-7

The Sunken Forest area of Fire Island is located on the lee side of the northern dunes (Figure 4) and contains a unique maritime holly (*Ilex opaca*) forest (FGDC 1997). Small wet depressions averaging 3-6 m (10-20 ft) wide are a common topographic feature on the protected side of the dunes, and each of the seven chosen as survey sites contained a shallow emergent marsh.

Vegetation at all seven sites was similar; each dominated by sphagnum moss (*Sphagnum spp.*), emergent rushes, ferns, sedges, and cattail (*Typha spp.*).

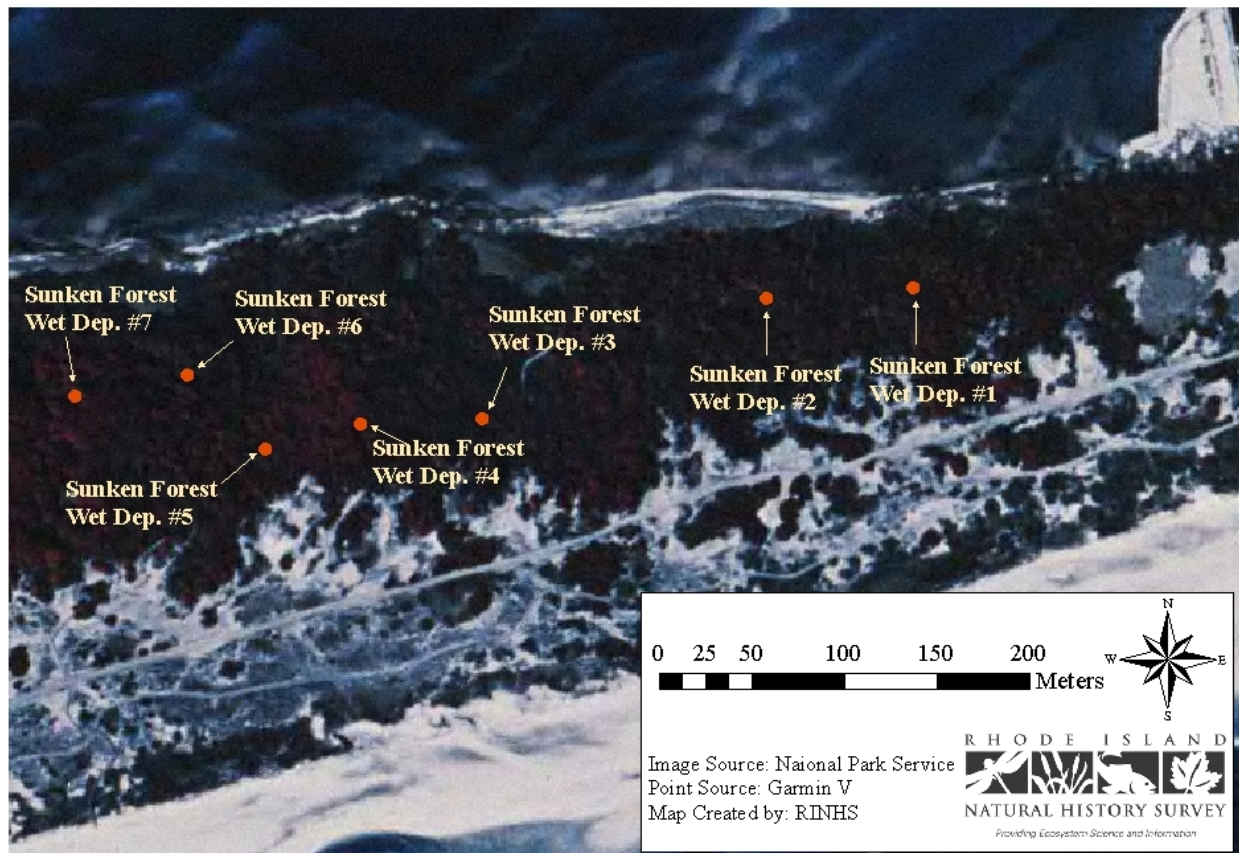


Figure 4. Map of Odonate survey sites at Fire Island National Seashore, New York: Sunken Forest, 2004-2005.

Sailor's Haven Maintenance Pond

This artificial pond contained what can best be classified as a blueberry (*Vaccinium sp.*) wetland thicket (FGDC 1997) and did not undergo seasonal flood events (Figure 5). The pond was approximately 0.45 m (18 in) deep, 4 m (12 feet) wide, and contained a shallow organic layer over sandy substrate. Fencing surrounds the pond on the south side and highbush blueberry (*Vaccinium corymbosum*) and other woody vegetation borders the bay side.

Sailor's Haven Entrance Road

Sailor's Haven entrance road parallels the lee side of the dune (Figure 5). The entrance road is unpaved, and is surrounded by northern bayberry dune shrubland (FGDC 1997). The back side of the dune is sparsely vegetated, and contains a mix of dune grasses and poison ivy (*Toxicodendron radicans*) growing in a sandy substrate.

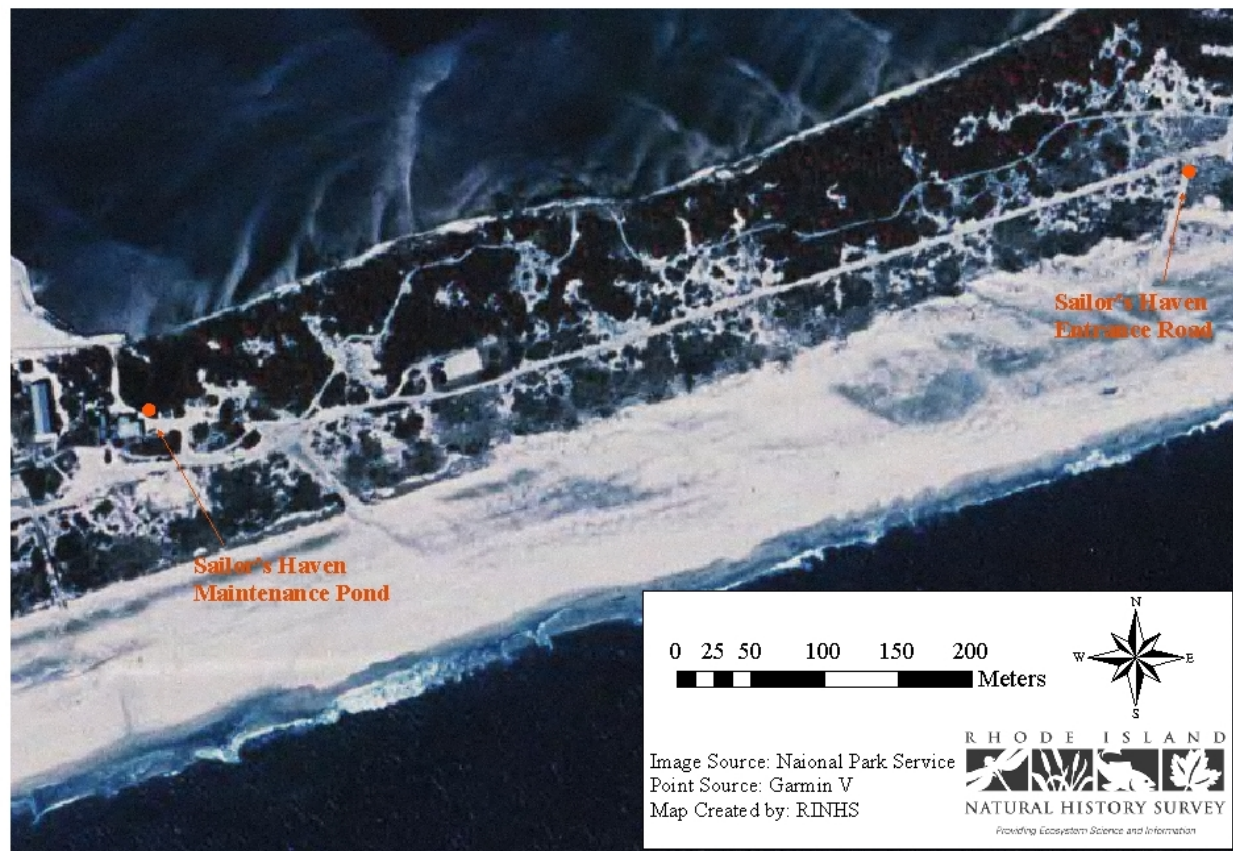


Figure 5. Map of Odonate survey sites at Fire Island National Seashore, New York: Sailors Haven, 2004-2005.

Fire Island Pines -Carrington Swamp

Carrington Swamp is a poorly drained, red maple (*Acer rubrum*) black gum (*Nyssa sylvatica*) swamp (FGDC 1997) with nutrient poor soils (Figure 6). Although the site is dominated by black gum, it also contains dense stands of common reed. There are tussocks of sedges and rushes with shallow pools of standing water around them. Carrington Swamp was not resurveyed in 2005 because no standing water remained on the survey dates (Table 1).

Fire Island Pines -Smokey Hollow Bog

Smokey Hollow Bog is approximately 17 m² (55 ft²) and located within a northern interdunal cranberry (*Vaccinium oxycoccos*) swale (FGDC 1997) (Figure 6). The bog did not contain any standing water at survey time, however it supports hydrophytic vegetation such as smartweed (*Polygonum sp.*), marsh St. John's wort (*Triadenum virginicum*), and twig rush (*Cladium mariscoides*) (Caldecut 1997). In addition to its limited potential as a breeding site, Smokey Hollow Bog also appeared to represent poor adult odonate foraging habitat; the bog itself is surrounded by a dense residential area and is within 100 m (330 ft) of the coast. Smokey Hollow Bog was not resurveyed in 2005 because it lacked standing water and overall was a small, poor-quality habitat (Table 1).



Figure 6. Map of Odonate survey sites at Fire Island National Seashore, New York: Fire Island Pines, 2004-2005

Talisman Road

Talisman Road is a 3 m (10 ft) wide, unpaved road that parallels the lee side of a dune behind the primary, active dune system and is primarily used by off road vehicles (Figure 7). The environs of the road are a northern bayberry dune shrubland (FGDC 1997) containing a sparse mix of dune grasses and poison ivy in addition to bayberry. This site was examined as a potential feeding and migration area.

