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Inventory of Amphibians and Reptiles at the William Floyd Estate, Fire Island National Seashore

Natural Resource Report NPS/NCBN/NRTR—2010/380

ON THE COVER
Eastern Box Turtle (*Terrapene c. carolina*). Already an adult when originally marked by naturalist and William Floyd Estate resident J.T. Nichols in July 1921, male JN21_21 was over 100 years old when photographed in September 2002 by David Brotherton.

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This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Executive Summary

Under a National Park Service (NPS)/Wildlife Conservation Society Cooperative Agreement, we inventoried amphibians and reptiles at the William Floyd Estate (WFE), in Mastic, New York from April to September 2002. Six standardized sampling methods were used; anuran calling surveys, egg mass counts, visual encounter surveys, coverboards, turtle trapping surveys, and minnow trapping surveys. We also recorded animals encountered outside of standardized surveys as incidental encounters, including some after 2002.

Eleven species were recorded representing 46% (11/24) of the historically-occurring species. These included one frog species, two salamander species, four turtle species, and four snake species. Spring peeper, eastern red-backed salamander, eastern box turtle, and eastern garter snake were the most abundant and widely distributed species in each taxonomic group. The spring peeper was the only anuran recorded. Its current presence at WFE is the result of a recent experimental translocation. Three four-toed salamanders found in 2002 were the first records of this species here, although we believe it was present all along. An eastern milk snake and painted turtle, found by NPS staff in 2004 and 2008 respectively, were the only records of these species. The only “listed” species found was eastern box turtle (Species of *Special Concern*). Incidental encounters recorded 7 of 11 species, followed by stream visual survey (5), woodland visual survey and coverboards (4), field visual survey (3), turtle trap survey (2), and anuran calling survey and minnow trap survey (1). Seven species were recorded in fields, five in woodland and freshwater stream, four in freshwater marsh, and one each in freshwater and brackish ponds.

The herpetofauna of WFE has experienced significant declines. Only nine of the 24 species that occurred historically appear to have stable population trends. Of the15 species that have declined, 11 appear extirpated: nearly all the anurans, three snake species that feed on anurans; and the eastern mud turtle. Exact causes for the decline and extirpation of many species are not certain, but WFE has been subjected to a number of severe stressors, particularly DDT in the 1950’s, salt water intrusion following the natural creation but artificial maintenance of the Moriches Inlet, and residential development of the adjacent landscape. These, plus other less well documented stressors, such as acid precipitation, mercury deposition, and diseases have all likely contributed. The relatively small patch size of WFE is also likely an important factor in the loss of species. In contrast, the nearby Carmen’s River system, with over 4000 acres of similar upland and wetland habitat preserved along 6.6 miles of river has not experienced a similar loss of species, despite being subjected to many of the same stressors as WFE.

WFE is well known for its eastern box turtles and a number of seminal papers on them are based on research conducted here. Of special interest in this survey was a box turtle first captured in 1921 at a minimum age of 20 years by naturalist J. T. Nichols. Its re-capture in 2002 makes it a centenarian. WFE now exists as an isolated, moderately-sized habitat island in an urbanized landscape. Its ability to support species with large area requirements and complex habitat needs is uncertain. Data collected in this survey suggest that recruitment into the box turtle population is declining and estimated population size and density was relatively low. More intensive study of WFE’s box turtle population is needed to provide better estimates of population size and structure, and take advantage of historic data to estimate trends in survival and other population parameters. Efforts to restore some of the extirpated species should be undertaken.

Acknowledgments

Funding for this project was provided by the National Park Service, and numerous people assisted with the project. Charlie Eichelberger and Linh Phu spent countless hours in the field at all hours of the day and night, organized and summarized the data gathered, and provided summaries of their findings. Richard Stavdal, recently retired WFE site manager was especially helpful with his insight into the land use history of the park, his many field observations and notes on WFE herpetofauna, and in identifying important habitats likely to support amphibians and reptiles. MaryLaura Lamont also provided valuable insight and a significant field observation. We are grateful to park staff for providing access to and interpretation of important materials catalogued in the park museum.

We are also grateful to a number of Long Island biologists/naturalists who graciously shared their notes, data, and observations of the herpetofauna in and around WFE and Wertheim NWR. They are: Alex Chmeilewski, US Fish and Wildlife Service; Jeremy Feinberg, Rutgers University; Joseph Kinneary, formerly of Rutgers University; and Peter R. Warney.

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Introduction

The William Floyd Estate (WFE), former home and estate of General William Floyd, a signer of the Declaration of Independence was donated by the Nichols family to the National Park Service (NPS) in 1965. Included on the 248 ha (613 ac) site are the 25 room historic house, 11 historic buildings, and family cemetery. WFE is located on the south shore of Long Island in Mastic Beach, Suffolk County, New York (40° 46' N, 72° 49’ W). Although it is managed by the NPS as a unit of Fire Island National Seashore (FIIS), because WFE is geographically distinct from Fire Island, for the purposes of this inventory it was considered separately.

In 1998, a Cooperative Agreement between the National Park Service and the Wildlife Conservation Society was formed to assess amphibian and reptile populations at parks within the Northeast Region of the National Park Service. While the goals of the project vary between parks, they generally are as follows:

- Inventory and record at least 90% of the species currently estimated to occur in the park.
- Determine the occurrence and status of species of management concern (e.g., state and federal *Threatened*, *Endangered*, and *Special Concern Species*, and other declining species).
- Determine abundance categories, distribution, and habitat use of documented species.
- Identify critical habitats of *Threatened*, *Endangered*, and *Special Concern* species.
- Provide basis for future development of a long term monitoring program.
- Analyze species occurrence against historical occurrence and evaluate the state of the park’s herpetofauna, on a site and regional scale.

An “estimate” of species historically present at WFE was generated using historic literature and documents, NPS reports, and discussion with knowledgeable park staff. The primary sources of historic information on WFE herpetofauna are the records of John Treadwell (J.T.) Nichols. Nichols, who founded the American Society of Ichthyologists and Herpetologists and served as the first editor of its scientific journal *Copeia*, lived here from the early 1900’s until his death in 1958. Nichols recorded many of his observations of the herpetofauna and other wildlife at WFE, and marked and measured hundreds of eastern box turtles. Through his journal (Nichols 1904-1958) and publications (Engelhardt et al. 1915; Nichols 1914, 1916, 1917ab, 1933, 1939abc, 1940,1947) Nichols recorded nine species of amphibians and 13 species of reptiles from WFE and the area north of the present estate along the Forge River (Appendix A). However, in reading Nichols’ journal, it is apparent that he did not record all he saw, and many presumably common species have a limited number of entries. For example, in the first of only two records of red-backed salamanders, Nichols notes that he has only found lead-backed forms at Mastic, indicating he has made other, unrecorded observations. Thus, although Nichols journal is an excellent source of information on species occurrence, it is a selective record and does not always provide explicit insight into abundance.

Schlauch (1974) mapped the distribution of amphibians and reptiles on Long Island based on museum specimens, published records, and observations made by reliable naturalists in the 1960's and 1970's. Although WFE was not a focus of this work and the publications of Nichols were not included, Schlauch (1974) lists observations from Mastic Beach, including ring-necked snake (a species not recorded by Nichols), as well as specimens collected by Nichols and others.

As part of an extensive "Environmental Inventory" of FIIS and WFE that covered all groups of wildlife and their habitats, McCormick (1975) produced a list of amphibians and reptiles known or expected to occur at WFE, based primarily from the literature on Long Island herpetofauna. This list totaled 25 species, seven of which were "known" to occur at WFE and 18 that were "expected". There is no explanation of the basis for listing a species as "known" to occur and of the 18 "expected" species, 13 had been recorded at WFE by Nichols. Thus, it is apparent that the records in Nichol's journal were not included and most of this list is speculative. Four species "expected" to occur at WFE and never documented (spotted salamander, Jefferson salamander, marbled salamander, eastern tiger salamander) were listed based on species range and habitat affinities. Because the McCormick (1975) list is not based on any significant field work (FIIS and WFE were visited from 9 to 12 April 1974) and does not include the most detailed historic record of species' occurrences at WFE (i.e. Nichols journal), it does not provide any new or meaningful information about amphibians and reptiles at WFE, in either the early 20th century or circa 1974. Consequently, although included in our summary of literature on WFE herpetofauna (Appendix A), our "estimate" of the historic herpetofauna of WFE does not incorporate McCormick (1975).

More recently, NPS Ranger Richard Stavdal continued Nichol's box turtle surveys from 1981 to 2006, collecting data on more than 700 box turtles, including 17 individuals marked by J.T. Nichols. Lynch (1986) recorded two amphibian and nine reptile species in the course of an ecological inventory of WFE and Klemens et al. (1988ab) recorded the eastern red-backed salamander and eastern box turtle. Sprenger et al. (1987) analyzed DDT residue in the flora in fauna at WFE, including road kill spotted turtle and eastern box turtle and the presence of diamond-backed terrapins was re-confirmed in 1989 by Morreale (1992). Collectively, these sources indicate that 23 of the 38 species of amphibians and reptiles historically resident on Long Island (Noble 1927) have been historically recorded at WFE (Appendix A). Among these 23 species are one currently listed as "endangered" by New York State (Eastern mud turtle) and five listed as "special concern" (Eastern spadefoot toad, Southern leopard frog, Eastern box turtle, spotted turtle, and eastern hog-nosed snake) (NYSDEC 2000).

Although the historic herpetofauna of WFE had a high degree of species richness, there were indications that applications of DDT in the 1950's and 1960's had lead to a decline and/or loss of many species (Lynch 1986, Jankowski 2004). At the time of this survey, many of the species recorded by Nichols (1904-1958) had not been observed in decades and the status of most was unknown. Consequently, the target species of this inventory were all of the site's historically known herpetofauna. These are broad in terms of taxonomic groups and habitat affinities and the inventory employed six standardized methods in a variety of habitats. Incidental encounters were also recorded to provide additional information on species presence and distribution. The habitat type of all sites where amphibians and reptiles were found was described, and the species and the habitat types they occupied were analyzed.

Study Area

Settled by the Floyd family in 1724, the original Floyd Estate extended north from Moriches Bay and west from the Forge River to encompass 1781 ha (4400 ac) in Mastic, Suffolk County, New York (Torres-Reyes 1974). The estate was primarily used for agriculture until the 1870's and was eventually divided among the family. Most of the original property was sold, except for the 248 ha (613 ac) remaining today. Over the past few hundred years the vegetative communities and land use of the property has changed from coastal plain forest to agricultural fields and back to a mixture of mowed fields/meadows and woodlands. Habitats in WFE range from maintained grass, mowed fields, deciduous forest, several ponds, streams, fresh water marsh and salt marsh habitats, with a network of dirt roads and trails throughout. The fields are mowed annually or semi-annually during the fall, or in times of drought during hot summer months. All of the land surrounding WFE has been developed into residential communities.

Methods

Sampling Overview

We sampled WFE with a three person crew as part of an effort to survey the herpetofauna of three NPS units over the course of the 2002 field season. Because the herpetofauna of the northeast United States consists of a variety of species, each with differing periods of activity (which can also vary somewhat annually), we distributed sampling effort over the course of the spring and summer activity season. Given this and the logistics of sampling three separate NPS units on Long Island (WFE; Fire Island NS; Sagamore Hill NHS, Oyster Bay) we sampled them in bouts that varied in duration in proportion to each's size and presumed faunal/zoogeographic complexity. Over the course of a month the crew sampled one and then moved on to the next, such that a full round of sampling was conducted each month during the months of April, May, June, August, and September. For WFE, each monthly sampling bout was generally one week long.

The general approach of sampling was to balance the need for standardized methods and quantifiable results with the primary goal of determining species presence. Since amphibians and reptiles found at WFE are variable in habitat use and seasonal patterns of detectability, we employed a number of methods, both general and habitat/taxa specific (Table 1). These were; Anuran Calling Surveys (ACS), Egg Mass Counts (EMC), Coverboard Surveys (CB), Turtle Trap Surveys (TTS), Minnow Trap Surveys (MTS), Habitat or Area-specific Visual-encounter Surveys (VES), and Incidental Encounters (IE). We employed general methods (i.e.VES) across all habitats for the entire field season, whereas habitat/taxa specific methods were employed at those times of the year when the target species/habitat are known to be most efficiently sampled.

The combination of methods chosen recognized that multiple methods were necessary to detect the wide range of potentially-occurring species and that some species are difficult to detect due to rarity or behavior. Thus, a degree of redundancy was needed to increase the likelihood of encountering these rare/hard to find species, most all of which were "target species". Collectively, the methods we employed were designed to provide a comprehensive list of species occurrence and a reasonable estimate of relative abundance and habitat use. Site selection for standardized surveys was designed to sample across the range of habitat types present as well as to be spatially balanced. Based on existing maps of the park, as well as field reconnaissance, most of the ponds/wetlands, tidal saltmarsh/ditches, field and woodland habitats were identified (Figure 1). Due to the park's relatively small size, the number of ponds/wetlands and streams were limited, such that all were sampled. Similarly, woodland habitat in the park was partitioned into seven "sections", and field habitat was partitioned into nine "sections" and all were sampled We divided habitats into two categories, wetland or upland, and further sub-divided these into seven habitat types to provide a description of each survey site (Appendix B).

Marking, Measurement, and Aging/Sexing of Captured Animals

Captured animals were treated differently in terms of marking and measurements, with exact details determined by whether a species was a "target" species, as well as the inherent ability to mark a species. While several different methods were employed to capture/sample animals, details of marking and measuring were based on details of species, not method of capture.

Table 1. Overview of standardized survey sites and sampling methods used at each.