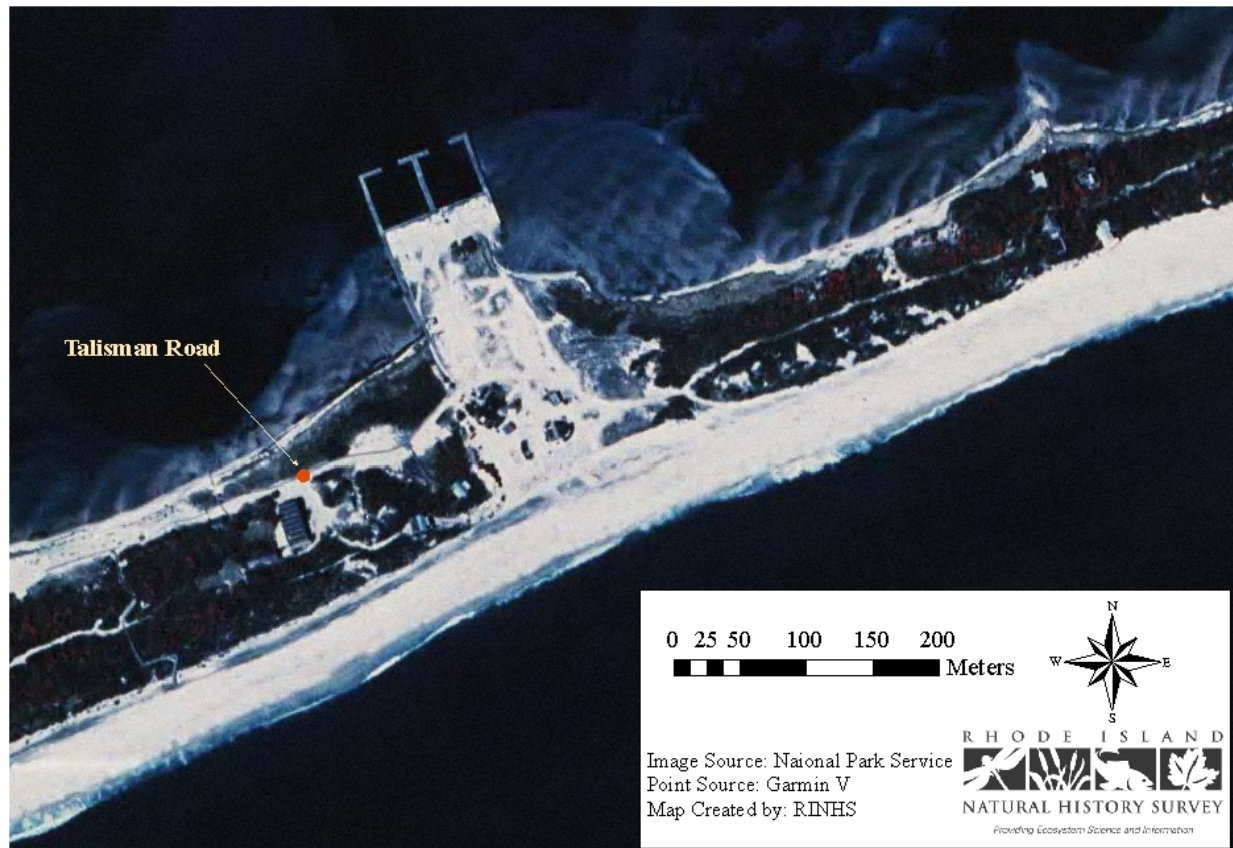


Figure 7. Map of Odonate survey sites at Fire Island National Seashore, New York: Talisman, 2004-2005

Watch Hill House 12

This site contains a shallow emergent marsh located alongside and extending under House #12 and an adjacent mown path (Figure 8). Parts of the wetland had been mowed, but a portion of the emergent sedges in the wetland were undisturbed. The water source was not obvious. Due to its small size and poor quality, the site was not resurveyed in 2005 (Table 1).

Watch Hill Marsh

This site is a shallow emergent marsh with sections of eastern reed marsh (Figure 8). Previous studies documented dense assortments of rushes and ferns (*Osmunda spp.*) interspersed with dense stands common reed and cattail (Caldecutt 1997). Although described as wetland by Caldecutt (1997), no significant amount of water was observed in 2004 and therefore, the site was not resurveyed in 2005 (Table 1).



Figure 8. Map of Odonate survey sites at Fire Island National Seashore, New York: Watch Hill, 2004-2005.

Otis Pike Wilderness Area (OPWA) Bellport Beach Marsh West and Bellport Marsh East

Both Bellport marsh sites (East and West) are eastern reed marshes (FGDC 1997) approximately 7.5 m (25 ft) wide (Figure 9). Common reed dominates the vegetation at these marshes, leaving minimal composition of native plants. Although included in this study as potential habitat, neither marsh had standing water when surveyed in 2004. They were not resurveyed in 2005 (Table 1).

OPWA Bellport Salt Marsh

Bellport Salt Marsh is a north east facing salt marsh that is 20 m across at its greatest width and approximately 60 m long (Figure 9). The marsh contains areas with North American high marsh, North American low marsh, and salt pannes and pools. The south western edge of the marsh is bordered with common reed.

OPWA, Bellport Swales #1-3

Three interdunal swale sites are located behind the backdunes (Figure 9). All three were between 4 and 6 m (15 to 20 ft) wide, contained dense stands of rushes and herbaceous plants, and a ground layer of small cranberry (*Vaccinium oxycoccos*). Although this type of interdunal swale is typically seasonally flooded, we did not observe standing water during our site visits. The swales were not resurveyed in 2005 (Table 1).

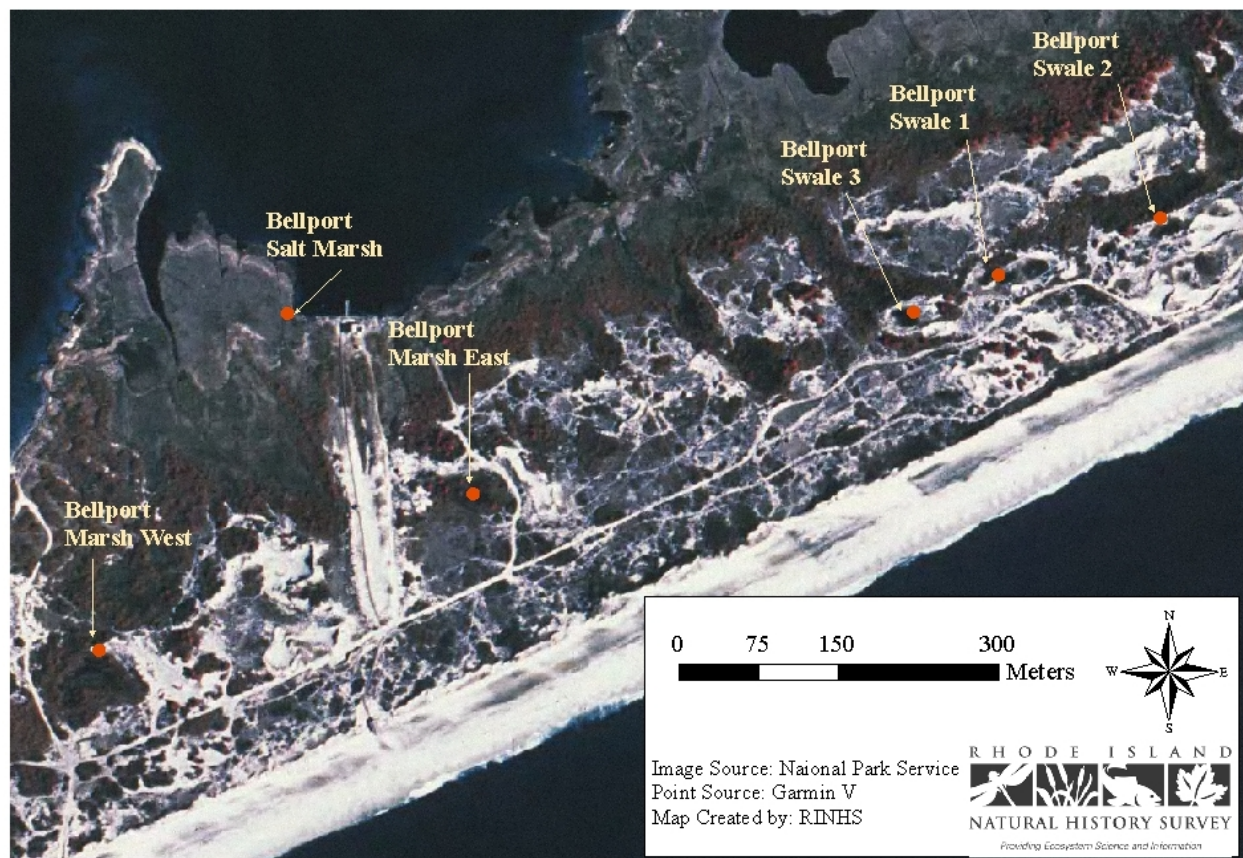


Figure 9. Map of Odonate survey sites at Fire Island National Seashore, New York: Bellport, 2004-2005.

Table 1. Sites surveyed for odonates at Fire Island National Seashore, Suffolk County, New York, in 2004 and 2005. Sites that were surveyed in a given year are noted with an X. Rationale is provided for sites that were not resurveyed.

Site Name	Year(s) surveyed		Rationale if not resurveyed
	2004	2005	
- Fire Island Sites -			
Bellport Salt Marsh	X		Habitat appropriate for only one species (seaside dragonlet), which was recorded in 2004.
Bellport Swale 1	X		No standing water remained
Bellport Swale 2	X		No standing water remained
Bellport Swale 3	X		No standing water remained
Bellport Marsh East	X		No standing water remained
Bellport Marsh West	X		No standing water remained
Fire Island Pines: Carrington Swamp	X		No standing water remained
Kismet Pond	X	X	
Sailor's Haven Entrance Road	X	X	
Sailor's Haven Maintenance Pond	X	X	
Fire Island Pines: Smokey Hollow Bog	X		No standing water, poor quality habitat
Sunken Forest Wet Depression #1	X	X	
Sunken Forest Wet Depression #2	X	X	
Sunken Forest Wet Depression #3	X	X	
Sunken Forest Wet Depression #4	X	X	
Sunken Forest Wet Depression #5	X	X	
Sunken Forest Wet Depression #6	X	X	
Sunken Forest Wet Depression #7	X	X	
Talisman Road	X		Lack of activity
Watch Hill Marsh	X		No standing water remained
Watch Hill House 12	X		Small, poor quality habitat
- Mainland Sites -			
William Floyd Estate: Field F12	X	X	
William Floyd Estate: Field F15	X	X	
William Floyd Estate: Field G5	X	X	
William Floyd Estate: Field G7	X	X	
William Floyd Estate: Field H4	X	X	
William Floyd Estate: Field H7	X	X	
William Floyd Estate: Field H9	X	X	
William Floyd Estate: Field J10	X	X	
William Floyd Estate: Field J12	X	X	
William Floyd Estate: Home Creek	X	X	
William Floyd Estate: Teal Pond	X	X	
William Floyd Estate: Seep	X		Inaccessible
William Floyd Estate: Saltmarsh	X	X	
Total number of sites surveyed	34	25	

Methods

Site Selection and Documentation

Potential breeding, feeding, and migrating sites were identified using 3 approaches. Given that odonates and amphibians require similar habitat to breed, potential breeding sites of odonates were identified using habitat descriptions and maps of sites surveyed during an amphibian and reptile inventory at FIIS (Behler 2002). Similarly, aerial photos and USGS topographic maps were analyzed for landscape features that could provide odonate breeding, feeding, or migration habitat. In addition, wetland maps provided by NPS staff were reviewed, and local amateur odonatists were consulted for their knowledge of the odonate habitats and fauna within FIIS.