Sample Site	Habitat Type	Call Count	Egg Mass Count	VES Stream	VES Woodland	VES Field	VES Wetland/Pond	Coverboard	Turtle Trap	Minnow Trap
Floyd Pond & Ditches	brackish pond						X		X	
Folly Pond	brackish pond						X		X	
Rye Pond	brackish pond	X					X		X	X
South Pond	brackish pond						X		X	
Field F/G7	field					X				
Field F12	field					X				
Field F15	field					X		X		
Field F6	field					X				
Field H9	field					X		X		
Field I14	field					X				
Field J10	field					X				
Field J12	field					X		X		
Field M11	field					X		X		
Teal Hole Bog	marsh	X	X				X		X	X
Woodlot 5 Marsh	marsh									X
Teal Hole	permanent pond	X	X				X		X	X
Home Creek	permanent stream			X					X	
O'Dell Creek	permanent stream			X					X	X
O'Dell Pond	temporary pond	X	X				X		X	X
Woodlot 1	woodland				X					
Woodlot 2	woodland				X			X		
Woodlot 3	woodland				X			X		
Woodlot 4	woodland				X					
Woodlot 5	woodland				X					
Woodlot 6	woodland				X			X		
Woodlot 7	woodland				X			X		

Figure 1. Location of standardized sampling sites and time-constrained search areas used in herpetofaunal inventory at the William Floyd Estate, 2002

We classified amphibians as larvae or adult-form, and adult-form individuals into age categories (metamorph, juvenile, adults) but did not mark, measure, or weigh them. We measured snakes' snout-vent length (SVL), total length (TL), and mass, and sexed them based on degree of tail contour (Conant and Collins 1998), but did not mark them. We marked all turtles for individual identification, with each given a unique set of notches in the marginal scutes, using a code system modified from Cagle (1939). For all turtles captured, we measured carapace length (CL), carapace width (CW), plastron length (PL), and mass. Turtles were sexed based on external features for each species described in Ernst et al. (1994). Individuals were classified as adult, as opposed to juvenile, based on the following size criteria: snapping turtles, males with CL >210 mm and females with CL>200 mm (Congdon et al. 1987, 1992, Ernst et al. 1994); spotted turtles, PL>80 mm Graham (1995); mud turtles CL>75mm (Frazer et al. 1991); box turtles CL>120 mm (Dodd 2001).

Anuran Calling Surveys

Anuran calling surveys (ACS) were conducted using the Wisconsin frog and toad survey method (Heyer et al. 1994). ACS records the presence of species calling at specific sites and provides an index of abundance based on the calling intensity. Call index (CI) values and criteria for assigning them are; 0 = no calls, 1 = individuals can be counted (no overlapping of calls), 2 = overlapping of calls (can still be counted), 3 = full chorus-calls are constant and individually indistinguishable. The surveyors arrived at each sample site at least one half-hour after dusk. Surveyors listened for anuran calls for five minutes, recording species heard, the number of individuals heard, if any, and the call index for each species.

We surveyed four pre-selected sites between March 27 and June 19, 2002. Although the original plan called for sampling each site an equal number of times, the exigencies of field work prevented this, and sites were sampled from two to nine times, as detailed below. Because of the unequal number of sampling occasions, and the low number of occasions at some sites, there is some bias against detecting species with low detection probabilities. Multiple call counts at a site, conducted over the entire spring and early summer months are necessary to document species presence over time, as different anuran species are active at different times of the season (Conant and Collins 1998; Crouch and Paton 2002).

Survey sites were:

1. Teal Hole Bog – 9 call counts
2. Teal Hole – 6 call counts
3. O'Dell Pond – 4 call counts
4. Rye Pond – 2 call counts

Egg Mass Counts

Amphibians such as spotted salamanders and wood frogs (*Rana sylvatica*) migrate to ponds in early spring to breed, depositing gelatinous egg masses attached to fallen tree branches and vegetation in the water (Petranka 1998). Egg mass counts (Cook and Boland 2005) were conducted to determine presence of these species. In these counts, the observer traversed the entire pond, searching for, identifying and counting all egg masses observed. While every effort was made to count all masses in a pond, because spawning is only loosely synchronized, counts based on a single survey may underestimate total numbers of egg masses laid.

Survey sites were:
1. O'Dell Pond – 1 search (28 March 2002)
2. Teal Hole Bog – 2 searches (29 March and 25 April 2002)
3. Teal Hole – 2 searches (29 March and 25 April 2002)

Visual Encounter Surveys

We conducted habitat-specific visual encounter surveys (VES) (Crump and Scott 1994) in all habitats likely to support amphibians and reptiles, i.e. stream, ponds/wetlands, woodland, and field. Each wetland or upland VES area (Figure 1) was searched thoroughly and time taken to do so recorded. Searchers used an approach intended to maximize the numbers and diversity of captures by moving through the area and searching under the best available cover (e.g. logs, boards, metal debris) favored by amphibians and reptiles (Bury and Raphael 1983), and by dip netting ponds (Heyer et al. 1994). Although the original plans called for sites within each habitat type to be sampled the same number of times, this was not always the case. We standardized results of VES as a capture rate (CR) for each species, calculated by dividing the total number of individuals recorded by the total search effort (person hours) spent for each search. Person hours are the total amount of time spent searching, multiplied by the number of people participating in the search.

Stream VES

We surveyed two spring feds streams, Home Creek located along the northeastern border of the park and O'Dell Creek along the western border of the park, five and four times respectively between 26 April and 16 September 2002. Home Creek was searched from its confluence with the tidal lagoon at the south end of the creek to a spring fed marsh at the north end near the cemetery. Searches in O'Dell Creek began at the south end of the creek where a house and cement wall border the creek, and continued north to an area where the creek narrows and becomes a spring fed skunk cabbage marsh located adjacent to houses and maintained lawns. Investigators systematically moved upstream, using a dip net in the stream to capture amphibians. Rocks, logs, vegetation, and debris on the bank were overturned and searched under. Identification and life stage (adult or larva) were recorded for each animal captured. The adult life stage was defined as any individual not in the larval stage and the larval stage, was defined as an individual with gills, showing pre-metamorphic characteristics. Total search time was 9.5 search hours at Home Creek and 4.7 search hours at O'Dell Creek. Starting and ending times (Eastern Standard Time) and the number of people searching were recorded.

Woodland VES

We searched seven woodland areas five times each between 29 March and 20 September 2002. Start and end times, number of searchers, and the identification, and number of individuals found were recorded. As detailed below, total search time ranged from 6.2 to 12.2 search hours/site.

Woodland survey sites were:
1. Woodlot 1 – 8.3 search hours.
2. Woodlot 2 – 11.6 search hours.
3. Woodlot 3 –7.8 search hours.
4. Woodlot 4 – 7.2 search hours.
5. Woodlot 5 – 6.4 search hours.
6. Woodlot 6 – 12.2 search hours.

7. Woodlot 7 – 6.2 search hours.

Field VES

We searched eight fields six times and one field twice between 28 March and 20 September 2002. Start and end times, number of searchers, and the identification and number of individuals found were recorded. As detailed below, total search time ranged from 1.1 to 6.3 search hours/site.

Field survey sites were:

1. Field F/G7- 6 surveys, 4.0 search hours.
2. Field F12 – 6 surveys, 4.6 search hours.
3. Field F15 – 6 surveys, 4.4 search hours.
4. Field F6 – 2 surveys, 1.1 search hours.
5. Field H9 – 6 surveys, 4.6 search hours.
6. Field I14 – 6 surveys, 4.6 search hours.
7. Field J10 – 6 surveys, 4.1 search hours.
8. Field J12 – 6 surveys, 6.3 search hours.
9. Field M11 –6 surveys, 3.4 search hours.

Wetland VES

We searched six wetland sites five times each, and one wetland six times between 28 March and 18 September 2002. Searches were conducted by traversing the entire pond, sampling with a dip-net for amphibian larvae and adults, as well as turtles and snakes. Start and end times, number of searchers, and the identification, and number of individuals found were recorded. As detailed below, total search time ranged from 1.1 to 10.3 search hours/site.

Wetland survey sites were:

1. Floyd Pond & Ditches (brackish) - 5 surveys, 10.3 search hours.
2. Folly Pond (brackish) - 5 surveys, 4.6 search hours.
3. Rye Pond (brackish) - 6 surveys, 3.5 search hours.
4. South Pond (brackish) - 5 surveys, 5.7 search hours.
5. O'Dell Pond (temporary) – 5 surveys, 1.1 search hours.
6. Teal Hole (permanent) - 5 surveys, 2.8 search hours.
7. Teal Hole Bog (marsh) - 5 surveys, 1.7 search hours.

Coverboards

We used coverboards (Grant et al. 1992) primarily to inventory snakes, but they were also expected to detect terrestrial amphibians. Boards were 0.6 m x 1.2 m (2' x 4') and made of corrugated sheet metal or plywood. In March 2002, coverboards were deployed at four woodland (Woodlots 2, 3, 6, 7) and four field sites (Field F15, H9, J12, M11) (Figure 1). We placed eight boards five meters apart in linear "arrays" consisting of alternating wood and metal boards. We checked coverboards twice/month in April, May, June, August, and September, and once in July. Thus each array had a total of 11 visits and 88 boardchecks.

We calculated a capture rates (CR) as the number of snake captures under boards divided by the total number of board checks for each site. Each time a board was checked constituted a "board check". Therefore, a site with eight boards visited six times equaled 48 board checks. The number of snake captures per 100 coverboard checks was calculated as:

$$CR = \frac{(\# of\ snake\ captures)}{(total\ \# of\ board\ checks)} \times 100$$

Turtle Trap Surveys

We used welded-wire crab traps measuring 30.5cm x 30.5cm x 60.1cm (12"x12"x 24"), with a mesh size of 1.3cm x 2.5cm (0.5" x 1") to sample shallow areas for small aquatic/semi-aquatic turtles such as spotted (*Clemmys guttata*) and eastern mud turtles (*Kinosternon subrubrum*). We used funnel traps made of D-shaped metal hoops and 2.6cm (1") nylon mesh to sample deeper pond areas for aquatic turtles such as painted (*Chrysemys picta*) and snapping turtles (*Chelydra serpentina*) (Harless and Morlock 1989). One to six traps, baited with sardines in vegetable oil and checked daily, were set for five-day periods between 21 May and 20 June 2002 at nine sites. Each turtle was assigned a unique, individual identification number and, using a three-sided file, triangular notches were made on marginal scutes, to represent that number (Cagle 1939).

Trap sites were:

1. Home Creek – (2, 5 day trapping periods, 2 traps)
2. O'Dell Creek – (2, 5-day trapping periods, 1 to 2 traps)
3. Teal Hole Bog – (2, 5-day trapping periods, 3 traps)
4. Floyd Pond and Ditches – (2, 5-day trapping periods, 3 to 6 traps)
5. Folly Pond – (2, 5-day trapping periods, 3 traps)
6. Rye Pond – (2, 5-day trapping periods, 3 to 4 traps)
7. South Pond – (2, 5-day trapping periods, 3 traps)
8. O'Dell Pond – (1, 5-day trapping period, 2 traps)
9. Teal Hole – (2, 5-day trapping periods, 4 traps)

Minnow Trap Surveys

We used wire mesh minnow traps measuring 15.2 cm x 15.2 cm x 30.5 cm (6"x 6"x 12") to sample shallow pond areas for adult and larval salamanders, adult and larval anurans, and aquatic snakes (Heyer et al. 1994). One to three traps each were deployed at six sites for two or five-day periods between 23 April and 23 August 2002. Since this method primarily captures amphibians, which were not marked for individual recognition, abundance was quantified as total captures (rather than unique individuals) per 100 trap nights.

Trap sites were:

1. O'Dell Creek – (4, 5-day trapping periods, 1 to 2 traps)
2. Teal Hole Bog – (4, 5-day trapping periods, 2 traps)
3. Woodlot 5 Marsh – (1, 2-day trapping period, 4 traps)
4. Rye Pond – (2, 2-day trapping periods, 2 traps)
5. O'Dell Pond – (2, 5-day trapping periods, 2 to 3 traps)
6. Teal Hole – (4, 5-day trapping periods, 2 to 3 traps)

Incidental Encounters

Any encounter with an amphibian or reptile not recorded as data in one of the standardized surveys was considered an incidental encounter. We recorded these to augment data collected during formal surveys, including credible observations made by park staff and visitors. For each incidental encounter, species, life stage, method of documentation, as well as location, habitat, and UTM coordinates were recorded, though some of these data were sometimes missing from visitor reports. Two incidental encounters that occurred after this survey was completed have been included, because they involve species not recorded during the 2002 survey. These are an eastern milk snake recorded on 7/24/04 (R. Stavdal, pers. comm.) and a painted turtle recorded on 7/10/08 (ML Lamont, pers. comm.).

Quantifying Abundance and Distribution

Quantifying actual abundance of the species encountered was not possible for a number of reasons. The methods we used generally did not estimate actual population size, but rather provided a method-specific index of abundance, such as a capture rate (catch per unit effort). In addition, each of the seven methods provided a sample possibly biased towards a particular species or group of species or sex. Although sampling effort was divided among the different methods in an attempt to compensate for possible sampling bias, the amount of sampling bias, the extent to which the use of different methods may have balanced this bias, and the influence of other covariates, such as habitat type and breeding habits, were not estimated.