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) (Appendix A). 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) (see Appendix A).

Potential Species Lists

A checklist of species likely to be found at FIIS (Appendix C) was generated using a four-step process. First, RINHS odonate specialists compiled a list of potential species that they would expect to find at FIIS 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 Suffolk County or, when possible, within the Park itself. All potential species were then compiled in a single table, see Appendix C.

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). In 2005, sites visits were in June, July, and August. Cold and stormy weather during May 2005 did not permit sampling. No survey was conducted in September 2005 because odonates specialists believed it was unlikely that any new species would be recorded based on the number of new species detected during surveys in June, July, and August 2005 (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 FIIS 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 Appendix D) 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 Fire Island National Seashore, Suffolk County, New York, during 2003-2005. No surveys were conducted during May and September 2005.

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

* EM: Erica Malmberg, ET: Emily Troiano, JS: Jaqueline Sones, MV: Michael Veit,
NB: Nina Briggs, RW: Richard Wahlfield, SJ: Sarah Jennings, VB: Virginia Brown

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.

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 m²) 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 m²) 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 address two primary objectives: (1) determine the abundance, defined as the number of sighted individuals of each species at FIIS and at each survey site, (2) determine species richness, defined as the total number of species present in a given area.. Outputs of each query were summarized using Excel.

In order to discuss the conservation value of survey sites, we had to derive a measure to help interpret the quantitative values of abundance for each species. Therefore, we created a measure called Categorical Abundance that contained three classifications: Numerous, Present, and Unusual. Using the biology and natural history of each species in its primary habitat, odonate specialists determined a range of abundance values for each classification (see Appendix E). A species was defined as “Numerous” if the population at the site is large given the biology of the species, suggesting that breeding or foraging is occurring in the habitat. A species was defined as “Present” if the population at the site is average or meets expectations given the biology of the species. A species was defined as “Unusual” if that species is either often not found in such

habitat or when found is usually present is greater numbers. Using the ranges provided in Appendix E, quantitative abundance data was classified into one of the three categories noted above. We note that when a quantitative value fell in between two categories, an odonate specialist (N.B.) would determine the appropriate category based on factors that may have influenced quantitative abundances, such as weather during surveys, unique habitat characteristics, and seasonality affects.

Investigator Effort

To provide a measure of investigator effort we calculated the raw and adjusted survey effort for each site (Appendix F). 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., V.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.), 0.5 (S.J.) or 0.0 (E.M., R.W.) 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

Surveys conducted during 2004 and 2005 ($n = 2,142$ and $1,825$ survey minutes, respectively; Appendix F) recorded 27 odonate species at 18 of the 34 survey sites at FIIS (Table 3). Twenty-five species were recorded during 2004 and two additional species were detected at Kismet Pond during 2005 (Table 3, Figure 10). Of the 27 species recorded at FIIS, 19 were dragonflies and 8 were damselflies (Table 3). Ninety two voucher specimens were collected in 2004 and 2005; representing 25 of the 27 species documented at FIIS (Table 4). All odonate species recorded during this project have been previously documented in Suffolk County, NY (Donnelly 1999) and appeared on the List of Potential species (Appendix C).

Of the three National Parks in New York and New Jersey that were surveyed for odonates in 2004 and 2005 (FIIS, Sagamore Hill National Historic Site [SAHI], and Gateway National Recreation Area [GATE]), FIIS trailed only GATE in the number of sites with odonate species and species richness (Table 5). At FIIS, the largest measures of species richness were recorded at Kismet Pond ($n = 23$ species) and Sailor's Haven Maintenance Pond and William Floyd – Field H9 ($n = 10$ species each) (Table 4). Across all FIIS sites, the most widely distributed species were common green darner, seaside dragonlet, painted skimmer (*Libellula semifasciata*), and spot-winged glider (Table 4). Given that survey sites at the William Floyd Estate (i.e. located on the mainland) are geographically separated from sites on Fire Island, results for each area will be presented separately.

Species inventoried on the Mainland

During 2004-2005 at survey sites on the mainland (see Table 1), the greatest number of odonates were observed at William Floyd - Salt Marsh ($n = 62$ individuals), William Floyd Field H9 ($n = 40$ individuals), William Floyd Field F12 ($n = 37$ individuals), and William Floyd Field G7 ($n = 12$ individuals) (Table 4). Similarly, these four sites also showed the greatest species richness (Table 4). For example, William Floyd Field H9 had the greatest species richness ($n = 10$ species), followed by Floyd Field F12 ($n = 9$ species), and Floyd Field G7 ($n = 4$ species). The most commonly observed species at mainland sites were seaside dragonlet ($n = 66$ individuals), black saddlebags (*Tramea lacerate*; $n = 36$ individuals), and common green darner ($n = 20$ individuals).

During 2004-05, no odonates were observed at William Floyd Estate Field F15, G5, J12, Home Creek, or Seep. William Floyd Estate – Seep was also not resurveyed in 2005 because the site was deemed inaccessible due to an extreme abundance of ticks (e.g. deer, dog, and lone star ticks) and bull briar. More specifically, the bull briar was so dense that researchers continually tore their protective Tyvek suits while attempting to move around. Crew leaders determined that working at this site without protective equipment was not safe and thus, the site was not resurveyed in 2005.

Table 3. Odonate species (damselflies and dragonflies) recorded at Fire Island National Seashore, New York, in 2004 and 2005 (n = 27). Species noted as present (X) if voucher specimen and/or sight record was recorded.

Common Name	Scientific Name	2004	2005
- Damselflies -			
Azure bluet	<i>Enallagma aspersum</i>		X
Citrine forktail	<i>Ischnura hastata</i>	X	
Eastern forktail	<i>Ischnura verticalis</i>	X	
Familiar bluet	<i>Enallagma civile</i>	X	
Fragile forktail	<i>Ischnura posita</i>	X	X
Rambur's forktail *	<i>Ischnura ramburii</i> *	X	
Slender spreadwing	<i>Lestes rectangularis</i>	X	
Sweetflag spreadwing	<i>Lestes forcipatus</i>	X	
- Dragonflies -			
Bar-winged skimmer	<i>Libellula axelina</i>	X	
Black saddlebags	<i>Tramea lacerata</i>	X	
Blue dasher	<i>Pachydiplax longipennis</i>	X	X
Calico pennant	<i>Celithemis elisa</i>		X
Carolina saddlebags	<i>Tramea carolina</i>	X	
Cherry-faced meadowhawk	<i>Sympetrum internum</i>	X	X
Common green darner	<i>Anax junius</i>	X	
Common whitetail	<i>Libellula needhami</i>	X	
Eastern amberwing	<i>Perithemis tenera</i>	X	
Eastern pondhawk	<i>Erythemis simplicicollis</i>	X	
Halloween pennant	<i>Celithemis eponina</i>	X	X
Needham's skimmer *	<i>Libellula needhami</i> *	X	
Orange bluet	<i>Enallagma signatum</i>	X	
Painted skimmer	<i>Libellula semifasciata</i>	X	
Seaside dragonlet	<i>Erythrodiplax berenice</i>	X	X
Spot-winged glider	<i>Pantala hymenaea</i>	X	
Swamp darner	<i>Epiaeschna heros</i>	X	
Wandering glider	<i>Pantala flavescens</i>	X	X
Widow skimmer	<i>Libellula lydia</i>	X	
Number of species recorded		25	8

* Needham's skimmer and Rambur's forktail are listed as imperiled species (S2S3 and S2, respectively) in New York by the NY Natural Heritage Program.

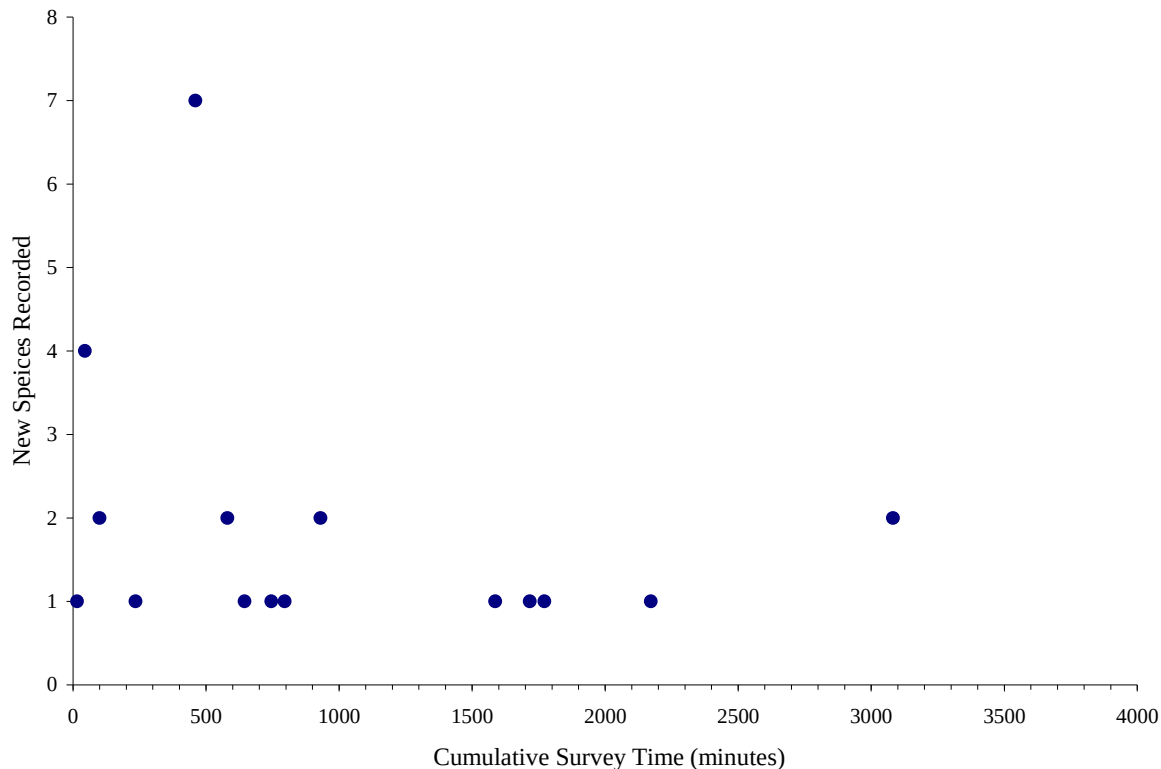


Figure 10 New species recorded by cumulative survey time ($n = 3,967$ -min) at Fire Island National Seashore, New York, during 2004-2005. Cumulative survey time was calculated using Raw Effort (see Appendix F and Methods). To more accurately convey when a new species was detected, we excluded surveys conducted by researchers with a weighted adjustment of "0" (E.M., R.W). Note that 12 of 27 species were first recorded at Kismet Pond; including the last 2 species to be recorded at ~3,082-min.