We derived an index of overall abundance for each species by summing the number of adult form individuals (as opposed to larvae) encountered during each of the seven survey methods. For visual encounter surveys, coverboard checks, turtle and minnow traps, and incidental encounters, the numbers of adult form individuals of a given species encountered during each sampling occasion were summed. Turtle shells (carapace/plastron), snake skins, and reptile nests were also considered to represent one adult individual. Because we did not mark amphibians, for the purposes of estimating an overall index of abundance, we also treated reptiles as though they had not been marked. Because anuran calling surveys do not directly count adults, index values were converted to conservative estimates of the number of calling males present, based on data collected at Cape Cod National Seashore where both index values and estimates of numbers calling were made (Cook, unpublished data).

Although the total numbers recorded for each species provide an index of overall abundance, it is an uncalibrated index, and its relationship to actual abundance is unknown. These numbers, and their derivatives, are best viewed as indicating the order of magnitude of a species' abundance and providing a reasonably accurate representation of relative and ranked abundance within each taxonomic group (i.e. frogs/toads, turtles, snakes). Although these numbers are of value for some inter-specific comparisons and community analysis, and are likely accurate in identifying abundant versus rare species, differences between species whose index of abundance are of the same order of magnitude may not reflect true differences in abundance.

Incidental encounters represent occasions when animals were encountered outside of formal standardized surveys. Such occasions include when a species that is not the target of a given survey method is encountered during a standard survey, such as when an amphibian is observed while checking a turtle trap. Thus incidental encounters may occur at sites where standardized surveys were conducted, but often occur at other locations in the park. A measure of a species' overall distribution was obtained by combining the number of standardized survey sites and incidental encounter locations at which it was recorded. This summed term is referred to as "localities". There were 30 localities. Of these, 26 were standardized survey sites, ten were standardized survey sites at which incidental encounters occurred, and four were incidental encounter locations only

Data Management

Common and scientific names and spellings are those of Crother et al. (2000, 2003). A Garmin III Plus Global Positioning System (GPS) unit was used to record the distance or area searched during time-constrained surveys and the coordinates of coverboard arrays (Appendix C). Coordinates of each site surveyed during standardized surveys and location identified during incidental encounters were also recorded. GPS locality data were recorded as Universal Transverse Mercator (UTM) (zone 18N) grid coordinates X=x-axis or Easting, and Y=y-axis or Northing, using NAD83.

Data collected in the course of this study, original data sheets, and voucher photos are archived with the National Park Service, Northeast Coastal and Barrier Inventory and Monitoring Network at the University of Rhode Island (http://science.nature.nps.gov/im/units/ncbn/).

Results

Overview of Park Herpetofauna

Including two post-survey incidental encounters, a total of 11 species, three amphibian (two salamander and one anuran) and eight reptile (four turtle and four snake) were recorded. Of the 211 individuals recorded, 50.7% were reptiles and 49.3% were amphibians. By taxonomic group, salamanders comprised 48.8% of all individuals, turtles 39.3%, snakes 11.4%, and frogs 0.5%. The most abundant species in each taxonomic group, based on total numbers recorded were eastern red-backed salamander (*Plethodon cinereus*), spring peeper (*Pseudacris crucifer* – the only anuran, 1 individual), eastern box turtle (*Terrapene c. carolina*), and eastern garter snake (*Thamnophis s. sirtalis*) (Table 2). Of the 11 species recorded, the four-toed salamander had never been recorded at WFE and the spring peeper had not been recorded in decades.

Animals were recorded from 23 of 30 (77%) locations (26 standardized survey sites plus 4 incidental encounter locations) (Figures 2, 3, 4). Based on frequency of occurrence, the most widespread species in each taxonomic group was eastern box turtle (20 or 67% of all localities), eastern red-backed salamander (12 or 40%), eastern garter snake (10 or 33%), and spring peeper (1 or 3%) (Table 3). The most species rich sites were Field J12, Home Creek, O'Dell Creek, Teal Hole Bog, Woodlot 2 and Woodlot 3, each with four species recorded (Figure 5). Woodlots 1 and 2 accounted for the greatest number of individuals, 31 and 29 respectively. The majority of these individuals were eastern red-backed salamanders (Table 4).

By habitat, the number of individuals recorded was greatest in uplands (170/211 or 80.6% of individuals recorded), followed by streams (33/211 or 15.6%), and wetlands (8 or 3.8%) (Table 2). Similarly, species richness was greatest in uplands (8 of 11 species), followed by five species each in stream and wetland habitats (Table 2, Figure 5). Within the seven habitat sub-categories, species richness was greatest in field habitat (7 species), followed by woodland and stream (5 species each), marsh (4 species), and brackish pond and permanent pond (1 species each). Despite extensive searches, no species were found in temporary pond habitats (Table 2).

Survey Methods Summary

Incidental encounters detected the greatest number of species, seven of 11, produced the only records of painted turtle (ML Lamont, pers. comm.) and eastern milk snake (R. Stavdal, pers. comm.), and more records of snapping turtle than any other method (Tables 5 and 6). In terms of individuals captured, it was the second-most productive method, accounting for 25.6% of all animals recorded. Of the standardized surveys, Stream VES produced the greatest number of species (5). Woodland VES produced the greatest number of individuals (94 or 44.5% of individuals) and was the most productive method for eastern red-backed salamander and eastern box turtle. Coverboards produced four species and was the most productive method for the northern black racer and northern brown snake. Field VES produced three species representing 11.8% of individuals. Turtle trapping produced two species and was the only method to capture northern diamond-backed terrapin (1 individual) (Tables 6 and 13). Anuran calling surveys produced one spring peeper, the only anuran recorded in the park (Tables 5 and 7). Wetland/Pond VES and Minnow Trap Surveys produced one species each, accounting for <1% each of all individuals recorded (Table 6). No species were recorded during Egg-Mass Counts.

Table 2. Number of adult form amphibian and reptile captures recorded during all surveys by habitat category at the William Floyd Estate. Data include turtle shells and nests, and snake skins. Data were collected primarily from March to September 2002, but more recent, significant incidental encounters (i.e. painted turtle and eastern milk snake) are also included. Relative abundance (RA) within taxonomic groups is the total number of a species recorded divided by total number recorded within each group (order), expressed as a percentage.

	Stream	Wetland				Upland			
	Permanent stream	Marsh	Brackish pond	Temporary pond	Permanent pond	Woodland	Field	Total	RA (%)(Rank)
Salamanders									
Eastern red-backed salamander	9	1				84	6	100	97.1 (1)
Four-toed salamander	2					1		3	2.9 (2)
Frog									
Spring peeper		1						1	100 (1)
Turtles									
Snapping turtle	13	2			1			16	19.3 (2)
Painted turtle							1	1	1.2 (3)
Eastern box turtle	5	2				35	23	65	78.3 (1)
N. diamond-backed terrapin			1					1	1.2 (3)
Snakes									
Eastern garter snake	4					7	6	17	70.8 (1)
Northern brown snake						1	4	5	20.8 (2)
Northern black racer							1	1	4.2 (3)
Eastern milk snake							1	1	4.2 (3)
Total # of Adults	33	6	1	0	1	128	42	211	
% of Total	15.6%	2.8%	0.5%	0.0%	0.5%	60.7%	19.9%	100.0%	
Total # of Species	5	4	1	0	1	5	7	11	
	5	5				8			

Figure 2. Location of amphibian species recorded at William Floyd Estate.

Figure 3. Location of turtle species recorded at William Floyd Estate.

Figure 4. Location of snake species recorded at William Floyd Estate.

Figure 5. Species richness of areas sampled for amphibians and reptiles at William Floyd Estate.

Table 3. Distribution by habitat category of amphibians and reptiles recorded at the William Floyd Estate. Table entries indicate number of localities at which a species was recorded. Frequency of Occurrence (FO) is total number of localities a species was recorded from divided by total number (30). Number of localities includes both standardized survey sites (26) and incidental encounter locations (4). All data from 2002, plus subsequent significant incidental encounters are included.

	Stream	Wetland				Upland			
	Permanent stream	Marsh	Brackish pond	Temporary pond	Permanent pond	Woodland	Field	Total	FO (%)
Salamanders									
Eastern red-backed salamander	1	1				7	3	12	40
Four-toed salamander	1					1		2	6.7
Frog									
Spring peeper		1						1	3.3
Turtles									
Snapping turtle	2	1			1			4	13.3
Painted turtle							1	1	3.3
Eastern box turtle	2	2				8	8	20	67.7
Northern diamond-backed terrapin			1					1	3.3
Snakes									
Eastern garter snake	2					5	3	10	33.3
Northern brown snake						1	2	3	10
Northern black racer							1	1	3.3
Eastern milk snake							1	1	3.3
# of Localities Sampled	2	3	4	1	1	9	10	30	

Table 4. Number of captures and total number of species recorded (S) at each of 26 standardized surveys sites and 4 incidental encounter locations at the William Floyd Estate. Species totals include all adult form individuals, plus nests (N) and turtle shells (S). Frequency of Occurrence (FO) is number of localities at which a species was recorded divided by total number of localities (30).

	Eastern red-backed salamander	Four-toed Salamander	Spring peeper	Snapping turtle	Painted turtle	Eastern box turtle	Northern diamond-backed terrapin	Eastern garter snake	Northern brown snake	Northern black racer	Eastern milk snake	Total #	% of Total	S
Standardized Survey Sites														
Field F/G7						3						3	1.4%	1
Field F12	2					3, 1N		3				9	4.3%	3
Field F15														
Field F6														
Field H9	3					4				1		8	3.8%	3
Field I14						2, 4N						6	2.8%	1
Field J10						1						1	0.5%	1
Field J12						1		1	2			4	1.9%	3
Field M11	1					1		2	2			6	2.8%	4
Floyd Pond & Ditches							1					1	0.5%	1
Folly Pond														
Home Creek	9			8, 1S		2, 1S		3				24	11.4%	4
O'Dell Creek		2		4		2		1				9	4.3%	4
O'Dell Pond														
Rye Pond														
Teal Hole Bog	1		1	2		1						5	2.4%	4
South Pond														
Teal Hole				1								1	0.5%	1

	Eastern red-backed salamander	Four-toed salamander	Spring peeper	Snapping turtle	Painted turtle	Eastern box turtle	Northern diamond-backed terrapin	Eastern garter snake	Northern brown snake	Northern black racer	Eastern milk snake	Total #	% of Total	S
Woodlot 1	23					4, 4S						31	14.7%	2
Woodlot 2	20	1				3, 2S		3				29	13.7%	4
Woodlot 3	15					7		1	1skin			24	11.4%	4
Woodlot 4	3					1, 2S		1				7	3.3%	3
Woodlot 5	2					3S		1				6	2.8%	3
Woodlot 5 Marsh														
Woodlot 6	9					5, 1S, 1N						16	7.6%	2
Woodlot 7	12					1S						13	6.2%	2
Incidental Encounter Locations														
Historic Core (Field G5)					1	3					1	5	2.4%	3
Vista Marsh						1						1	0.5%	1
Rye Pond Woodlot						1S						1	0.5%	1
South Pond Woodlot								1				1	0.5%	1
Total # of Adults	100	3	1	16	1	65	1	17	5	1	1	211	100	11
Total Locations Recorded	12	2	1	4	1	20	1	10	3	1	1	23		
FO (%)	40.0%	6.7%	3.3%	13.3%	3.3%	66.7%	3.3%	33.3%	10.0%	3.3%	3.3%	76.7%		

Table 5. Number of adult form amphibian and reptile captures recorded by each survey method at the William Floyd Estate. VES=Visual Encounter Survey.

Survey Method	Eastern red-backed salamander	Four-toed salamander	Spring peeper	Snapping turtle		Painted turtle	Eastern box turtle			Northern diamond-backed terrapin	Eastern garter snake	Northern brown snake		Northern black racer	Eastern milk snake	Total Recorded	Total Number of Species
	live	live	live	live	shell	live	live	shell	nest	live	live	live	shed	live	live		
Anuran Calling Survey			1													1	1
Egg Mass Count																0	0
VES Stream	8	1		4	1		2	1			3					20	5
VES Woodland	64	1					13	12			4					94	4
VES Field	5						13		3		4					25	3
VES Wetland/pond							1									1	1
Coverboard	3										2	4	1	1		11	4
Turtle Trap Survey				3						1						4	2
Minnow Trap Survey				1												1	1
Incidental Encounter	20	1		7		1	15	2	3		4				1	54	7
Total	100	3	1	15	1	1	44	15	6	1	17	4	1	1	1	211	11

Table 6. Percentage of adult form individuals of each species (including turtle shells, nest, and shed skins) recorded by each survey method. VES=Visual Encounter Survey. Derived from Table 5.

Survey Method	Eastern red-backed salamander	Four-toed salamander	Spring peeper	Snapping turtle	Painted turtle	Eastern box turtle	Northern diamond-backed terrapin	Eastern garter snake	Northern brown snake	Northern black racer	Eastern milk snake	% 0f Total Captures
Anuran Calling Survey			100%									0.5%
Egg Mass Count												0%
VES Stream	8%	33%		31%		5%		18%				9.5%
VES Woodland	64%	33%				38%		24%				44.5%
VES Field	5%					25%		24%				11.8%
VES Wetland/pond						2%						0.5%
Coverboard	3%							12%	100%	100%		5.2%
Turtle Trap Survey				19%			100%					1.9%
Minnow Trap Survey				6%								0.5%
Incidental Encounter	20%	33%		44%	100%	31%		24%			100%	25.6%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100.0%

Table 7. Maximum calling index (CI) and number of calling males recorded during anuran calling surveys at the William Floyd Estate, 2002.