Species inventoried on Fire Island

At survey sites on Fire Island (see Table 1) during 2004-2005, the greatest number of odonates were observed at Kismet Pond ($n = 481$ individuals), Sailor's Haven Maintenance Pond ($n = 139$ individuals), Sailor's Haven Entrance Road Pond ($n = 25$ individuals), and OPWA - Bellport Swale #3 ($n = 13$ individuals) (Table 4). In general, sites with the greatest abundance of odonates also showed the greatest species richness (Table 4). For example, Kismet Pond had the greatest species richness ($n = 23$ species), followed by Sailor's Haven - Maintenance Pond ($n = 10$ species), and OPWA - Bellport Swale #3 and Fire Island Pines - Smokey Hollow Bog ($n = 4$ species, each). The most commonly observed species at survey sites on Fire Island were familiar bluet ($n = 218$ individuals), fragile forktail (*Ischnura posita*; $n = 127$ individuals), eastern pondhawk (*Erythemis simplicicollis*; $n = 45$ individuals), and orange bluet (*Enallagma signatum*; $n = 36$ individuals).

During 2004-05, no odonates were observed at OPWA - Bellport - Swale #1 and #2, OPWA - Bellport Marsh East and West, Fire Island Pines - Carrington Swamp, Sunken Forest Wet Depression #1, #2, #4, #5, #6, and #7, and Watch Hill Marsh. Several sites on Fire Island were not resurveyed in 2005 because of lack of standing water (e.g Bellport - Swale #1, #2, and #3, Bellport - Marsh East and West, and Fire Island Pines - Carrington Swamp and Smokey Hollow

Bog, Watch Hill Marsh, and Watch Hill House #12). Talisman Road was also not resurveyed in 2005 because the site showed little odonate abundance and species richness in 2004 and was not easily accessible (Table 1).

Rare Species Inventoried

Two NY State listed species (NYNHP 2006) were observed during 2004 (e.g. Needham's skimmer and Rambur's forktail; Table 1). Needham's skimmer (Appendix G) was recorded at Kismet Pond and at William Floyd Field F12 and H9 (Table 4). At Kismet Pond, Needham's skimmer was found to be categorically "numerous" (Table 6) and we observed breeding. At the William Floyd Estates Needham's skimmer was found to be categorically "present" in two fields and likely use these sites for foraging and cover. Rambur's forktail (Appendix G) was recorded at the Fire Island Pines' Smokey Hollow Bog and at the Sailor's Haven Maintenance Pond (Table 6). At Fire Island Pines' Smokey Hollow Bog Rambur's forktail was found to be categorically "unusual" (Table 9) and was likely to be using the habitat as cover, because there was no standing water present. At Sailor's Haven Maintenance Pond Rambur's forktail was found to be categorically "present" (Table 6). Although we did not observe oviposition (i.e. the laying of eggs), the habitat was appropriate for breeding.

Recorded vs. Potential Species List

During 2004 and 2005, 27 of the 53 species (51%) from the potential species list (Appendix C) were recorded at FIIS (Table 7). Given that our potential species list (Appendix C) was created using a combination of empirical data (e.g. published species lists and historical collections) and expert opinion, statistical analyses could not be conducted to determine whether the number of species recorded at FIIS differed from those species listed in the potential species list. However, given the available habitat, we believe that detecting 27-odonate species shows that FIIS, in general, has a viable odonate community. Unfortunately, due to a lack of historical and recent records of odonate species at FIIS, we could not determine if the odonate community at FIIS has changed over time. We can confidently state that all of the species we detected have been previously recorded in Suffolk County, NY (Donnelly 1999).

Table 4. Abundance of odonate species by site at Fire Island National Seashore, New York, during 2004-2005. Abundance is presented as sight records followed by voucher specimens in parenthesis.

Scientific Name	Kismet - Kismet Pond	Fire Island Pines - Smokey Hollow Bog	OPWA - Belpport Salt Marsh	OPWA - Belpport Swale	OPWA - Belpport Swale #1	Sailor's Haven - Maintenance Pond	Sailor's Haven - Entrance Road	Sunken Forest - Wet Depression 3	Talisman Road	Watch Hill - House #12	William Floyd - Field F12	William Floyd - Field G7	William Floyd - Field H4	William Floyd - Field H7	William Floyd - Field H9	William Floyd - Field J10	William Floyd - Salt Marsh	William Floyd - Teal Pond	Total
<i>Anax junius</i>	20				1 (1)		6 (1)			8	2			8 (1)	1	1			47 (3)
<i>Celithemis elisa</i>	2 (1)																		2 (1)
<i>Celithemis eponina</i>														2 (2)					2 (2)
<i>Enallagma aspersum</i>	1 (1)																		1 (1)
<i>Enallagma civile</i>	209 (4)	2 (2)	1 (1)			6 (1)								1 (1)					219 (9)
<i>Enallagma signatum</i>	36 (4)																		36 (4)
<i>Epiaeschna heros</i>	2																		2
<i>Erythemis simplicicollis</i>	45 (3)																		45 (3)
<i>Erythrodiplax berenice</i>	2 (2)		10 (4)							1	1 (1)			2 (2)	1	61 (4)			78 (13)
<i>Ischnura hastata</i>	1	6 (5)		3 (2)	10 (1)				1 (1)										21 (9)
<i>Ischnura posita</i>	7 (1)					120 (3)											4		131 (4)
<i>Ischnura ramburii</i> *		1 (1)				2 (1)													3 (2)
<i>Ischnura verticalis</i>	18 (4)					3 (1)													21 (5)
<i>Lestes forcipatus</i>	2 (2)																		2 (2)
<i>Lestes rectangularis</i>	4 (1)																		4 (1)
<i>Libellula axilena</i>						1													1
<i>Libellula lydia</i>	21 (3)									1 (1)			1						23 (4)
<i>Libellula needhami</i> *	18 (4)									3				3 (1)					24 (5)
<i>Libellula pulchella</i>	8 (1)					1				1				1 (1)					11 (2)
<i>Libellula semifasciata</i>	3				1 (1)	1 (1)	7			6 (1)	3 (1)			6 (1)					27 (6)
<i>Pachydiplax longipennis</i>	22 (2)					3		1 (1)						1			1		28 (3)
<i>Pantala flavescens</i>	3 (1)	1										1							5 (1)
<i>Pantala hymenaea</i>	7 (1)				1	1	12 (1)		1 (1)	1									23 (3)
<i>Perithemis tenera</i>	17 (4)																		17 (4)
<i>Sympetrum internum</i>								2 (2)											2 (2)
<i>Tramea carolina</i>	9 (1)					1				1				1					12 (4)
<i>Tramea lacerata</i>	24 (2)									15 (1)	6 (1)			15 (1)					60 (5)
Total	481 (40)	10 (8)	11 (5)	3 (2)	13 (3)	139 (7)	25 (2)	3 (3)	1 (1)	1 (1)	37 (3)	12 (3)	1	1	40 (10)	2	62 (4)	5	847 (92)
Species Richness	23	4	2	1	4	10	3	2	1	1	9	4	1	1	10	2	2	2	

* State listed species in New York (NYNHP 2006)

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). GATE and SAHI data are from Briggs et al. (2006a and 2006b, respectively).

Location	Species Richness	Number of Sites Where		Number of		
		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

Categorical Abundance

Survey sites that showed greater species richness often showed greater measures of categorical abundances compared to other survey sites with the same vegetative community type (Table 6, 8). For example, the eastern reed marsh community type at Kismet Pond not only supported the greatest species richness ($n = 23$ species) of all sites surveyed (Table 8), but 48 % of the species recorded had a categorical abundance of numerous, including Needham's skimmer, a NY State listed species (NYNHP 2006) (Table 6). Kismet Pond also showed categorical abundances of present and unusual for 7 and 5 species, respectively. In comparison, other survey sites with eastern reed marsh community type (e.g. OPWA- Bellport Marsh – West and William Floyd – Teal Pond) showed lower measures of species richness (Table 6). Combined, species at these two sites had categorical abundances of numerous ($n = 1$ species), present ($n = 1$ species) and unusual ($n = 2$ species) (Table 6).

Similarly, survey sites and vegetative community types with greater species richness (Table 4, 8) showed greater measures of categorical abundance (Table 6). For example, successional old field community types were found to support moderate species richness at two survey sites (e.g. William Floyd Estate – Field H9 and F12; Table 7). Species recorded at the William Floyd Estate – Field H9 ($n = 10$ species, Table 7) showed categorical abundances of numerous ($n = 1$ species), present ($n = 4$ species), and unusual ($n = 5$ species). Species recorded at the William Floyd Estate – Field F12 ($n = 9$ species, Table 7) showed categorical abundances of numerous ($n = 1$ species), present ($n = 3$ species), and unusual ($n = 5$ species). At both sites, Needham's skimmer, a NY State listed species (NYNHP 2006) was found at categorical abundance levels of present (Table 6).

The blueberry wetland thicket community type at Sailor's Haven Maintenance Pond also supported moderate species richness ($n = 10$ species; Table 7) and showed categorical abundances of numerous ($n = 1$ species), present ($n = 3$ species), and unusual ($n = 6$ species) (Table 6). Rambur's forktail, a NY State listed species (NYNHP 2006) was one of the three species recorded with a categorical abundance of present at Sailor's Haven Maintenance Pond.

Table 6. Categorical abundance of odonate recorded per site at Fire Island National Seashore, New York, 2004-2005. Categorical Abundance is based on the biology and life history of a given species at a specific habitat (see Methods and Appendix D).

Survey		Quantitative Abundance	Categorical Abundance			Habitat Type ^a
Site	Species		Numerous	Present	Unusual	
Sailor's Haven - Maintenance Pond						1
	<i>Enallagma civile</i>	6			X	
	<i>Ischnura posita</i>	120	X			
	<i>Ischnura ramburii</i> *	2		X		
	<i>Ischnura verticalis</i>	3		X		
	<i>Libellula axelina</i>	1			X	
	<i>Libellula pulchella</i>	1			X	
	<i>Libellula semifasciata</i>	1			X	
	<i>Pachydiplax longipennis</i>	3		X		
	<i>Pantala hymenaea</i>	1			X	
	<i>Tramea carolina</i>	1			X	
Sailor's Haven - Entrance Road						2
	<i>Anax junius</i>	6		X		
	<i>Libellula semifasciata</i>	7		X		
	<i>Pantala hymenaea</i>	12	X			
Talisman Road						2
	<i>Pantala hymenaea</i>	1			X	
Fire Island Pines - Smokey Hollow Bog						3
	<i>Enallagma civile</i>	2			X	
	<i>Ischnura hastata</i>	6		X		
	<i>Ischnura ramburii</i> *	1			X	
	<i>Pantala flavescens</i>	1			X	
OPWA - Bellport Swale #1						3
	<i>Ischnura hastata</i>	3		X		
OPWA - Bellport Swale #3						3
	<i>Anax junius</i>	1			X	
	<i>Ischnura hastata</i>	10		X		
	<i>Libellula semifasciata</i>	1		X		
	<i>Pantala hymenaea</i>	1			X	

Table 6. Categorical abundance of odonate recorded per site at Fire Island National Seashore, New York, 2004-05. Categorical Abundance is based on the biology and life history of a given species at a specific habitat (see Methods and Appendix D) (continued).