Site (# of surveys)	Date	Start Time	End Time	Spring peeper CI	Spring peeper Number
O'Dell Pond (4)	28-Mar	16:15	16:20		
	22-Apr	20:05	20:10		
	21-May	21:03	21:08		
	17-Jun	19:42	19:47		
Rye Pond (2)	22-Apr	18:22	18:27		
	21-May	20:10	20:15		
Teal Hole Bog (9)	29-Mar	10:52	10:57		
	22-Apr	18:56	19:01		
	22-Apr	19:02	recorder		
	25-Apr	14:25	14:30		
	20-May	15:40	recorder		
	21-May	19:51	19:56		
	17-Jun	21:31	21:36	1	1*
	18-Jun	-	recorder		
	19-Jun	-	recorder		
Teal Hole (6)	22-Apr	19:21	19:26		
	23-Apr	13:40	recorder		
	25-Apr	14:55	15:00		
	21-May	19:29	19:34		
	21-May	19:40	recorder		
	17-Jun	20:20	20:25		
Total				1	1

*1 male captured and photographed

Amphibian Calling Surveys

One spring peeper at Teal Hole Bog on 17 June 2002 was the only anuran heard during calling surveys at five sites (Table 7). It was captured while perched on a fern at the edge of the marsh, photographed, and released.

Egg Mass Counts

Egg mass counts at O'Dell Pond (0.25 search hours), Teal Hole Bog (0.47 search hours), and Teal Hole (0.34 search hours) found no eggs or any other evidence of breeding amphibians.

Visual Encounter Surveys

Stream VES

Five species were detected during VES in two streams. Eastern red-backed salamander, recorded along the bank of Home Creek, was the most abundant species (CR=0.56 captures/search hour). One four-toed salamander was recorded from sphagnum moss overhanging O'Dell Creek at the northern end (CR=0.07) (Table 8). Two eastern box turtles and a shell were captured in the marshy area of Home Creek dominated by skunk cabbage (*Symplocarpus foetidus*) and Phragmites. Snapping turtles were recorded from both Home Creek (3 individuals, 1 shell) and O'Dell Creek (1 individual) in the streams, on the bank, and in the mud. Three eastern garter snakes were found on the bank and in the marsh area of Home Creek (CR=0.21) (Table 8).

Woodland VES

Four species were detected during woodland VES in seven areas. The eastern red-backed salamander and eastern box turtle were the most widespread species, recorded in all seven woodlands surveyed, and were also the abundant species, CR=1.08 and 0.2, respectively. Eastern garter snake and four-toed salamander were less widespread and abundant (Table 9). Based on this method, Woodlot 2 had the greatest species richness, four species recorded, and Woodlot 1 the greatest number of animals recorded (33% of individuals) (Table 9).

Field VES

Three species were detected during field VES in nine areas. The eastern box turtle was the most widespread , recorded in seven fields surveyed, followed by eastern red-backed salamander and eastern garter snake(Table 9). Eastern box turtle was also the most abundant species (CR=0.5), followed by eastern red-backed salamander and eastern garter snake (CR=0.1 for each). Field F12 had the greatest species richness with three species recorded, and also the greatest number of animals recorded (Table 9).

Based on VES, woodlands were slightly more species rich than fields, with four and three species recorded respectively, and also had a greater abundance; woodland (CR=1.6) compared to field (CR=0.7) (Table 9).

Wetland VES

Eastern box turtle was the only species detected during pond VES at seven sites in brackish ponds, freshwater temporary and permanent ponds, and marsh habitats. A single adult was found on 21 August, buried under sedges in the dry basin of Teal Hole Bog (Table 10).

Coverboards

Coverboards detected four species, northern brown snake, eastern garter snake, northern black racer and eastern red-backed salamander (Table 11, Appendix E). There were a total of 11 capture events (CR=1.56 captures/100 board check), five in woodland and six in field. Three eastern red-backed salamanders were recorded under boards in Woodlot 3 and northern black racer was only found under a board in Field H9. Both northern brown snake and eastern garter snake were recorded from both woodland and field. Field J12 had the greatest number of snakes (n=3) (Table 11).

The majority of coverboard checks (64%) occurred from April to July and most (75%) snakes observed under coverboards were also recorded during this time period (Table 12). Thus, there was no seasonal difference in snake capture rates (χ^2=0.44, p=0.51).

Turtle Trapping Surveys

We trapped four individual turtles of two species at four of nine sites sampled (Table 13, Appendix F). Three snapping turtles were captured at three of nine sites (33%), and one northern diamond-backed terrapin was captured at one site, Floyd Pond & Ditches (Table 13). The snapping turtle was trapped from permanent stream, marsh, and permanent pond habitats.

Minnow Trapping Surveys

One snapping turtle was captured using minnow traps at six sites (Table 14). This was a juvenile captured on 17 June at Teal Hole Bog. No other amphibians or reptiles were captured.

Incidental Encounters

Seven species were recorded as incidental encounters from 14 locations, 10 of which were standardized survey sites. Based on number of locations recorded, the most widespread species were eastern box turtle (9 locations total) and eastern red-backed salamander (7 locations) (Table 15). Of the 54 total records, eastern red-backed salamander and eastern box turtle were most numerous, with 20 records each (37%), followed by snapping turtle (15%), eastern garter snake (9%), and four-toed salamander (2%) (Table 15).

Table 8. Number of amphibians and reptiles recorded during stream visual encounter surveys at the William Floyd Estate, 2002. The capture rate (in parentheses) is number of individuals divided by search hours. S=species richness.

					Species								
					Eastern red-backed salamander	Four-toed salamander	Snapping turtle		Eastern box turtle		Eastern garter snake		
Location	First Date	Last Date	# of Surveys	Search Hours	live adult	live adult	live adult	shell	adult	shell	live adult	Total	S
Home Creek	26-Apr	16-Sep	5	9.5	8 (.84)		3 (.32)	1 (.11)	2 (.21)	1 (.11)	3 (.32)	18 (1.89)	4
O'Dell Creek	20-May	16-Sep	4	4.7		1 (.21)	1 (.21)					2 (.43)	2
		Total	9	14.2	8	1	4	1	2	1	3	20	5
			Capture Rate		.56	0.07	.28	0.07	.14	0.07	.21	1.41	

Table 9. Number of amphibians and reptiles recorded during woodland and field visual encounter surveys at the William Floyd Estate, 2002. The capture rate (in parentheses) is number of individuals divided by search hours. S=species richness.

Habitat	Site	First Date	Last Date	# of Surveys	Search Hours	Species: Eastern red-backed salamander	Eastern box turtle			Eastern garter snake	Four-toed salamander	Total	S
						live adult	live adult	shell	nest	live adult	live adult		
Woodland	Woodlot 1	29-Mar	18-Sep	5	8.3	23 (2.8)	4 (0.5)	4 (0.5)				31 (3.7)	2
	Woodlot 2	29-Mar	16-Sep	5	11.6	10 (0.9)		2 (0.2)		3 (0.3)	1 (0.1)	16 (1.4)	4
	Woodlot 3	29-Mar	19-Sep	5	7.8	9 (1.2)	5 (0.6)					14 (1.8)	2
	Woodlot 4	29-Mar	19-Sep	5	7.2	3 (0.4)	1 (0.1)	2 (0.3)		1 (0.1)		7 (1.0)	3
	Woodlot 5	29-Mar	19-Sep	5	6.4	2 (0.3)		2 (0.3)				4 (0.6)	2
	Woodlot 6	29-Mar	19-Sep	5	12.2	6 (0.5)	3 (0.2)	1 (0.1)				10 (0.8)	2
	Woodlot 7	29-Mar	19-Sep	5	6.2	11 (1.8)		1 (0.2)				12 (1.9)	2
			Total	35	59.7	64 (1.08)	13 (0.22)	12 (0.2)	0	4 (0.07)	1 (0.02)	94 (1.6)	4
Field	Field F/G7	28-Mar	18-Sep	6	4		3 (0.8)					3 (0.8)	1
	Field F12	28-Mar	20-Sep	6	4.6	2 (0.4)	3 (0.7)		1 (0.2)	3 (0.7)		9 (2.0)	3
	Field F15	28-Mar	20-Sep	6	4.4							0	0
	Field F6	29-Jun	18-Sep	2	1.1							0	0
	Field H9	28-Mar	18-Sep	6	4.6	3 (0.7)	4 (0.9)					7 (1.5)	2
	Field I14	28-Mar	20-Sep	6	4.6				2 (0.4)			2 (0.4)	1
	Field J10	28-Mar	18-Sep	6	4.1		1 (0.2)					1 (0.2)	1
	Field J12	28-Mar	18-Sep	6	6.3		1 (0.2)					1 (0.2)	1
	Field M11	28-Mar	20-Sep	6	3.4		1 (0.3)			1 (0.3)		2 (0.6)	2
			Total	50	37.1	5 (0.1)	13 (0.4)	0	3 (0.1)	4 (0.1)	0	25 (0.7)	3

Table 10. Number of amphibians and reptiles recorded during wetland/pond visual encounter surveys at the William Floyd Estate, 2002. The capture rate (in parentheses) is number of individuals divided by search hours. S=species richness**.**

Habitat	Site	First Date	Last Date	# of Surveys	Search Hours	Eastern box turtle	Total	S
Brackish pond	Floyd Pond & Ditches	22-Apr	17-Sep	5	10.3		0	0
	Folly Pond	22-Apr	17-Sep	5	4.6		0	0
	Rye Pond	28-Mar	17-Sep	6	3.5		0	0
	South Pond	22-Apr	17-Sep	5	5.7		0	0
	Total			21				
Temporary pond	O'Dell Pond	28-Mar	18-Sep	5	1.1		0	0
Permanent pond	Teal Hole	22-Apr	17-Sep	5	2.8		0	0
Marsh	Teal Hole Bog	22-Apr	17-Sep	5	1.7	1 (0.59)	1 (0.59)	1

Table 11. Number of amphibians and reptiles recorded during woodland and field coverboard surveys at the William Floyd Estate, 23 April to 20 September 2002. Capture rate (in parentheses) is number of individuals captured/100 board checks. Board checks are number of boards/site, multiplied by number of site visits.

		Species										
Habitatt	Site	Northern brown snake	Eastern garter snake	Northern black racer	Eastern red-backed salamander	# of Snakes	S	Snake CR	# of Boards/Site	# of Site Visits	Board Checks	# of Boards w/ Snakes
Woodland	Woodlot 2					0	0	0.00	8	11	88	0
	Woodlot 3	1 skin (1.14)	1 (1.14)		3 (3.41)	2	3	2.28	8	11	88	2
	Woodlot 6					0	0	0.00	8	11	88	0
	Woodlot 7					0	0	0.00	8	11	88	0
	Total (CR)	1 (0.28)	1 (0.28)	0	3(0.85)	1	2	0.28	32	44	352	2
Field	Field F15					0	0	0.00	8	11	88	0
	Field H9			1(1.14)		1	1	1.14	8	11	88	1
	Field J12	2 (2.27)	1(1.14)			3	2	3.41	8	11	88	3
	Field M11	2(2.27)*				2	1	2.27	8	11	88	1
	Total (CR)	4 (1.14)	1 (0.28)	1 (0.28)	0	6	3	1.70	32	44	352	7

*1 new and 1 recapture

Table 12. Seasonal variation in snake captures during coverboard surveys at the William Floyd Estate, April to July versus August to September 2002. Board checks are the number of boards per site, multiplied by the number of site visits.

Dates	Number (%) of Board Checks	# of Board Checks Producing Snakes	% of Board Checks Producing Snakes	Number (%) of Snakes
April – July	448 (64%)	5	1.12%	6 (75%)
August – September	256 (36%)	2	0.78%	2 (25%)
Total	704	7	0.85%	8

Table 13. Number of turtle captures in turtle traps at the William Floyd Estate, 2002. Capture rate (in parentheses) is number of captures per 100 trap nights.

						Species	
Habitat	Site	First Date	Last Date	# of Traps	# of Trap Nights	Snapping turtle	Northern diamond-backed terrapin
Permanent stream	Home Creek	21-May	20-Jun	2	16	1 (6.25)	
	O'Dell Creek	21-May	20-Jun	1 to 2	12		
				Habitat Total	28	1(3.57)	0
Marsh	Teal Hole Bog	21-May	20-Jun	3	24	1(4.17)	
Brackish pond	Floyd Pond & Ditches	21-May	20-Jun	3 to 6	48		1 (2.08)
	Folly Pond	21-May	20-Jun	3	24		
	Rye Pond	21-May	20-Jun	3 to 4	28		
	South Pond	21-May	20-Jun	3	24		
				Habitat Total	124	0	1 (0.81)
Temporary pond	O'Dell Pond	17-Jun	20-Jun	2	8		
Permanent pond	Teal Hole	21-May	20-Jun	4	32	1(3.13)	

Table 14. Number of amphibian and reptile captures during minnow trap surveys at the William Floyd Estate, 2002. Capture rate (in parentheses) is number of captures per 100 trap nights.

Site	First Date	Last Date	# of Traps	# of Trap Nights	Snapping Turtle
O'Dell Creek	24-Apr	23-Aug	1 to 2	22	
Teal Hole Bog	27-Mar	23-Aug	2	36	1 (2.78)
Woodlot 5 Marsh	27-Mar	29-Mar	4	8	
Rye Pond	27-Mar	23-Apr	2	6	
O'Dell Pond	27-Mar	20-Jun	2 to 3	22	
Teal Hole	22-Apr	23-Aug	2 to 3	36	
			Total	130	1 (0.77)

Table 15. Number of amphibians and reptiles recorded as incidental encounters at 14 locations at the William Floyd Estate. Includes painted turtle and eastern milk snake recorded subsequent to 2002.