Survey		Quantitative Abundance	Categorical Abundance			Habitat Type ^a
Site	Species		Numerous	Present	Unusual	
William Floyd - Field F12						4
	<i>Anax junius</i>	8		X		
	<i>Erythrodiplax berenice</i>	1			X	
	<i>Libellula lydia</i>	1			X	
	<i>Libellula needhami</i> *	3		X		
	<i>Libellula pulchella</i>	1			X	
	<i>Libellula semifasciata</i>	6		X		
	<i>Pantala hymenaea</i>	1			X	
	<i>Tamea carolina</i>	1			X	
	<i>Tamea lacerata</i>	15	X			
William Floyd - Field G7						4
	<i>Anax junius</i>	2		X		
	<i>Erythrodiplax berenice</i>	1			X	
	<i>Libellula semifasciata</i>	3		X		
	<i>Tamea lacerata</i>	6		X		
William Floyd - Field H7						4
	<i>Libellula lydia</i>	1			X	
William Floyd - Field H9						4
	<i>Anax junius</i>	8		X		
	<i>Celithemis eponina</i>	2			X	
	<i>Enallagma civile</i>	1		X		
	<i>Erythrodiplax berenice</i>	2			X	
	<i>Libellula needhami</i> *	3		X		
	<i>Libellula pulchella</i>	1			X	
	<i>Libellula semifasciata</i>	6		X		
	<i>Pachydiplax longipennis</i>	1			X	
	<i>Tamea carolina</i>	1			X	
	<i>Tamea lacerata</i>	15	X			

Table 6. Categorical abundance of odonate recorded per site at Fire Island National Seashore, New York, 2004-05. Categorical Abundance is based on the biology and life history of a given species at a specific habitat (see Methods and Appendix D) (continued).

Survey		Quantitative Abundance	Categorical Abundance			Habitat Type ^a
Site	Species		Numerous	Present	Unusual	
William Floyd - Field J10						4
	<i>Anax junius</i>	1			X	
	<i>Erythrodiplax berenice</i>	1			X	
Kismet - Kismet Pond						5
	<i>Anax junius</i>	20	X			
	<i>Celithemis elisa</i>	2		X		
	<i>Enallagma aspersum</i>	1			X	
	<i>Enallagma civile</i>	209	X			
	<i>Enallagma signatum</i>	36	X			
	<i>Epiaeschna heros</i>	2		X		
	<i>Erythemis simplicicollis</i>	45	X			
	<i>Erythrodiplax berenice</i>	2			X	
	<i>Ischnura hastata</i>	1			X	
	<i>Ischnura posita</i>	7		X		
	<i>Ischnura verticalis</i>	18	X			
	<i>Lestes forcipatus</i>	2			X	
	<i>Lestes rectangularis</i>	4		X		
	<i>Libellula lydia</i>	21	X			
	<i>Libellula needhami</i> *	18	X			
	<i>Libellula pulchella</i>	8		X		
	<i>Libellula semifasciata</i>	3			X	
	<i>Pachydiplax longipennis</i>	22	X			
	<i>Pantala hymenaea</i>	7	X			
	<i>Pantala flavescens</i>	3		X		
	<i>Perithemis tenera</i>	17		X		
	<i>Tramea carolina</i>	9	X			
	<i>Tramea lacerata</i>	24	X			
William Floyd - Teal Pond						5
	<i>Pachydiplax longipennis</i>	1			X	
	<i>Ischnura posita</i>	4		X		

Table 6. Categorical abundance of odonate recorded per site at Fire Island National Seashore, New York, 2004-05. Categorical Abundance is based on the biology and life history of a given species at a specific habitat (see Methods and Appendix D) (continued).

Survey		Quantitative Abundance	Categorical Abundance			Habitat Type ^a
Site	Species		Numerous	Present	Unusual	
William Floyd - Salt Marsh						6
	<i>anux junius</i>	1			X	
	<i>Erythrodiplax berenice</i>	61	X			
Watch Hill - House #12						7
	<i>Ischnura hastata</i>	1		X		
William Floyd - Field H4						8
	<i>Pantala flavescens</i>	1			X	
Sunken Forest - Wet Depression 3						9
	<i>Pachydiplax longipennis</i>	1			X	
	<i>Sympetrum internum</i>	2			X	
OPWA - Bellport Salt Marsh						10
	<i>Enallagma civile</i>	1			X	
	<i>Erythrodiplax berenice</i>	10		X		

^a Classified using National Vegetation Classification Standards (FGDC 1997)

1 = Blueberry Wetland Thicket

2 = Unpaved Road/Path ^b

3 = Northern Interdunal Cranberry Swale

4 = Successional Old Field

5 = Eastern Reed Marsh

6 = Salt Panne Pool

7 = Mowed Roadside/Pathway ^b

8 = Mowed Lawn ^b

9 = Maritime Holly Forest

10 = North Atlantic Low Salt Marsh

^b Habitat type is not recognized by National Vegetation Classification Standards

* State listed species in New York (NYNHP 2006)

Migration Events

Migration events were not observed at odonate survey sites at FIIS during 2004 and 2005; however, a migration event was documented by one researcher (S.J.) at Bellport Beach on FIIS during 2004. More specifically, 230 common green darners were counted flying overhead in a 3-minute interval at Bellport Beach on September 10, 2004 (Jennings personal communication). It's believed that such migration events of common green darners occurred throughout the day at Bellport Beach on that date (Jennings personal communication). Similar migration events were also recorded along the coast in Rhode Island that day. For example, 351 common green darners were counted in 1 hour on the South Kingstown Beach, RI (Sones personal observation). A large movement of common green darners was also reported in Barrington, Rhode Island that day (Brown personal communication).

Table 7. Species richness and proportion of species recorded compared to the Potential Species List (Appendix C) at Fire Island National Seashore, New York, during 2004-2005. Species richness was defined as the total number of species present in a given area. The Proportion of Species Recorded from Potential Species List was calculated by dividing the number of species recorded at a given site by the number of species listed in Appendix C ($n = 53$). Only survey sites with odonate records are shown.

Site Name	Species Richness	Proportion of	
		Total species recorded	Potential Species List recorded
Kismet Pond	23	0.85	0.43
Sailor's Haven Maintenance Pond	10	0.38	0.19
William Floyd Estate: Field H9	10	0.38	0.19
William Floyd Estate: Field F12	9	0.35	0.17
Fire Island Pines: Smokey Hollow Bog	4	0.15	0.08
OPWA: Bellport Swale 3	4	0.15	0.08
William Floyd Estate: Field G7	4	0.15	0.08
Sailor's Haven Entrance Road	3	0.12	0.06
OPWA: Bellport Salt Marsh	2	0.08	0.04
Sunken Forest: Wet Depression #3	2	0.08	0.04
William Floyd Estate: Field J10	2	0.08	0.04
William Floyd Estate: Salt Marsh	2	0.08	0.04
William Floyd Estate: Teal Pond	2	0.08	0.04
OPWA: Bellport Swale 1	1	0.04	0.02
Talisman Road	1	0.04	0.02
William Floyd Estate: Field H4	1	0.04	0.02
William Floyd Estate: Field H7	1	0.04	0.02
Watch Hill House 12	1	0.04	0.02
Total	27	1.0	0.51

Table 8. Habitat types where odonate species were recorded at Fire Island National Seashore, New York, during 2004-2005. Habitat types were classified using National Vegetation Classification Standards (FGDC 1997).

Scientific Name	Blueberry Wetland Thicker	Unpaved Road/Path ^a	Northern Interdunal Cranberry Swale	Successional Old Field	Eastern Reed Marsh	Salt Pannes Pool	Mowed Roadside/Pathway ^a	Mowed Lawn ^a	Maritime Holly Forest	North Atlantic Low Salt Marsh	Total
<i>Anax junius</i>		X	X	X	X	X					5
<i>Celithemis elisa</i>					X						1
<i>Celithemis eponina</i>				X							1
<i>Enallagma aspersum</i>					X						1
<i>Enallagma civile</i>	X		X	X	X				X		5
<i>Enallagma signatum</i>					X						1
<i>Epiaeschna heros</i>					X						1
<i>Erythemis simplicicollis</i>					X						1
<i>Erythrodiplax berenice</i>				X	X	X			X		4
<i>Ischnura hastata</i>			X		X		X				3
<i>Ischnura posita</i>	X				X						2
<i>Ischnura ramburii</i> *	X		X								2
<i>Ischnura verticalis</i>	X				X						2
<i>Lestes forcipatus</i>					X						1
<i>Lestes rectangularis</i>					X						1
<i>Libellula axelina</i>	X										1
<i>Libellula lydia</i>				X	X						2
<i>Libellula needhami</i> *				X	X						2
<i>Libellula pulchella</i>	X			X	X						3
<i>Libellula semifasciata</i>	X	X	X	X	X						5
<i>Pachydiplax longipennis</i>	X			X	X			X			4
<i>Pantala flavescens</i>			X		X		X				3
<i>Pantala hymenaea</i>	X	X	X	X	X						5
<i>Perithemis tenera</i>					X						1
<i>Sympetrum internum</i>								X			1
<i>Tramea carolina</i>	X			X	X						3
<i>Tramea lacerata</i>				X	X						2
Specis Richness	10	3	7	12	23	2	1	1	2	2	

^a Habiat type is not recoginized by National Vegetation Classification Standards

* State listed species in New York (NYNHP 2006)

Discussion

During 2004 and 2005 ($n = 2,142$ and $1,825$ survey minutes, respectively; Appendix F) we documented 27 species of odonates at FIIS. The majority (92%) of these species were first recorded during the 2004 field season (Table 3). Only 2 additional new species were found during the 2005 field season (Table 3) and both of these new species were detected at Kismet Pond. The lack of new species recorded during 2005 (Figure 10), suggests that substantial survey effort would have been required to document 1-additional new species. Based on the trend in new species detection (Figure 10) and general odonate observations in the field, odonate specialists believe that $\geq 90\%$ of the odonate species present at FIIS survey sites were documented during this study. We note, however, that surveys could not be completed at two survey sites at the William Floyd Estate (Teal Pond and the Seep, discussed in detail below) and therefore the species composition is unknown for these sites. Recall that prior to conducting field surveys, odonate specialists produced a list of odonate species that could possibly be found at FIIS (i.e. Potential Species List, Appendix C). Although the potential species list was by design a “guide” of species that could be present based largely on identification of potential habitat, an obvious questions begs; why aren’t more odonate species from that list present at FIIS?

One possible reason for not supporting more species is that, in general, FIIS lacks habitats with permanent water. Although some odonates are capable of reproducing in temporary waters, the majority require permanent waters to complete their life cycle (Walker 1953). It was apparent in our results, as well as to odonate specialists in the field that water levels (i.e. water retention and annual rainfall) influenced odonate species richness and abundance across FIIS. The effects of water level on odonates will be discussed in more detail below. In short, we found that sites containing water in 2004 and 2005 were productive in both years (e.g. Kismet Pond) and sites where water levels fluctuated (e.g. Sailor’s Haven Maintenance Pond) were unproductive in dry years (2005).