	Eastern red-backed salamander	Four-toed salamander	Snapping turtle	Painted turtle	Eastern box turtle			Eastern garter snake		Eastern milk snake	
Locality	adult	adult	adult	adult	adult	shell	nest	adult	kill	adult	Total
Historic Core (Field G5)				1	3					1	5
Field I14					2		2				4
Field M11	1							1			2
Home Creek	1		4								5
O'Dell Creek		1	3		2				1		7
Rye Pond Woodlot						1					1
Teal Hole Bog	1										1
South Pond Woodlot								1			1
Vista Marsh					1						1
Woodlot 2	10				3						13
Woodlot 3	3				2						5
Woodlot 5						1		1			2
Woodlot 6	3				2		1				6
Woodlot 7	1										1
Total	20	1	7	1	15	2	3	3	1	1	54
Total # of Localities	7	1	2	1	7	2	2	3	1	1	14

Discussion

Community Composition

Of the 38 species of amphibians and reptiles native to and resident on Long Island (Noble 1927), 11 were recorded in this inventory. This includes 10 of the 23 species previously recorded at WFE, plus an 11th species, the four-toed salamander. Because four-toed salamanders can be difficult to detect, it is likely this species has been present at WFE all along and we considered it part of the "historic" herpetofauna. If so, then the current herpetofauna of WFE represents 11 of the 24 (46%) known historically-occurring species.

The present-day low species richness of amphibians and reptiles at WFE reflects a naturally modest species richness that has been further reduced by human impacts over the course of the 20th century. Long Island is geologically young, formed of glacial moraine and outwash plains, and was only briefly connected to the continental mainland prior to sea level rise since the last glacial retreat (Pough and Pough 1968). Because of its recent creation, insular nature, and lack of certain habitats, Long Island lacks several species found on the adjacent mainland (Noble 1927). Species richness is further reduced on the outwash plain (Noble 1926), which extends southward from the terminal moraines down to Long Island's south shore, where WFE is located. An estimated 31 species of amphibians and reptiles (six salamanders, nine anurans, six turtles, and 10 snakes) occurred historically along the south shore of Long Island (Cook, in prep.). Of the 24 species historically-occurring at WFE, there were two salamanders, eight anurans, six turtles, and eight snakes, indicating that WFE once supported most of the area's anurans, turtles, and snakes, but either lacked salamanders or they were present but went undetected. That the latter is at least partially true is suggested by the occurrence of red-spotted newts and spotted salamanders at nearby Wertheim NWR (A. Chmielewski, pers. comm.; P. Warny, pers. comm.) but this question is complicated by the fact that Wertheim NWR is much larger than WFE, and contains more freshwater and upland habitat.

The loss of more than half of WFE's historically-occurring amphibian and reptile species has not been uniform across taxonomic groups. Historically, reptiles were only slightly more speciose than amphibians on Long Island's south shore and at WFE, whereas now the herpetofauna of WFE is dominated by reptiles, which account for 72.7% of species recorded and slightly over half (50.7%) of all records in this inventory. The current dominance of WFE herpetofauna by reptiles reflects a significant change in community composition here, and regardless of whether or not WFE once supported populations of salamanders no longer present, this change is primarily the result of losing most of WFE's anuran species.

This decline in overall species richness and dramatic loss of anurans is or may be the result of several factors operating independently and in concert, directly or indirectly through food chain and endocrine effects. These include: the application and "mis-application" of DDT, during the 1950's and 1960's and/or other pesticides more recently (Jankowski 2004); acid precipitation and atmospheric mercury deposition; changes in the salinity of Moriches bay and its tributaries following the creation of the Moriches Inlet (Nichols 1947); loss of habitat adjacent to the estate due to urbanization over the course of the 20th century; and diseases. Although these factors have led to the extirpation of both amphibians and reptiles, because amphibians are generally more sensitive to pesticide impacts and salinity than reptiles (Henry 2000), they have been the group most affected at WFE. Because anurans dominated the known WFE amphibia, it follows that they were most affected. In contrast, because there was so little historic documentation of salamanders, and their more fossorial lifestyle in woodland habitats may have reduced their exposure to pesticides applied primarily to marsh and pond habitats, the number of salamander species known from WFE has actually increased. Of course, whether other salamander species historically present but never recorded have been extirpated is not knowable at this point.

Although reptiles dominated species richness, 8 reptiles to 3 amphibians, the two groups were roughly equal in terms of numbers recorded, 107 reptiles to 104 amphibians. Although this may suggest that amphibians are not as impoverished at WFE as the species richness data suggest, in comparable inventories we conducted (same methods, Northeast coastal sites), the numbers of amphibians recorded usually greatly outnumbered the reptiles, even when amphibian species richness was much less than reptile. For example, on Fire Island, with two amphibian and eight reptile species recorded, amphibians accounted for 92% of all animals recorded (Cook et al., 2010). At Assateague Island, the numbers are 4, 12, and 95% respectively and on Mt. Desert Island (Acadia National Park), they are 11, 7, and 88% (Brotherton et al. 2004). Even at Gateway NRA, another park where amphibians are impoverished, there were five amphibian and 15 reptile species, but amphibians accounted for 67.4% of all animals recorded (Cook, in prep).

Further illustrating the depauperate nature of WFE's amphibians and the dramatic decline in anurans is the fact that 103 of the 104 amphibians recorded in this survey were red-backed salamanders. Of WFE's eight known naturally occurring anuran populations, all have declined and seven have been extirpated (Table 16). The eastern spadefoot toad has not been recorded at WFE since Nichols' time and may also be extirpated, but because it is a species with a very low detection probability that can remain undetected for many years and then be "re-discovered", we have conservatively called it "status uncertain". The only anuran recorded in this survey was a single spring peeper. As will be discussed below, spring peepers were experimentally translocated to WFE from 1999 to 2001 after several decades of absence (R. Stavdal, pers. comm.) and although the long-term fate of this translocation is not known, we consider the original population of spring peepers at WFE to be extirpated.

In terms of number of species, the reptiles of WFE are balanced between turtles and snakes, with four species each, but in terms of numbers recorded, turtles dominated, comprising 77.6% of all reptiles recorded (83/107). There is little balance among reptile species. The majority of records (61%) were of eastern box turtles and four of the eight reptile species were recorded only once (Table 2). Thus, WFE's herpetofaunal community has changed dramatically over the 20^{th} century due to the extirpation of over half its original species, especially anurans, and is one that is very depauperate and dominated by a small number of species that are generally urban tolerant and/or pesticide/xenobiotic resistant.

Important Sites and Habitats

The "importance" of sites and/or habitats can be approached from a number of perspectives, such as species richness, numbers of individuals, or importance to particular species such as keystone species or rare or "listed" species. From a species richness perspective, uplands had the greatest species richness with eight species, followed by wetlands and streams with five species each. The most species rich specific habitats were field (7 species), stream, and woodland both with

Table 16.“Historic” and current status, and apparent trends in amphibians and reptiles at the William Floyd Estate. *not recorded in this survey or more recently. **original spring peeper population extirpated; current rarity follows pilot translocation study.

Common Name	Historic Status	Current Status	Apparent Trend
Four-toed salamander	rare	rare	stable
Eastern red-backed salamander	abundant	abundant	stable
Eastern spadefoot*	common	uncertain	decline*
Fowler’s toad*	abundant	extirpated	decline*
Gray treefrog*	common	extirpated	decline*
Spring peeper**	abundant	extirpated, rare	decline**
Green frog*	common	extirpated	decline*
Pickerel frog*	uncommon	extirpated	decline*
Wood frog*	uncommon	extirpated	decline*
Southern leopard frog*	common	extirpated	decline*
Snapping turtle	common	common	stable
Eastern mud turtle*	common	extirpated	decline*
Painted turtle	abundant	rare	decline
Spotted turtle*	common	uncertain	decline*
Northern diamond-backed terrapin	uncommon	uncommon	stable
Eastern box turtle	abundant	abundant	stable
Northern black racer	common	uncommon	decline
Northern ring-necked snake*	rare	rare	stable*
Eastern hog-nosed snake*	common	extirpated	decline*
Eastern milk snake	uncommon	uncommon	stable
Northern water snake*	common	extirpated	decline*
Northern brown snake	uncommon	uncommon	stable
Eastern ribbon snake*	common	extirpated	decline*
Eastern garter snake	common	common	stable

five species recorded. By individual site, species richness was greatest at Field M11, Home Creek, O’Dell Creek, Teal Hole Bog, Woodland 2, and Woodland 3, each with four species (Tables 2 and 4). Three of these six sites were also among the top sites in numbers of individuals recorded (Home Creek-24, Woodlot 2 - 29, and Woodlot 3-24). However, the site with the greatest number of individuals recorded was Woodlot 1, with 31 individuals (Table 4).

Several species were found more frequently in specific habitats. For example, 84% of all eastern red-backed salamanders were recorded in woodlands, as were 53% of eastern box turtles, and 41% of eastern garter snakes. Similarly 80% of all snapping turtles and 67% of four-toed salamanders were recorded in streams (Table 2). The pattern of habitat use shown by these species, and the overall pattern of habitat use reflected in the numbers recorded by habitat (Table 2) is pretty consistent with known habitat affinities of the species present. Moreover, although amphibians and reptiles commonly utilize specific habitats for part of the year, the complex life cycle of most species usually requires the use of multiple habitats for foraging, basking, hibernation, mating, and/or nesting/egg laying/larval development. For example, four-toed salamanders mate on land, eggs are laid in nests in moss overhanging streams and wetlands, and hatchling larvae wriggle down and drop into the water below, where they complete larval development and metamorphose into a terrestrial adult form (Petranka 1998). Many anurans, such as spring peepers, lay eggs and undergo larval development in wetlands but otherwise forage and hibernate in the uplands (Conant and Collins 1998) and female aquatic turtles, such as snapping turtles and diamond-backed terrapins, migrate to uplands in the late spring to nest in open areas with loose, sandy soil (Ernst et al. 1994). Eastern box turtles thermoregulate by shifting seasonally among woodlands, fields, and wetlands (Reagan 1974; Donaldson and Echternacht 2005) and snakes such as eastern garter and black racer also typically use the edges of open habitats to bask in spring and fall.

Because of these complex life cycles, and the need to seasonally shift among habitats, what is more important than any single habitat type is a landscape that provides all the necessary habitat elements, in sufficient quantity and degree of interspersion to allow animals to move among them safely. WFE has a good mix of salt marsh, field, and woodland habitat but a limited amount of freshwater wetland. All of these habitats are important and should be managed to perpetuate them.

Species at Risk

Over half of WFE's original herpetofauna has been extirpated by the combined effects of several stressors and most of the survivors, the 11 species documented in this survey, are fairly common in the Northeast (Conant and Collins 1998; Klemens 1993) and widespread in North America. Consequently, WFE does not currently support any species that are exceptionally rare, but eastern box turtle, northern black racer, and eastern milk snake have declined regionally or locally, and are of conservation concern. The eastern box turtle is a *Special Concern* species in New York State (NYSDEC 2000). Box turtles have declined throughout much of their range due to habitat loss, fragmentation, suburbanization, overcollection, and road kill (Klemens 2000; Dodd 2001) and are declining on Long Island (Gibbs et al. 2007). WFE has long been known as an important site for box turtles, with approximately 1500 marked by Nichols (1904-1958), over 700 marked by Richard Stavdal (1980 to 2006, pers. comm.), and 44 recorded in 2002. Given its history of supporting such a robust population of eastern box turtles, from a preservation of "species at risk" perspective, WFE is an important site for box turtles. In addition, although not formally listed, the black racer has also declined dramatically on Long Island (Schlauch 1976) and is declining in New York State (Gibbs et al. 2007). It typically occurs in open habitats and requires fairly large patches of habitat, as does the eastern milk snake (Kjoss and Litvaitis 2001), another species that appears to be declining regionally (Klemens 1993; Gibbs et al. 2007).

Because these species do not fare well on the increasingly fragmented and suburbanized landscape of Long Island, WFE with its 613 acres of woodland, field, and wetland provides an important site for the preservation of these species. However, as will be discussed in greater detail below, because WFE is only a fraction of its original size, the very same stressors that have raised concerns about these species regionally are operating to some extent at WFE too.

Population Trends

Determining population trends is always challenging and although Nichols (1904-1958) recorded over 2000 observations over the course of 54 years, it is fairly clear that he was selective in what he recorded. Thus, although his records are excellent in documenting species presence, the number of records for a species do not always accurately reflect a species' abundance, particularly in the case of common species, where recording every encounter would have been onerous. Moreover, as noted earlier, WFE is only a fraction (14%) of the original Floyd Estate and some of Nichols observations were from outside the current estate, at a time when the landscape was far more rural. Using Nichols' journal and publications, together with other early accounts of Long Island herpetofauna, and a sense of habitat suitability and animal behavior (i.e. how likely a species is to be encountered by someone not actively seeking them), we have inferred past abundance at WFE. Similarly, in the species accounts below, we have attempted to assess each species current status and population trends, comparing our data, nearly all collected in a single season (2002) with the historical data, collected over a period of many years.

Based on this somewhat subjective approach, nine of the 24 species known to have occurred historically in the park appear to be stable in terms of their population trends and 15 have experienced decline (Table 16). Of those that have declined, 11 appear to be extirpated, whereas the remaining four are status uncertain (eastern spadefoot toad, spotted turtle), rare (painted turtle), or uncommon (northern black racer). As noted above, spadefoot toads have not been recorded since Nichols' time, but because they are highly fossorial and often only emerge for a few days after very heavy rainfall events, they can go undetected for many years. Spotted turtles, another species that can be difficult to detect when rare, were last recorded in the mid-1980's, when three individuals were marked (R. Stavdal, pers. comm.) and a road kill recorded (Sprenger et al. 1987). Although neither of these two species have been recorded at WFE for 20+ years, their low detection probability leaves some uncertainty about their being extirpated. Of the 15 species that have undergone decline, 12 went unrecorded during this survey and the remaining three (spring peeper, painted turtle, black racer), were each recorded only once. The spring peeper is a special situation because, as mentioned above and detailed in its species account below, the original population of spring peepers was extirpated and the individual recorded in 2002 was due to a translocation. In a herpetofauna where decline and extirpation was the dominant trend, the one exception was the four-toed salamander. The three four-toed salamanders found in 2002 were the first records for this species in the park. It has likely been a rare resident of WFE for some time and has gone undetected due to its elusive nature, the limited amount of *sphagnum* habitat in the park, lack of searching, and limited numbers.

The results of this survey confirm the long-held perceptions of park staff that the herpetofauana of WFE has been reduced significantly since the time of J.T. Nichols (Lynch 1986; R. Stavdal, pers. comm.). Declines and extirpations have reduced the park's herpetofauna to less than half of its original species, and those still present tend to be urban tolerant and/or pesticide resistant. That WFE provides such a dramatic case of herpetofaunal community decline is the result of the rare alignment of a comprehensive and well documented historic baseline at a site subjected to numerous stressors, some of which appear to have been extreme.

Stressors

The amphibian and reptile community of WFE has been subjected to a broad range of stressors over the past couple of centuries that have collectively lead to the extirpation of over half the species occurring here. These include global, regional, and local stressors, all of which may work together to bring about a species decline, either directly or indirectly. Global stressors, which tend to affect large geographic areas, are often far removed from the ultimate cause or source whereas regional/local stressors work at a more localized level. Global stressors include ultraviolet-B radiation and atmospherically transported pollutants such as mercury and acid rain, and global warming (Blaustein et al. 1994; Blaustein and Dobson 2006). Stressors such as other heavy metals, chemicals found in fertilizers, herbicides, and pesticides, habitat degradation, disease such as viral and fungal infections, road mortality, and introduced species (Dunson et al. 1992; Blaustein 1994; Pechmann and Wilbur 1994; Daszak et al. 2000; Knapp and Matthews 2000) may also be widespread in their scope, but tend to be more variable across the landscape in their extent. Thus their impacts may be at either a regional or local level.

A number of these global or regional stressors are known to occur at WFE. Mercury is transported atmospherically and deposited, often far from the source, and can be accumulated by aquatic organisms to the point of causing lethal or sub-lethal effects. Mercury deposition occurs throughout the Northeast, and even aquatic systems of relatively undeveloped areas such as Acadia National Park (Bank et al. 2006) and Cape Cod National Seashore contain high levels of mercury. The problem occurs when low pH, in part due to acid rain, leads to elevated levels of mercury. This process has been linked to the decline of northern dusky salamanders at Acadia NP (Bank et al. 2006) and elevated, but non-lethal levels in snapping turtles (Golet and Haines 2001). Research elsewhere has shown that increased mercury levels increase abnormalities and mortality in larval southern leopard frogs (Unrine et al. 2004). Given that both acid precipitation and mercury deposition occurs in the vicinity of WFE (Kroenke et al. 2003; NYS DEC 2008) it is reasonable to conclude that WFE is subjected to both of these stressors, but we are not aware of any data on mercury levels or impacts to biota at WFE.

Pesticides are a significant stressor at WFE. DDT was sprayed extensively to control mosquitoes in Suffolk County wetlands and grasslands for 15 years ending in 1966, and many marine invertebrates in Great South Bay were locally extirpated. In addition, extremely high DDT levels in some areas of the Floyd Estate suggest a "misapplication" occurred there (Jankowski 2004). DDT residues were greatest in the water and sediments in and surrounding Floyd's Pond, South Pond, and upper Home Creek and in the tissues of the flora and fauna from Floyd's pond. DDT was also found to be biologically available in the marsh but total DDT residues from a spotted turtle found DOR above South Pond in 1986 (204 parts per billion; Sprenger et al. 1987) were only slightly higher than levels found in Ontario spotted turtles in 1975 (130 parts per billion; Pauli and Money 2000). DDT and other pesticides, and their decay products, may cause direct mortality to amphibians and also lead to population declines indirectly by affecting reproduction, competitive fitness, and ability to resist disease and escape predators (Cowman and Mazanti 2000; Hayes et al. 2002; Bridges and Semlitsch 2005). Although reptiles tend to be less sensitive than amphibians to the short-term direct effects of pesticides and other contaminants due to a less permeable skin (Palmer 2000), among reptiles the short-term effects of DDT appear to be more lethal to snakes than turtles (Stickel 1951; Hall 1980). In addition, over time, pesticides, including DDT and its decay products, can mimic and inhibit endocrine functions and disrupt reproduction in a number of different ways that ultimately can lead to population declines (Guillette 2000).

Diseases are another group of stressors that may be impacting WFE herpetofauna. Three major diseases have been documented in Long Island amphibians (J. Feinberg, pers. comm.), although little is known of their population impacts, either directly or in combination with sub-lethal levels of contaminants. One disease implicated in global amphibian declines is Chytrid fungus, *Batrachochytridium dendrobatidis*. Although it appears to infect amphibians throughout most of the Northeast, there is no evidence of a significant impact in the region (Longcore et al. 2006). Less is known regarding diseases in reptiles. However, respiratory tract illnesses are present in Long Island box turtles (Lee 2004) and if not already present at WFE, may be introduced via the unauthorized release of animals "rescued" from harm's way and released at WFE, which is well known in the community for its box turtles.

Several more localized stressors have also been operating here, primarily in the form of habitat alterations, both on and adjacent to what is now WFE. Much of the original landscape was altered for agriculture during colonial times and in the early 20th century there was much less woodland habitat at WFE than there is now. Although good for woodland species, those that prefer open habitats or a mix, such as black racers, appear to be declining in some parts of New York State due to natural reforestation of fields (Gibbs et al. 2007) and loss of habitat to development. Maintenance of the cultural landscape at WFE through field mowing is valuable for maintaining open habitat and habitat diversity, but can also be a stressor in that it exposes animals, especially turtles and snakes, to direct mortality if done during the warm months.

Freshwater habitat can limit amphibians and reptiles in coastal habitats and the lands that now comprise WFE do not appear to have had a great abundance of it historically. Home Creek and several other creeks through the marshes appear to have been the most significant freshwater habitats present (Nichols 1914) although there were a number of other smaller, temporary ponds (Nichols 1904-1958). An impounded ice pond on upper Home Creek (Torres-Reyes 1974) also once provided some permanent freshwater habitat. Although there is little documentation, it is likely that some of WFE's wetlands were filled or drained for agriculture and/or mosquito control, judging from the extensive ditching in the salt marshes, as well as ditching that extends inland to Teal Hole, now one of WFE's most significant freshwater ponds. Non-native plants (i.e. *Phragmites*) have invaded the salt marsh following ditching and can alter wetland and upland habitats to the detriment of native wildlife (Klemens 1993). The Moriches inlet has also been a significant factor affecting WFE's freshwater habitats. It was created by a storm in 1931 and greatly widened by the Hurricane of 1938 (Psuty et al. 2005). Moriches inlet closed naturally between 1951 and 1953, but was subsequently opened by dredging and is now a hardened and artificially maintained inlet (Hinga 2005; Psuty et al. 2005). This inlet allowed a more direct connection to the ocean and the salinity of Moriches Bay increased from 13‰ to 26‰ (Moskowitz 1976). The long term effect has been to shift Home Creek and the other marsh creeks of WFE that empty into Moriches Bay from essentially freshwater (Nichols 1947) to a more saline condition today (R. Stavdal, pers. comm.). Nichols (1904-1958) wrote of freshwater fish species and eastern mud turtles in Home Creek that are no longer present there and are now only found in the northern tidal stretches of the Carman's River. Several other amphibian and reptile species observed by Nichols in Home Creek are also no longer present (see species accounts below). While the northern section of Home Creek is presently a spring fed, freshwater wetland, it is influenced by the tidal waters to the south where it joins with the bay, which limits the current amount of freshwater habitat on the property.

The other significant local stressors have been those associated with the urbanization that now surrounds WFE, making it a habitat island. Urbanization reduces herpetofaunal diversity by extirpating some species, primarily those with complex life histories, specialized habitat requirements and/or large home ranges, and reducing the distribution of surviving species, mostly widespread generalists, to suitable habitat remnants (Schlauch 1976; Klemens 1985; Gibbs 1998; Germaine and Wakeling 2001; Rubbo and Kiesecker 2005). The extirpation and reduction of herpetofauna in urbanized landscapes is due to habitat loss, alteration, and fragmentation, pollution, and direct and indirect mortality. WFE is essentially a habitat remnant, albeit a moderately-sized one and the adjacent lands are probably now more a "population sink" than an extension of usable habitat, with the likelihood of loss to road kill and collection greater outside WFE's boundaries than within. In areas such as the Northeastern United States, models predict that snapping turtles and box turtles are particularly vulnerable to road kill (Gibbs and Shriver 2002). However, these stressors also operate to a lesser extent within the boundaries of WFE, considering that specimens of spotted turtle and box turtle analyzed for DDT by Sprenger et al. (1987) were road kills within WFE. Thus road kill is also a stressor within WFE, primarily on the entrance road and the dirt roads used by park service personnel and there is also some potential for collection of box turtles by visitors.

Another aspect of urbanization and fragmentation is the decreased ability of animals to move successfully between habitat patches, resulting in a lack of gene flow. Populations in isolated habitat patches, such as WFE, are often affected by decreased reproductive success, increased mortality, decreased genetic diversity, and are more vulnerable to extirpation (Primack 1993; Byers and Mitchell 2005). In addition, because of isolation, dispersal barriers, and lack of source populations, the odds of natural recolonization following a localized extinction are low (Scott et al. 2001). The effects of these urbanization-related stressors can be appreciated by comparing WFE with the Carmen's River system, five kilometers to the west. The Carmen's River is the largest undeveloped estuary system remaining on Long Island (USFWS 2006). Over 6.6 miles of river and over 4000 acres of upland and wetland habitat along this New York State designated Wild and Scenic River are protected in parks, preserves, private campgrounds and Wertheim National Wildlife Refuge. With this much larger patch size and correspondingly greater habitat diversity, including freshwater wetlands beyond the reach of saltwater intrusion, this system, although subjected to most of the same stressors as WFE, still contains populations of most of the species that have been extirpated from WFE (A. Chmeilewski, unpublished data; J. Kinneary, pers. comm.; P. Warney, pers. comm.).

Considering this broad suite of stressors, there are many factors potentially responsible for the decline and extirpation of species at WFE. Although determining the cause(s) of a given species declines at WFE is not always possible, particularly since we lack data on the timing of their disappearance, for many species the most likely causes are reasonably identifiable. The heavy application of DDT in the 1950's and early 1960's appears to have been a major factor, either direct or indirect, in the decline and ultimate disappearance of many species at WFE. DDT spraying eliminated populations of Fowler's toad on several small islands off the coast of Cape Cod (Lazell 1976) and probably also at Sandy Hook, NJ (Cook, in prep) and has also been linked to the decline of gray treefrogs on Long Island (Schlauch and Burnley 1968). Thus, pesticides likely affected most of WFE's anurans, although increasing salinity of freshwater habitats probably also played an important role, particularly for species dependant on Home Creek, such as the green frog (Nichols 1904-1958). In contrast, Southern leopard frogs were present along upper O'Dell Creek until disappearing sometime in the 1970's (R. Stavdal, pers. comm.). Given the timing of their extirpation on Long Island, during the 1970's and 80's, it is possible that factors other than pesticides and salinity, such as disease, may also have played a role in their disappearance (J. Feinberg, pers. comm.).

Hog-nosed snakes on Long Island feed almost exclusively on Fowler's toads, and although they have been dramatically impacted here by urbanization and human persecution (Murphy 1950; Smith 1963) their extirpation from a protected site the size of WFE is more likely due to loss of prey species. Populations of hog-nosed snakes at Gateway NRA have similarly been extirpated following loss of toad populations (Cook 2008). Because they feed heavily on frogs and toads (Ernst and Ernst 2003), the decline and eventual extirpation of WFE's anurans likely also lead to the extirpation of Eastern Ribbon snakes and Northern Water snakes. For species such as Eastern Mud Turtle and spotted turtle, it was probably a combination of pesticides, increased salinity, and urbanization/small patch size that caused their decline. Painted turtles, on the other hand, are generally fairly urban tolerant (Schlauch 1976) and their decline at WFE is most likely related to loss and alteration of the freshwater habitats associated with Home Creek, where they once were common (Nichols 1904-1958). Species such as black racer and eastern box turtle, although still present at WFE, face a number of stressors relating to habitat change and maintenance, and patch size. Both need and utilize open habitats and are at risk of being killed by warm season mowing. Also, for both species, the development surrounding WFE creates a "population sink" where animals that move outward from WFE are more likely to be lost to road kill, outright killing, or collection.

Because amphibians and reptiles utilize both aquatic and terrestrial habitats, they are important indicators of overall environmental quality. The semi-permeable skin of amphibians makes them more susceptible to changes in their environment than other vertebrates, and they are often among the first species to respond to changes in environmental conditions (Pough et al. 2004). The loss of keystone species and important habitats can alter the sustainability of herpetofaunal communities and the ecosystem as a whole. From what we have been able to determine, the herpetofaunal community of WFE has been impacted by a number of severe stressors over the course of the 20th century and has been changed dramatically by them.