In general, ponds at FIIS with permanent water are very important for odonates. For example, the greatest measures of species richness and abundance were recorded at ponds with permanent water such as, Kismet Pond and Sailor’s Haven Maintenance Pond previous to 2005. Unfortunately, Sailor’s Haven Maintenance Pond lost its permanent water status during 2005 when its water source was diverted (discussed below in more detail). The lack of odonate species detected at Sailor’s Haven Maintenance Pond during 2005 when no standing water remained illustrates the importance of permanent water and stable habitat for odonates. We note that many sites at FIIS, even those without permnant water, can at times serve as important and sometimes critical foraging, mating, and migration habitat for odonates.

FIIS is located within the odonate migration corridor and offers important habitat for migrating odonates (Shannon 1935). Although migration events were not observed at FIIS during odonate surveys, survey sites contained appropriate habitat, such as coastal beaches and primary dunes, for odonate migration events (e.g. migratory events recorded at Bellport Beach at OPWA on 10 September 2004). Odonate specialists believe that the migratory flights of common green darners observed across New York and Rhode Island on 10 September 2004 were likely a result of a strong cold front that pushed south through the Northeast during 8-9 September 2004 (Sones and Briggs personal observation). Recall that odonate migration is strongly correlated with cold

front passages and large swarms of migrants often follow topographic leading lines such as coastlines (Russell et al. 1998). Unlike migrations of birds, odonate migrations are intergenerational movements in which an individual migrant carries out a migration in only one direction (Russell et al. 1998). For example, fall migrants often travel south to complete their life cycle and lay eggs. Unlike with most other insect species, some of the offspring from these fall-migrating odonates may in turn migrate back north the following spring to breed. We note that densities of odonates during spring migration are often much lower than during the fall and thus, spring migration events are difficult to detect (Russell et al. 1998).

Migration, in general, holds biological and conservation importance for odonate populations (Freeland et al. 2003). For example, migration influences genetic variation at both the local and regional population level and is believed to contribute to the long-term stability of some populations that are exposed to a range of environmental conditions, including predator species, prey, and temperature (Freeland et al. 2003). In addition, large migratory swarms of odonates can serve as prey for migrating birds, although the extent to which is not well understood (Russell et al. 1998). Overall, odonate migration appears to satisfy a biologically necessary aspect of odonate life history.

Overall, FIIS offers good migration habitat and contains sites that currently provide good and potential habitat for breeding and foraging odonates, as well as several unique habitats for imperiled species. For each area at FIIS (Mainland and Fire Island), we discuss survey sites with good conservation value (i.e. contain good breeding, foraging, or unique odonate habitat) and sites that could be potentially beneficial to odonates. We then discuss potential threats to odonate habitat at FIIS and conclude with some recommendations for future monitoring.

Mainland Sites

Overall, of the fields that were surveyed at William Floyd Estate larger fields (Field-F12, G7, H9) showed greater species richness and abundance compared to the smaller fields (Field-H4, H7, J10) (Table 4). In general, based on the habitat available we expected to find greater diversity of foraging odonates compared to what we observed. We note that dry, hot weather, such as that occurring during the 2005 season, may reduce the number of foraging odonates in a these habitats (e.g. old successional field, mowed lawn). Also, we are aware that towns adjacent to the William Floyd Estate spray for mosquitoes; however, we do not know if such practices affect any non-targeted species (discussed below in more detail).

Sites with high conservation value

The William Floyd Estate Salt Marsh provided good habitat for the seaside dragonlet, which is the only species in the Western Hemisphere to breed in undiluted seawater (Dunkle 2000). Seaside dragonlets are obligate predators during all life stages and are a beneficial for both the control of most flying insects, especially mosquitoes and may serve as a food source for birds (Walker 1953, Carpenter 1991). During both 2004 and 2005, we found seaside dragonlets to be “numerous” (Table 6) and observed all life stages, including newly emerged and mature adults and pairs breeding, suggesting that a viable population is present at the salt marsh.

The William Floyd Estate Salt Marsh is actively being restored (Stavdal, personal communication). Although the seaside dragonlet is presently “numerous” (Table 6) on the marsh, the effects salt marsh restoration on this species are unknown. Comparing hatch counts of seaside dragonlets between restored and non-restored sections of the marsh could provide an effective measure for determining the effects of restoration. Hatch counts are a common technique for determining the health and abundance of odonates in a specific habitat (Carpenter and Briggs 1994). In general, hatch counts are conducted by counting exuvia (cast larval skins that can be identified to species) in a specified area. We suggest that hatch counts be conducted at only 2 or 3 sites on the restored and non-restored marsh to protect the marsh from foot traffic.

In addition, Needham’s skimmer, a species listed as imperiled in New York (NYNHP 2006) was found to be “present” (Table 6) at Field F12 and H9 within the William Floyd Estate. Recall that species were given a categorical rating of present if the population at the site is average or meet expectations given the biology of the species. Given that Needham’s skimmer typically breed in coastal ponds (Dunkle 2000), we believe that the old successional field habitat (FGDC 1997) is being used for both foraging habitat and cover by adults. In addition, given that this species was not recorded in other fields and considering that nearly all of the surrounding area is heavily developed, these fields appear to contain habitat needed for Needham’s skimmer to complete part of its adult lifecycle.

Other sites of potential interest

It appears that both Teal Pond and the Seep have potential habitat for odonates. Unfortunately, both areas were inaccessible during our field surveys. However, if these areas could be made accessible (e.g. by cutting a path through the bull brier), it appears that these ponds offer potential habitat and should be surveyed.

Sites on Fire Island

Overall, Fire Island contains appropriate migratory, breeding, and foraging habitat for odonates. Fire Island, itself, is located along the odonate migratory corridor (Shannon 1935) and, in particular Bellport Beach has shown to support migrating odonates (Shannon 1935, Jennings personal communication). In addition, coastal habitat such as interdunal cranberry swales (e.g. Smokey Hollow Bog) and coastal ponds (e.g. Kismet Pond) are important foraging and breeding habitats for several species, including two state listed species (e.g. Rambur’s forktail and Needham’s skimmer). Fire Island also contains several dune areas with good upland habitat comprised of northern bayberry dune shrubland (FGDC 1997) that provides odonates with habitat for foraging and cover from predators

Sites with high conservation value

In general, within barrier island systems fresh water ponds provide the most permanent environment for odonates and typically show the greatest abundance and diversity of odonate species (McClure 2001). Therefore it was reassuring to find that Kismet Pond showed the greatest species richness and abundance of odonates of all sites at FIIS (Table 4). Also, Needham’s skimmer, a species listed as imperiled in New York and typically associated with coastal pond habitats, was found to be “numerous” (Table 6) at Kismet Pond. Recall that species with a categorical rating of numerous suggests that the population is large given the biology of the species and is likely breeding or foraging at the site. In addition to providing permanent water for breeding and larval development, Kismet Pond is surrounded by good foraging habitat

for adult odonates that also provides cover for adult and juvenile odonates (e.g. dunes with northern bayberry dune shrubland, dune grasses, poison ivy, and bayberry). This combination of permanent water and upland habitat creates good-quality habitat for all life stages of odonates.

Overall, we believe that Kismet Pond presents a high conservation value in regards to odonates at FIIS. We believe that Kismet Pond area is being managed appropriately for odonates, given that we observed few signs of humans or dogs (e.g. trash, worn paths or trails, or feces) in the upland habitat around the pond. In addition, water levels remained relatively consistent during our study, despite low rainfall during the 2005 field season. We emphasize that one of the greatest threats to odonates within a barrier beach system, such as Fire Island, is water draw-down or the drying up of coastal ponds (discussed in detail below).

The Bellport Salt Marsh at OPWA also processes high conservation value for odonates. As stated earlier, salt marshes provide critical habitat for seaside dragonlets. At Bellport Salt Marsh seaside dragonlets were found to be “numerous” (Table 6), suggesting that Bellport Salt West provides breeding and foraging habitat for this species. In addition, both Bellport Beach and Bellport Salt Marsh areas have shown to support large migrations of common green darners during fall migration (Shannon 1935, Jennings personal communication). Given its location along the odonate migration corridor, the Bellport Beach area is likely to also provide habitat for other species of odonate during migration, such as blue dasher, black saddlebags, Carolina saddlebags, and swamp darner.

Other sites of potential interest

On Fire Island one site in particular has potential conservation interest (e.g. Sailor’s Haven Maintenance Pond). In fact, Sailor’s Haven Maintenance Pond illustrates the significance of permanent water in coastal ponds for odonate populations. During the 2004 odonate survey of Sailor’s Haven Maintenance Pond, we recorded 9 odonate species, including a “present” (Table 9) population of Rambur’s forktail, a NY state listed species. At that time (2004), the habitat at Sailor’s Haven Maintenance Pond contained an artificial pond surrounded a blueberry wetland thicket (FGDC 1997). The artificial pond, however, was not subject to seasonal flooding and was fed primarily by a leaking artesian well at the Sailor’s haven Maintenance Building. Sometime between September 2004 and June 2005, the leaking artesian well was properly repaired, which cut-off the water supply for the pond. When we returned to conduct a second odonate survey in July 2005, the pond had dried up and all of the vegetation was defoliated leaving no aquatic habitat for odonate larvae. During 2005, we observed no odonate species at this site and assume the decline of odonate species was directly related to the lack of permanent water.

Sailor’s Haven Maintenance Pond illustrates the importance of permanent water for breeding odonates and shows that even artificial ponds can support a diverse suite of odonate species. However, we do not suggest building or creating artificial ponds for the benefit of odonate species, but rather suggest that ponds with permanent water be maintained.

Potential Threats to Odonate Populations

In general, current management practices at most survey sites appear to have either a neutral or beneficial effect on odonate populations at FIIS. For example, FIIS protects its vegetative communities by prohibiting off-road vehicle use, except in designated areas, and foot traffic,

except on marked trails, roads, or boardwalks. Both of these measures, by design, protect fragile habitats (e.g. northern interdunal cranberry swale, northern bayberry dune shrubland, etc.) commonly used by odonate species. We note, however, that several factors pose threats to both habitat and breeding and foraging odonate populations at FIIS.

The most serious threat appears to be the abundance of common reed at many odonate survey sites that had previously been surveyed for amphibians (e.g. Bellport Marsh East and West, Kismet Pond, and Watch Hill Marsh). We believe that water levels at Bellport Marsh East and West were likely higher when these sites were surveyed for amphibians compared to when we surveyed these sites for odonates in 2004 (see Table 1). The decline in water level is likely due, in part, to the abundance of common reed, which has been shown to affect site hydrology (Angerdi et al. 2001). In addition, common reed out competes native plants, causing a direct change in invertebrate abundance and assemblage (Angerdi et al. 2001). Studies have also found that sites containing common reed show reduced species diversity of damselflies (Catling and Brownell 2001).