Recommendations for Management and Future Monitoring and Restoration

Mowing/Field Management

Fields at WFE are maintained as part of the cultural landscape and their long term maintenance also benefits many species of wildlife dependant on edge or early successional stage habitat. This includes snakes and turtles, which use fields and their edges for basking and nesting. In particular, box turtles spend much of their time at the edge between fields and woodlands (Reagan 1974) and in 2002 many at WFE were found in fields. Although maintaining fields at WFE is critical to the long-term viability of box turtles and other reptiles here, it must be done in a way that minimizes the risk of killing them with mower blades and/or tractor wheels. It is our understanding that a plan for field maintenance at WFE calls for mowing fields annually, after October (R. Stavdal, pers. comm.). If the park is able to carry this out, it would be ideal, because the box turtle activity season, on average, extends from 21 April until 24 October on western Long Island (Cook 1996). Thus, mowing fields from November until mid-April poses minimal risks to box turtles and other reptiles. The worst times of year to mow would be June-early July, which is generally when turtles nest, and in mid to late spring and late summer-early fall, when they often bask at field edges. If mowing must occur in summer, it should be done during the hottest months (July-August) to reduce the risk of mower/turtle encounters, but never following rain, which stimulates activity at this time of year. Turtles tend to avoid open areas during times of drought and high heat intensity, making the heat of day on hot dry, days the best time to mow, if necessary, during the active season. Mowers with rotary blades or sickle bars are preferable to reel or flail mowers. Rotary blades and sickle bars are oriented horizontally and, if set to cut at least seven inches above ground, they will safely pass over many small animals and wear more slowly (MA NHESP 2007). Field mowing should always start in the center and spiral outward, so animals in the field are pushed out away from the mower.

Freshwater Monitoring
Considering how limiting freshwater habitat is for amphibians and reptiles at WFE, and all the stressors that have acted upon them, better data on basic water quality and quantity (salinity, conductivity, alkalinity, pH, depth) of WFE's creeks and ponds should be collected to provide information on habitat quality and to aid in evaluating the potential for habitat and population restoration. Data should be collected through the water column and creeks should be sampled at a series of points running from their headwaters down to Moriches Bay.

Population Studies of Eastern Box Turtles
The eastern box turtle population at WFE was the basis for a number of seminal works on the biology and behavior of box turtles (Nichols 1917b, 1939a, 1939b, 1939c, 1940) and because of this species' longevity, some of the individuals present during those historic studies are still alive (Behler 2003). Thus, in addition to their value as a significant natural resource, the box turtles of WFE also have historic significance. As detailed below in its species account, data have been collected on over 2200 box turtles over the course of the 20^{th} century (including over 700 since 1980) and these data represent a significant amount of unanalyzed data that could provide insight into movements, growth, survival, and population trends. The only comparable, long-term data set is that for a population of box turtles at Patuxent Wildlife Research Station in Maryland, with data back to the 1940's (Hall et al.1999; Henry 2003).

Although box turtles currently appear to be common and relatively well protected at WFE, they reside within a habitat island surrounded by dense residential development, essentially creating an isolated population. The adjoining landscape likely functions as a population "sink" and box turtles within WFE's boundaries face a number of potential stressors, including genetic isolation, illegal collection, and introduction of disease via release of other box turtles by visitors. Given these stressors, and data collected during this survey that suggest recruitment of young into the population has declined and the estimated population size is not that large (see species account below), the future viability of this population should not be taken for granted. The status and condition of this population needs to be looked at more intensely than was possible during this survey. Ideally, a multi-year study should be undertaken to provide a more robust estimate of current population size and structure, and radio-telemetry used to determine habitat use and movement, particularly the extent and fate of animals that move beyond WFE boundaries. Moreover, by incorporating the historic data of Nichols and Stavdal, as well as this survey, into the analysis, a future study could look at decadal-scale trends in population size and structure, survival, and growth. Considering the significance of this population and the stressors it faces, such a study would be a major contribution to our knowledge of this species and critical to NPS efforts to ensure that this population persists.

Habitat and Population Restoration

In urbanized regions, translocations into extinct sub populations may be the best strategy to promote regional persistence of species (Marsh and Trenham 2001). Although many of the species that comprised WFE's historic herpetofauna have been extirpated by pesticides, salinity changes, and wetland alterations, there is potential for restoring some, but certainly not all that have been lost. On a regional scale, WFE is a relatively large and significant habitat patch. Work conducted at Gateway NRA has demonstrated the feasibility of wetland creation and translocation for establishing populations of some species at isolated sites where natural colonization is not likely to occur (Cook and Pinnock 1987; Matthews et al. 1992; Cook 2008). The methods and approaches of this program could be readily applied to WFE. It has been over 40 years since the last applications of DDT and levels in sediments and marine invertebrates in Moriches Bay have been steadily decreasing, suggesting that marine communities are recovering (Jankowski 2004). Moreover, the records of calling spring peepers at Teal Hole Bog in 2002 and 2003, following experimental releases in 1999, 2000, and 2001 also suggest that habitat quality at WFE may have improved to the point where some species could now be supported. Although a detailed restoration plan is beyond the scope of this report, such a program should be based on more detailed assessment of water quality and hydroperiod of WFE's ponds and streams, and ditches, and should consider if and how ditches draining ponds, such as at Teal Hole, may be affecting habitat quality. Following this evaluation of freshwater habitats, and some possible freshwater habitat restoration, pilot translocations of a few thousand larvae of locally-collected, short hydro-period species such as spring peeper, gray treefrog, and/or Fowler's toad could be used to test the suitability of habitats present. Depending on habitat conditions and results of pilot studies, restoration of other species, such as wood frog and green frog should also be considered.

Summation

The eleven species of amphibians and reptiles recently recorded at WFE represent 46% (11/24) of the species known to have occurred here historically and indicate that the herpetofauna has experienced significant declines during the 20th century. Only nine of the 24 species that occurred here historically appear to be stable in terms of population trends. Of the 15 species that have declined, 11 appear to be extirpated: nearly all the anuran species, three snake species that fed on anurans, and the eastern mud turtle. Exact causes for the decline and extirpation of many species are not certain, but WFE has been subjected to a number of severe stressors, particularly DDT applications in the 1950's, salt water intrusion following the natural creation but artificial maintenance of the Moriches Inlet, and conversion of the adjacent landscape from rural to dense residential. These, plus other less well documented stressors, such as acid precipitation, mercury deposition, and diseases have all likely contributed. In contrast, the Carmen's River system, only five kilometers to the west, and containing over 4000 acres of upland and wetland habitat along 6.6 miles of river, has been subjected to most of the same stressors as WFE, but this larger protected area has not experienced such a dramatic loss of herpetofauna.

WFE is well known for its population of box turtles and a number of seminal papers on this species' behavior are based on research conducted here. However, WFE now exists as an isolated, moderately-sized habitat island within a highly developed landscape and its ability to support species with large area requirements and complex habitat needs is uncertain. Data collected in this survey suggest that recruitment into the box turtle population is declining and estimated population size and density was relatively low. More intensive study of the box turtle population here is needed to provide better estimates of population size and structure, and to take advantage of existing historic data to estimate trends in survival and other population parameters. Given the increased salinity of Moriches bay that has resulted from the artificial maintenance of the Moriches inlet, freshwater habitat at WFE has been reduced and may be a limiting factor. More intensive monitoring of pond and stream habitats at WFE is needed and freshwater habitat restoration should be explored. Translocation of amphibians to the freshwater wetlands in the park, including Teal Hole Bog, Vista Marsh, O'Dell Creek, and Home Creek, should be considered to restore some of the amphibian community lost years ago. Work conducted on western Long Island, at Gateway NRA, has shown that several of the species extirpated from WFE can be fairly easily restored.

Species Accounts

Four-toed Salamander (*Hemidactylium scutatum*)

The four-toed salamander gets its common name from the four toes on its hind foot while most salamanders have five toes on each hind foot. As an adult it is a terrestrial species inhabiting woodlands adjacent to swamps, bogs, and wetlands that serve as breeding sites (Petranka 1998). Females typically mate in the fall and migrate to their nesting wetlands in early spring, while the males remain in the woodlands (Blanchard 1934). Females are frequently found in spring in sphagnum moss "cliffs" overhanging standing water, where they deposit their eggs, often communally, and remaining with them until hatching occurs. Upon hatching, the larvae wiggle down through the moist sphagnum and drop into the water below, where they undergo a typical aquatic larval stage and metamorphose in about six weeks (Bishop 1941).

The historic record on four-toed salamanders is inconsistent and reflects the fact that this species has specialized behavior and habitat needs, and is seemingly hard to find. The encounter rate of four-toed salamanders under woody cover is relatively low, even next to wetlands where they are present (Cook, unpubl. data) and searching for nests within sphagnum hummocks at breeding ponds in early spring appears to be the only efficient survey method (Chalmers 2004; Corser and Dodd 2004,). Thus, early authors considered it wholly terrestrial, but whereas Ditmars (1905) considered it rare, Sherwood (1898) considered it "not frequent but abundant where found". Somewhat later into the 20th century its life history was better understood and it was recognized as being found the entire length of Long Island. However, records on Long Island were relatively few, mostly associated with terminal moraine rather than outwash plain (Bishop 1941; Yeaton 1968; Schlauch 1974), and it was still considered rare (Schlauch 1967). Given their dependence on swampy, sphagnaceous sites, four-toed salamanders are not very urban tolerant (Schlauch 1978a). Populations in Queens and Nassau counties (Bishop1941) are no longer extant and there are only a handful of recent records for Long Island (Breisch and Ozard, in prep.).

The discovery of four-toed salamanders at WFE was one of the most significant finds of this survey. It is a new species record for this site, and represents only the seventh recent known occurrence on Long Island (Breisch and Ozard, in prep.). One four-toed salamander was discovered under a log at the western edge of Woodlot 2, and two were found under sphagnum moss on the bank of O'Dell Creek (Tables 2, 3, and 4). Areas with s*phagnum* in the spring fed marshes and tributaries along O'Dell and Home Creeks provide suitable nesting habitat for this species. Although previously unrecorded here, the four-toed salamander has likely always been a rare resident of WFE and has gone undetected due to its elusive nature, the limited amount of *sphagnum* habitat in the park, lack of searching, and limited numbers.

Eastern Red-backed Salamander (*Plethodon cinereus*)

The Eastern Red-backed salamander is a lungless, terrestrial salamander that is widespread and common throughout the Northeast, including New York state (Gibbs et al 2007) and New England (Klemens 1993). They occur as a number of different color morphs, with the red striped and unstriped or lead-backed the two most common and widespread (Petranka 1998). Although they reach their greatest density in well drained deciduous and mixed forests with well developed leaf litter (Gibbs et al. 2007) and in some forest ecosystems they dominate vertebrate biomass (Burton and Likens 1975), they are not necessarily restricted to mature forest habitats (Klemens

1993). At Cape Cod National Seashore, they can also be found in open habitat such as powerlines and under woody debris deposited by storm surge at the upper limits of salt marshes (R. Cook, pers. obs.). Because all embryonic and larval development takes place within the "aquatic" environment within the egg membrane, red-backed salamanders are completely terrestrial and do not require wetlands for reproduction. This attribute, in conjunction with their small home range and limited movements, has facilitated their widespread distribution and made them one of the most urban tolerant amphibians (Schlauch 1976), capable of persisting in small woodland patches in highly fragmented urban landscapes (Gibbs 1998).

Historically, red-backed salamanders were considered widespread and very common on Long Island (Noble 1927). There are many historic records from Long Island (Bishop 1941) and) they are "found in woodlands everywhere" (Yeaton 1968). Although, their numbers have undoubtedly been reduced by urbanization, red-backed salamanders remain the most widespread and abundant salamander on Long Island (Breisch and Ozard, in prep.). Lead-backed morphs were recorded historically at Mastic by Nichols (1904-1958) and more recently in WFE woodlands under moist logs by Lynch (1986), Klemens et al. (1988b), and Stavdal (pers. comm.). In the current survey, the eastern red-backed salamander was the most frequently recorded species, accounting for 100 of 211 individuals recorded (Table 2, 4) and the second most widespread species, recorded from 12 of 30 sites, most of which were woodlands (Tables 3).

Of the 100 individuals recorded in this inventory, all were unstriped or lead-backed morphs. Although most populations of red-backed salamanders contain both color morphs (Petranka 1998), Long Island populations are unique in generally consisting of only one morph, with red-backed morphs dominating western Long Island and lead-backed populations dominating the east, particularly in pine forest and along the south shore (Williams et al. 1968). All observations of this species at WFE, both historic (Nichols 1904-1958; R. Stavdal pers. comm.) and current, are consistent with this pattern.

Although the earliest historic data are sparse, observations from the more recent past, as well as current, all suggest that the eastern red-backed salamander was and remains abundant and widespread at WFE, particularly in woodlands. Because it is a terrestrial species and only a small proportion of the population is active on the surface at any given time (Smith and Petranka 2000), red-backed salamanders at WFE do not appear to have been as vulnerable to the negative impacts of DDT spraying in the 1950's as the more aquatic species have been.

Eastern Spadefoot Toad (*Scaphiopus holbrookii*)

The eastern spadefoot toad occurs along the Northeast coast, as far north as Massachusetts, and extends south into and through the southeast (Conant and Collins 1998). It is rare and localized in southern New England (Klemens 1993) and in New York State it is occurs on Long Island and at a few scattered locations in the Hudson River Valley (Gibbs et al. 2007). The eastern spadefoot toad is derived from ancestors that inhabited deserts in the southwest United States, where ability to take advantage of unpredictable and infrequent rainfall events has resulted in a breeding strategy of "irrupting" after heavy rainfalls to breed in resultant puddles. Hence, spadefoot toads are able to breed in very short hydro-period wetlands and, because they spend most of their time burrowed underground, they can be common on landscapes dominated by sandy substrate, open vegetation, and an abundance of temporary ponds (Cook 2005).