All of the odonates recorded at Kismet Pond, the most productive odonate site at FIIS, were observed either on the pond or in the surrounding upland. Although common reed could technically be used as a perch by odonates, given that stands are not too dense, we observed no adults flying, perching, or otherwise in the dense stand of common reed that surrounds part of the Kismet pond. We observed a similar trend at Bellport Beach Marsh East and West where the entire vegetative community consisted of common reed. At these sites, no odonates observed. We note that common reed grew so densely at these sites that it was impractical to conduct odonate surveys.

In addition to common reed, a second potential threat could be the use of insecticides for mosquito control. The town of Moriches has an ongoing, annual program to control adult mosquitoes. This program applies Sumithrin and Resmethrin (common names: anvil and scourge, respectively) at dusk as an ultra low volume aerosol. Although spraying for mosquitoes is done with regularity, it is believed that using target pesticides and spraying at dusk has little direct effect on adult odonates (Ginsberg personal communication). However, mosquito control likely reduces food sources for adult odonates.

Conclusion

Overall, FIIS contains few habitats that are appropriate for odonate reproduction; however, several sites offer good foraging and migration habitat. Odonates have a 3-stage life cycle that includes an egg stage, an aquatic larval stage the commonly lasts one year, and a terrestrial adult stage. The most productive habitats for odonates are ponds, lakes, and streams with abundant aquatic vegetation (e.g. submersed, floating, and emergent) located in and surrounding them. Aquatic vegetation oxygenates water and provides protective cover, as well as food organisms for odonates (Walker 1953, Corbet 1980). Given that FIIS, in general, lacks habitats with these characteristics, we would have been surprised to have found great diversity of odonate species at FIIS.

During 2004 and 2005, odonates were recorded at 18 of the 34 sites surveyed at FIIS. In all, 27 species of odonates were recorded, including Needham's skimmer and Rambur's forkail, which are listed as imperiled in New York (NYNHP 2006). Of the three National Parks in New York and New Jersey that were surveyed for odonates in 2004 and 2005 (FIIS, SAHI, GATE), FIIS trailed only GATE in the number of sites with odonate species and species richness.

In general, survey sites on Fire Island contained appropriate migratory, breeding, and foraging habitat for odonates. In particular, Kismet Pond showed the greatest species richness and abundance of odonates of all sites at FIIS. Also, Needham's skimmer, a species listed as imperiled in New York (NYNHP 2006) and typically associated with coastal pond habitats, was found to in large numbers at Kismet Pond. The high level of odonate productivity was likely a result of permanent water levels in the pond. For example, in spite of the drought in 2005, water levels at Kismet Pond remained constant, while several ponds at FIIS, GATE, and SAHI dried up. The greatest threat to odonates using Kismet Pond is the presence of common reed, because odonate habitat usually decreases as common reed increases inside wetlands (Catling and Brownell 2001).

During the first year of odonate surveys (2004) Sailor's Haven Maintenance Pond was also a very productive site and supported Rambur's forkail, a species listed as imperiled in New York (NYNHP 2006). However, when we revisited the pond in (2005) no standing water and similarly, no odonate species were present at the site. During 2004, the primary odonate habitat at Sailor's Haven Maintenance Pond was an artificial pond fed primarily by a leaking artesian well at the Sailor's Haven Maintenance Building. After the leaking well was properly repaired, the pond lacked a water supply and dried up. Sailor's Haven Maintenance Pond illustrates the importance of permanent water for breeding odonates and shows that even artificial ponds can support a diverse suite of odonate species.

The OPWA contained several areas with unique breeding and foraging habitat, as well as critical habitat for migrating odonates. Bellport Salt Marsh was shown to provide breeding and foraging habitat for seaside dragonlets, which are restricted to breeding in salt marshes. In addition, Bellport Salt Marsh, as well as Bellport Beach supports large migrations of odonates during fall migration (Shannon 1935, Jennings personal communication). Given OPWA's location along the Atlantic coast, this area may serve as a critical site within the odonate migratory corridor.

Survey sites on the Mainland at the William Floyd Estate primarily served as foraging habitat for odonate species. We found that the larger fields (Field-F12, G7, H9) showed greater species richness and abundance of odonates. Needham's skimmer, a species listed as imperiled in New York (NYNHP 2006), was recorded in two fields (e.g. Field F12 and H9) on the Mainland. In general, based on the habitat available at the William Floyd Estate, we expected to find greater diversity of foraging odonates than what was observed. We believe that the dry, hot weather during 2005 may have reduced the number of foraging odonates in these habitats as standing water and insect populations essentially dried-up. It is also possible that spraying for mosquitoes in surrounding towns also reduced food supplies for foraging odonates.

The William Floyd Estate Salt Marsh provided good habitat for the seaside dragonlet, which are beneficial for both the control of most flying insects, especially mosquitoes and may serve as a food source for birds. However, the William Floyd Estate Salt Marsh is being restored and the effects of salt marsh restoration on this species are unknown. Also, two survey sites at the William Floyd Estate, the Seep and Teal Pond, were not completely inventoried because access to these sites was impeded by bull briar and an unhealthy abundance of ticks. We note that both wetlands could potentially support breeding odonates and thus, potential odonate populations.

Recommendations for Future Monitoring

Generally speaking, managing habitat for odonate species is managing for wetlands. Based on the results of our surveys and inventory, we have five recommendations for future monitoring.

1. Given the high levels of odonate productivity at Kismet Pond, we recommend that odonate surveys be conducted at the pond and in the surrounding upland habitat for 1-hour, at least once monthly during odonate flight season, late-May to mid-September. We also suggest that common reed and water levels be recorded and monitored at this site.
2. In general, we suggest that common reed be monitored and, if deemed necessary, reduced at Kismet Pond, Bellport Salt Marsh, Bellport Marsh East and West, and Watch Hill Marsh.
3. Although the Seep and Teal Pond at the William Floyd Estate could not be surveyed during our study, we believe that these sites potentially support odonate breeding. We suggest that FIIS explore establishing an access to the Seep and Teal Pond and survey each site for odonates. We suggest conducting odonate surveys at the Seep and Teal Pond at least once monthly starting in May until September. After one season of surveys, the need for additional inventory and monitoring should be assessed.
4. We suggest that FIIS conduct hatch counts of seaside dragonlets on restored and non-restored sections of the William Floyd Estate Salt Marsh. Comparing hatch counts of seaside dragonlets between restored and non-restored sections of the marsh could provide an effective measure for determining the effects of restoration. As stated earlier in the Discussion, hatch counts are a common technique for determining the health and abundance of an odonate in a specific habitat (Carpenter and Briggs 1994). In general, hatch counts are conducted by counting exuvia (cast larval skins that can be identified to species) in a specified area. We suggest that hatch counts be conducted by collecting

exuvia in 2 or 3 sections $\sim 10 \text{ m}^2$ in size on both the restored and non-restored marsh at least once every two weeks from late- June to -July. We suggest monitoring only a portion of the marsh to limit the effects of foot traffic at this site.

5. Given the location of FIIS along the odonate migration corridor, we recommend that FIIS monitor or record migration events at the Otis Pike Wilderness Area Bellport Beach area, when possible, using the techniques specified in the Methods section of this report. It is commonly believed that most efficient and accurate way to record such events is to coordinate with amateur odonatists.

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Appendix A.

Coordinates and habitat types of each odonate survey site at Fire Island National Seashore, New York, 2004-2005.

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	Habitat Type		Coordinates	
	NVC	NYNHP	UTMX	UTMY
<i>Fire Island</i>				
Bellport Saltmarsh	North Atlantic Low Salt Marsh, North Atlantic High Salt Marsh, Salt Panne Pool	Low Salt Marsh, High Salt Marsh, Salt Panne	4509315.29	675133.91
Bellport Marsh East	Eastern Reed Marsh	Reedgrass/Purple Loosestrife Marsh	4509145.60	675315.49
Bellport Marsh West	Eastern Reed Marsh	Reedgrass/Purple Loosestrife Marsh	4508999.08	674956.58
Bellport Swale 1	Northern Interdunal Cranberry Swale	Maritime Freshwater Interdunal Swale	4509351.43	675800.65
Bellport Swale 2	Northern Interdunal Cranberry Swale	Maritime Freshwater Interdunal Swale	4509405.36	675952.28
Bellport Swale 3	Northern Interdunal Cranberry Swale	Maritime Freshwater Interdunal Swale	4509317.36	675721.42
Fire Island Pines: Carrington Swamp	Lower New England Red Maple-Black Gum Swamp/ Eastern Reed Marsh and Blueberry Wetland Thicket	Red Maple-Black Gum Swamp/ Reedgrass/Purple Loosestrife Marsh and Eutrophic Pond/ Shrub Swamp	4503126.98	662507.03
Kismet Pond	Eastern Reed Marsh	Eutrophic Pond/ Reedgrass/Purple Loosestrife Marsh	4499767.53	651529.85
Sailor's Haven Entrance Road	Not recognized	Unpaved Road/Path	4502549.74	661103.42
Sailor's Haven Maintenance Pond	Blueberry Wetland Thicket	Artificial Pond/Shrub Swamp	4502387.75	660396.20
Fire Island Pines: Smokey Hollow Bog	Northern Interdunal Cranberry Swale	Maritime Freshwater Interdunal Swale/ Shallow Emergent Marsh	4503359.36	663567.94
Sunken Forest: Wet Depression #1	Maritime Holly Forest	Maritime Holly Forest/ Shallow Emergent Marsh	4502317.44	660009.77
Sunken Forest: Wet Depression #2	Maritime Holly Forest	Maritime Holly Forest/ Shallow Emergent Marsh	4502312.80	659930.21
Sunken Forest: Wet Depression #3	Maritime Holly Forest	Maritime Holly Forest/ Shallow Emergent Marsh	4502246.69	659776.07
Sunken Forest: Wet Depression #4	Maritime Holly Forest	Maritime Holly Forest/ Shallow Emergent Marsh	4502243.62	659710.61

Appendix A. Coordinates and habitat types of each odonate survey site at Fire Island National Seashore, New York, 2004-2005. 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) (continued).

Site Name	Habitat Type		Coordinates	
	NVC	NYNHP	UTMX	UTMY
<i>Fire Island (cont...)</i>				
Sunken Forest: Wet Depression #5	Maritime Holly Forest	Maritime Holly Forest/ Shallow Emergent Marsh	4502229.87	659659.01
Sunken Forest: Wet Depression #6	Maritime Holly Forest	Maritime Holly Forest/ Shallow Emergent Marsh	4502269.94	659616.13
Sunken Forest: Wet Depression #7	Maritime Holly Forest	Maritime Holly Forest/ Shallow Emergent Marsh	4502258.77	659555.69
Talisman Road	Not recognized	Unpaved Road/Path	4504166.81	665393.08
Watch Hill House 12	Not recognized	Mowed Roadside/Pathway and Shallow Emergent Marsh	4506358.46	669740.76
Watch Hill Marsh	Not recognized	Shallow Emergent Marsh	4506399.56	670032.20
<i>Mainland</i>				
William Floyd Estate: Field F12	Successional Old Field	Successional Old Field	4515092.19	683528.27
William Floyd Estate: Field F15	Successional Old Field	Successional Old Field	4514855.97	683694.66
William Floyd Estate: Field G5	Successional Old Field	Successional Old Field	4515756.13	683162.87
William Floyd Estate: Field G7	Successional Old Field	Successional Old Field	4515583.83	683253.31
William Floyd Estate: Field H4	Not recognized	Mowed Lawn	4515974.40	683191.52
William Floyd Estate: Field H7	Successional Old Field	Successional Old Field	4515597.15	683504.00
William Floyd Estate: Field H9	Successional Old Field	Successional Old Field	4515597.15	683504.00
William Floyd Estate: Field J10	Successional Old Field	Successional Old Field	4515454.13	683766.96
William Floyd Estate: Field J12	Successional Old Field	Successional Old Field	4515289.19	683948.88
William Floyd Estate: Salt Marsh	Salt Panne Pool	Salt Panne	4514589.66	684131.45
William Floyd Estate: Teal Pond	Eastern Reed Marsh	Eutrophic Pond/Reedgrass/ Purple Loosestrife Marsh	4514726.32	683766.96
William Floyd Estate: Home Creek	Eastern Reed Marsh	Tidal Creek	4515756.05	683463.59
William Floyd Estate: Seep	seasonally flooded mixed graminoid meadow	seasonally flooded mixed graminoid meadow	4514853.38	683845.11

Appendix B.

Photographs of different habitat types surveyed during the 2004 and 2005 Odonate inventory at Fire Island National Seashore, New York.

Community type names using the National Vegetation Classification Standard (FGDC 1997) are shown beneath the site name, in parenthesis.



Bellport Swale 1
(Northern Interdunal Cranberry Swale)



Bellport Swale 3
(Northern Interdunal Cranberry Swale)



Bellport Marsh West
(Eastern Reed Marsh)

Appendix B. Photographs of different habitat types surveyed during the 2004 and 2005 Odonate inventory at Fire Island National Seashore, New York. Community type names using the National Vegetation Classification Standard (FGDC 1997) are shown beneath the site name, in parenthesis (continued).



Fire Island Pines: Carrington Swamp
(Lower New England Red Maple-Black Gum Swamp)



Fire Island Pines: Turtle Pond
(Blueberry Wetland Thicket)



Fire Island Pines: Smokey Hollow Bog
(Northern Interdunal Cranberry Swale)

Appendix B. Photographs of different habitat types surveyed during the 2004 and 2005 Odonate inventory at Fire Island National Seashore, New York. Community type names using the National Vegetation Classification Standard (FGDC 1997) are shown beneath the site name, in parenthesis (continued).



Sailors Haven Entrance Road
(Unpaved Road)



Sailors Haven Maintenance Pond
(Blueberry Wetland Thicket)



Sunken Forest: Wet Depression 1
(Maritime Holly Forest)

Appendix B. Photographs of different habitat types surveyed during the 2004 and 2005 Odonate inventory at Fire Island National Seashore, New York. Community type names using the National Vegetation Classification Standard (FGDC 1997) are shown beneath the site name, in parenthesis (continued).



Sunken Forest: Wet Depression 6
(Maritime Holly Forest)



Talisman Section: Talisman Road
(Unpaved Road/Path)



William Floyd Estate: Field F15
(Successional Old Field)

Appendix B. Photographs of different habitat types surveyed during the 2004 and 2005 Odonate inventory at Fire Island National Seashore, New York. Community type names using the National Vegetation Classification Standard (FGDC 1997) are shown beneath the site name, in parenthesis (continued).



William Floyd Estate: Field F12
(Successional Old Field)



William Floyd Estate: Field H4
(mowed lawn)



William Floyd Estate: Field J10
(Successional Old Field)

Appendix B. Photographs of different habitat types surveyed during the 2004 and 2005 Odonate inventory at Fire Island National Seashore, New York. Community type names using the National Vegetation Classification Standard (FGDC 1997) are shown beneath the site name in parenthesis (continued).



William Floyd Estate: Salt Marsh
(Salt Panne Pool)



Watch Hill House #12



Watch Hill Marsh

Appendix C.

Potentially occurring odonate species at Fire Island National Seashore, New York (i.e. Potential Species List).

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

Appendix C. Potentially occurring odonate species at Fire Island National Seashore, New York (i.e. Potential Species List). 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) (continued).

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

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

Appendix D. Example of voucher card template used for all voucher specimens collected during the 2004 and 2005 odonate survey of Fire Island National Seashore, New York.

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

Appendix E.

Expected abundance of odonate species in their primary habitat at Fire Island National Seashore, New York, 2004-2005.

Expected Abundance is based on the biology and life history of a given species in its primary habitat (see Methods). Species were considered Unusual if their recorded abundance was $\leq$ the expected abundance, Present if their recorded abundance was within the expected abundance range, and Numerous if their recorded abundance was $\geq$ to the expected abundance.

Species	Expected Abundance		
	Unusual	Present	Numerous
<i>Anax junius</i>	2	4-12	15
<i>Celithemis elisa</i>	1	3-6	8
<i>Celithemis eponina</i>	3	5-16	20
<i>Enallagma aspersum</i>	1	3-8	10
<i>Enallagma civile</i>	10	20-90	100
<i>Enallagma signatum</i>	2	4-16	20
<i>Epiaeschna heros</i>	1	3	5
<i>Erythemis simplicicollis</i>	2	4-12	15
<i>Erythrodiplax berenice</i>	1	10 - 12	20
<i>Ischnura hastata</i>	1	4-30	35
<i>Ischnura posita</i>	1	3 - 10	12
<i>Ischnura ramburii</i> *	1	3-16	20
<i>Ischnura verticalis</i>	2	4-16	20
<i>Lestes forcipatus</i>	2	4-10	12
<i>Lestes rectangularis</i>	2	4-15	18
<i>Libellula axelina</i>	1	3	5
<i>Libellula lydia</i>	4	6-8	10
<i>Libellula needhami</i> *	2	4-8	10
<i>Libellula pulchella</i>	2	4-10	12
<i>Libellula semifasciata</i>	3	5-8	10
<i>Pachydiplax longipennis</i>	2	4-16	20
<i>Pantala hymenaea</i>	1	3	5
<i>Pantala flavescens</i>	1	3-5	6
<i>Perithemis tenera</i>	2	4-16	20
<i>Sympetrum internum</i>	2	4-6	8
<i>Tamea carolina</i>	2	4-8	10
<i>Tamea lacerata</i>	4	6-10	12

* State listed species in New York (NYNHP 2006)

Appendix F.

Investigator effort (min) during odonate surveys conducted at Fire Island National Seashore, 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).

Survey Site	2004 Effort		2005 Effort		Total Effort	
	Raw	Adjusted	Raw	Adjusted	Raw	Adjusted
Bellport Marsh East	40.0	35.0			40.0	35.0
Bellport Marsh West	40.0	35.0			40.0	35.0
Bellport Salt Marsh	60.0	52.5			60.0	52.5
Bellport Swale 1	40.0	35.0			40.0	35.0
Bellport Swale 2	20.0	17.5			20.0	17.5
Bellport Swale 3	32.0	28.0			32.0	28.0
Fire Island Pines: Carrington Swamp	60.0	50.0			60.0	50.0
Fire Island Pines: Smokey Hollow Bog	65.0	57.5			65.0	57.5
Kismet Pond	540.0	505.0	555.0	498.8	1,095.0	1,003.8
Sailor's Haven Entrance Road	140.0	140.0	20.0	17.5	160.0	157.5
Sailor's Haven Maintenance Pond	120.0	120.0	170.0	166.3	290.0	286.3
Sunken Forest Wet Depression #1	30.0	30.0	60.0	52.5	90.0	82.5
Sunken Forest Wet Depression #2	30.0	30.0	30.0	26.3	60.0	56.3
Sunken Forest Wet Depression #3	50.0	50.0	40.0	35.0	90.0	85.0
Sunken Forest Wet Depression #4	30.0	30.0	20.0	17.5	50.0	47.5
Sunken Forest Wet Depression #5	30.0	30.0	20.0	17.5	50.0	47.5
Sunken Forest Wet Depression #6	30.0	30.0	20.0	17.5	50.0	47.5
Sunken Forest Wet Depression #7	20.0	17.5	30.0	26.3	50.0	43.8
Talisman Road	20.0	20.0			20.0	20.0
Watch Hill House 12	30.0	30.0			30.0	30.0
Watch Hill Salt Marsh	45.0	30.0			45.0	30.0
William Floyd Estate: Field F12	70.0	70.0	30.0	26.3	100.0	96.3
William Floyd Estate: Field F15	30.0	30.0	15.0	13.0	45.0	43.0
William Floyd Estate: Field G5	30.0	30.0	15.0	13.0	45.0	43.0
William Floyd Estate: Field G7	60.0	60.0	70	62.5	130.0	122.5
William Floyd Estate: Field H4	10.0	10.0	35	31.25	45.0	41.3
William Floyd Estate: Field H7	30.0	27.5	20	17.5	50.0	45.0
William Floyd Estate: Field H9	190.0	175.0	30.0	26.3	220.0	201.3
William Floyd Estate: Field J10	70.0	62.5	20	17.5	90.0	80.0
William Floyd Estate: Field J12	30.0	30.0	15.0	13.0	45.0	43.0
William Floyd Estate: Home Creek	40.0	35.0	20	17.5	60.0	52.5
William Floyd Estate: Saltmarsh	90.0	75.0	480.0	435.0	570.0	510.0
William Floyd Estate: Seep	-	-	-	-	-	-
William Floyd Estate: Teal Pond	20.0	20.0	110.0	96.3	130.0	116.3
Total (min)	2,142.0	1,998.0	1,825.0	1,644.0	3,967.0	3,642.0
Total (hrs.)	35.7	33.3	30.4	27.4	66.1	60.7

Appendix G.

Photographs of two rare odonate species found in Fire Island National Seashore, New York.

Photographs are used by permission from Blair Nikula. Needham's skimmer was found in 2004 and 2005, and is ranked by the New York Natural Heritage Program (NYNHP) as an S2S3¹ species (NYNHP 2003). Rambur's forktail was only found in 2004, and is listed by the NYNHP with a ranking of S2² (NYNHP 2003). Both species have a global ranking of G5³.



Male Needham's skimmer (*Libellula needhami*)



Female Needham's skimmer (*Libellula needhami*)



Male Rambur's Forktail (*Ischnura ramburii*)



Female Rambur's Forktail (*Ischnura ramburii*)

¹S2: "Typically 6 to 20 occurrences, few remaining individuals, acres, or miles of stream, or factors demonstrably making it very vulnerable in New York State" (NYNHP 2003).

²S3: "Typically 21 to 100 occurrences, limited acreage, or miles of stream in New York State" (NYNHP 2003).

³G5: "Demonstrably secure globally, though it may be quite rare" (NYNHP 2003).

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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