Ditmars (1905) considered them rare but both he and other early authors recognized that their habits made them hard to find and they were more common than observations suggested (Sherwood 1898). Spadefoots were abundant and widespread on Long Island, occurring on both the moraine and outwash plains (Overton 1914 1915; Noble 1927; Schlauch and Burnley 1968; Schlauch 1974). Their historic abundance on Long Island reflects their burrowing habits and association with sandy habitats and the sandy nature of Long Island's glacial deposits. Because the open, sandy habitats that provide ideal habitat for spadefoot toads are easily developed (Gibbs et al. 2007), spadefoot toads have declined with urbanization (Schlauch 1976; Klemens 1993). Spadefoots are currently listed by the New York State Department of Enviromental Conservation as a "Special Concern" species and only a few spadefoot toad populations occur in Nassau and Suffolk counties (Breisch and Ozard, in prep.).

The observations of Nichols (1904 to 1958, 1917a) suggest that spadefoot toads were once fairly common at WFE, with up to 30 individuals calling and breeding on three separate occasions in "spadefoot pool" following rains in 1916, and again in 1920. There have been no records at WFE since, but there are recent records from nearby Bellport and Moriches (Breisch and Ozard, in prep.). Considering its current rarity on Long Island, development and habitat changes to the areas surrounding WFE, and the lack of records here over the past 80 years, this once common species appears to have declined and may be extirpated. However, considering that spadefoot toads have low detection probability and the low rainfall in 2002 was not conducive to their activity, plus it is present elsewhere along Suffolk County's south shore and spadefoots are sometimes "rediscovered" after going undetected for several decades, its status is uncertain.

Fowler's Toad (*Bufo fowleri*)

Fowler's toad is widespread in the eastern U.S., and in the Northeast is found mostly along the coastal plain, extending inland up river valleys (Klemens 1993). Fowler's toads are primarily terrestrial, foraging and hibernating on land and migrating to wetlands to breed. They are habitat specialists found primarily in sparsely vegetated, sandy areas (Breden 1988) and breed in both permanent and temporary freshwater wetlands, avoiding those with a canopy of woody vegetation (Tupper and Cook, 2008).

Historically, Fowler's toad was common and widespread in the New York Metropolitan area and Long Island (Noble 1927) and, although similar to and sometimes hybridizing with the American toad (*Bufo americanus*), is the only species of toad (i.e. *Bufo*) found on Long Island (Overton 1914). Although they were negatively impacted by intense urbanization in NYC by the mid-20th century (Kieran 1959), their relatively simple life cycle, ability to breed in various wetlands, including temporary and human-created ones, and to forage in suburban yards made Fowler's toad one of the most "urban tolerant" of Long Island amphibians (Schlauch 1976). Thus, Yeaton (1968) noted it was found everywhere on Long Island and was abundant in sand dunes. However, throughout the Northeast U.S., Fowler's toad is now becoming less common due to habitat loss, pesticides (Lazell 1976), and hydrologic alterations (Tupper et al. 2007).

Fowler's toads were common at WFE in the early to mid 20th century. Nichols (1904-1958) described "swarms" of toads on the Creek Road (25 June 1944), many found in the Upper Lane (17 July 1948), and toads that were "fairly numerous in Indian Point Road and across the lawn"

(18 July 1948). However, Lynch (1986) recorded only one, at the park entrance and Stavdal (pers. comm.), did not encounter any while working at WFE for 26 years (1980-2006).

The failure to find any Fowler's toads during this survey suggests this species has been extirpated from WFE, despite the fact that it is still moderately common and widespread in Suffolk County (Breisch and Ozard, in prep.), they are abundant at Fire Island and nearby Werthein NWR (Chmielwewski, pers. comm.) and WFE appears to have enough freshwater and upland habitat to support a population. Although WFE is now an island of habitat surrounded by urbanization, the timing of the Fowler's toad decline here, sometime between 1948 and 1980, suggests that DDT applications may have been the most important factor in their extirpation.

Subsequent to this survey, in 2004, ca. 500 Fowler's toad tadpoles were translocated to Teal Hole Bog from Calverton, Long Island (R. Stavdal, pers. comm.). Although the fate of this relatively small transplant effort is unknown and needs follow-up monitoring to ascertain, restoration of a Fowler's toad population at WFE is an appropriate and desirable activity, for which Teal Hole and Teal Hole Bog could serve as potential breeding sites. Cook (2008) has shown that Fowler's toad populations in this region can be fairly easily restored through translocation.

Gray Treefrog (*Hyla versicolor*)

The gray treefrog occurs throughout most of the eastern United States as a pair of sibling species distinguishable from each other in the field only by voice (Conant and Collins 1998). The species which occurs on Long Island, *Hyla versicolor*, is found throughout the Northeast and Canada (Klemens 1993). The gray treefrog has large toe pads, orange/yellow coloration on the underside of the hind limbs, and lives high in trees and shrubs, descending to wetlands to breed (Behler and King 1979). Their color ranges from gray to brown, green, light gray, to almost white depending on activity and environmental conditions (Conant and Collins 1998).

Historically, gray treefrogs were widespread and common on Long Island (Ditmars 1905; Noble 1927), with Overton (1914) stating its call was the most commonly heard and widely known frog call on Long Island. Gray treefrogs have declined regionally in the latter half of the 20th century. By the 1930's Leng and Davis (1930) noted their increasing rarity on Staten Island, as did Mathewson (1955), although Kieran (1959) considered it common in NYC parks. In Connecticut, urbanization and pollution have extirpated or greatly reduced gray treefrogs (Klemens 1993) and on Long Island, DDT spraying has also contributed to their decline (Schlauch and Burnley 1968). Although current records are limited, some populations still persist in Nassau and Suffolk Counties (Breisch and Ozard, in prep.).

Nichols only record of gray treefrog calling on 29 May 1916 (Nichols 1904-1958) provides little insight beyond presence into their historic status, but given the above accounts and the wetland and woodland habitat present, they were likely common. The lack of any encounters with gray treefrogs in the current survey, or in recent decades (R. Stavdal, pers. comm.) suggests this species is likely extirpated. Long Island gray treefrogs are known to have been adversely affected by DDT spraying (Schlauch and Burnley 1968) and although recently recorded in Bellport and Moriches (Breisch and Ozard, in prep.), given the history of DDT use in and around WFE (Sprenger et al. 1987) this is probably the prime cause of their extirpation.

Spring Peeper (*Pseudacris crucifer*)

The spring peeper is widespread throughout the eastern United States and Canada (Klemens 1993) and ubiquitous, breeding in a wide range of wetland habitats. Its unique, high-pitched breeding call is often a deafening chorus of hundreds of individuals. These loud and distinct calls, in combination with a prolonged calling season that stretches from mid-March to mid-May (Overton 1914), make it one of the most readily detected of local anurans (cite someone here). Spring peepers are terrestrial outside of the breeding season, and utilize a broad range of terrestrial habitats (Gibbs et al. 2007). Historically, spring peepers were widespread and common in the New York Metropolitan-Long Island area (Ditmars 1905; Noble 1927; Yeaton 1968) and because it is among the most urban tolerant of amphibians (Gibbs 1998), spring peepers still persist in many patches of remnant habitat on Long Island (Breisch and Ozard, in prep.)

The spring peeper is a common anuran on Long Island and is known to occur at the nearby Wertheim National Wildlife Refuge (J. Feinberg, pers. comm.). Nichols (1904-1958) recorded them calling abundantly from WFE and in Mastic in 1916 and 1918, but spraying of DDT for mosquito control in the 1950's appears to have eliminated a number of anuran species at WFE, including the spring peeper. The single spring peeper at Teal Hole Bog in 2002 and two males calling there in May 2003 (Virag 2003) are the only records of this species since the cessation of DDT applications, and the only current records of any anurans at WFE. These recent records are the result a pilot study in which 35 adults/year (mostly males) were translocated from Randalls Pond, Ridge, Long Island to Teal Hole Bog in 1999, 2000, and 2001 (R. Stavdal, pers. comm.).

These post-release records, up to two years after the last releases, indicate that at least some of the translocated individuals have successfully overwintered, but it is unknown whether there was any successful reproduction in 2002 and 2003. Even though spring peepers are short lived and males can call the year after they are spawned (Cook, in prep.), breeding choruses can contain individuals that are four years old (Lykens and Forester 1987) and the possibility that the two males calling in 2003 were individuals released in 2001, rather than their progeny, cannot be eliminated. Thus, although there are short term signs of success, it is uncertain if this male-dominated translocation effort has resulted in a breeding population. However, now that enough time has elapsed for the passing of all the released animals, three to four follow-up surveys at night in April, would be sufficient to resolve this uncertainty.

Regardless of the fate of these pilot releases, restoring spring peepers and other historically-occurring species that were extirpated by DDT is appropriate and desirable. It has been ca. 40 years since DDT applications on Long Island, and concentrations in organisms and sediments of Moriches Bay show decreasing levels and improving community health (Jankowski 2004). Thus it is possible that there has been enough time for DDT and DDE to break down to the point where it no longer limits amphibian survival at WFE. Translocation of larvae has been shown to be an easy and effective method and has been used to successfully establish a number of spring peeper populations at Gateway NRA on western Long Island (Cook 2008). Such an approach could easily be applied to WFE, but should be done in conjunction with efforts to better document water quality and hydroperiod regimes of WFE's freshwater wetlands.

Northern Green Frog (*Rana clamitans melanota*)

The northern green frog is a common and widespread species throughout the eastern United States and Canada, using a wide range of wetland habitats (Klemens 1993). However, in northern populations, green frog tadpoles must overwinter in the breeding pond (Wright and Wright 1949), limiting successful reproduction to ponds that are permanent and semi-permanent. Dorsolateral ridges extending back behind each eye help distinguish the northern green frog from the bullfrog; in bullfrogs, these ridges are absent. This species is readily found in and around ponds, streams, and marshes, and also on roads during rainy nights.

Historically, green frogs were widespread and common in Long Island pools and streams (Overton 1914; Noble 1927). Because permanent ponds tend to survive urbanization more so than shallow, temporary ones and may actually increase (Schlauch 1976), permanent pond species such as green frogs have remained one of the most widespread and abundant amphibians of urbanized landscapes. Thus, green frogs were considered the commonest frog on Long Island and in Suffolk County by Yeaton (1968) and Schlauch and Burnley (1968), respectively, and remain so today (Breisch and Ozard, in prep.)

Nichols (1904-1958) recorded northern green frogs on many occasions: calling from Mastic (9 July 1911, 26 April 1921, 12 April 1925), calling from the "spadefoot pool" (9 July 1916, 20 August 1916, 20 August 1919), and from Home Creek (2 June 1918, 14 August 1916, 14 October 1916, 16 April 1922). Considering the lack of any encounters in the current survey, or in recent decades (R. Stavdal, pers. comm.), and the high detectability of green frogs, this species appears to have gone from common to extirpated at WFE. Similar to the other anurans at WFE, their decline is likely due to the combined effects of DDT, salinity changes in the Moriches Bay area, and development surrounding the park. As with the other anurans extirpated from WFE, population restoration should be considered. Translocations conducted at Jamaica Bay Wildlife Refuge on western Long Island suggest that with a permanent freshwater pond available, a population of green frogs can be successfully translocated (Cook, 2008).

Pickerel Frog (*Rana palustris*)

The pickerel frog is common and widespread in the Northeast and mid-Atlantic regions (Conant and Collins 1998). It is found throughout New York state breeding in shallow permanent wetlands, and outside of breeding season, can be found in streams, springs, sphagnum bogs, fields and woodlands (Klemens 1993; Gibbs et al. 2007). This species is distinguished from the leopard frog by a dorsal pattern of brown squares arranged symmetrically, and the inner surfaces of the hind legs are orange or yellow (Conant and Collins 1998).

Historically, pickerel frogs were widespread and common in the New York City - Long Island region (Ditmars 1905; Noble 1927). On Long Island, they were recorded from Queens to eastern Suffolk county (Schlauch 1974) and were considered plentiful but not as common as leopard frogs (Overton 1914; Latham 1970). Pickerel frogs and leopard frogs on Long Island both utilized pools and streams, but partitioned these habitat spatially, with pickerel frogs dominating away from salt meadows and low plains Overton (1914). Pickerel frogs are less tolerant of urbanization than green and bull frogs (Klemens 1993) and recent data (Breisch and Ozard, in prep.) suggest they are no longer that common on Long Island.

Nichols' single record of pickerel frog at Mastic on 7 July 1915 (Nichols 1904-1958) provides little insight beyond presence into their historic status. Based on Overton (1914) leopard frogs would be expected to be more common at WFE than pickerel frogs and the historic record (Nichols 1904-1958) seems to bear this out. Thus, pickerel frogs were probably not common here. Considering the lack of records during the current survey, and in the decades preceding it (R. Stavdal, pers. comm.), it appears that pickerel frog no longer occur at WFE. Reasons for their disappearance are likely DDT, salinity changes in Moriches Bay and tributaries following the hurricane of 1938, and adjacent development.

Wood Frog (*Rana sylvatica*)

The wood frog has an extensive range that includes Appalachia, the Northeast, most of Canada, and Alaska (Conant and Collins 1998). It is widespread in New England, occurring both inland and on the coastal plain (Klemens 1993) and has a similar distribution in New York State (Gibbs et al. 2007). Wood frogs are terrestrial, typically associated with forested landscapes, except during the breeding season when they breed in fishless vernal pools (Conant and Collins 1998). Breeding in early spring (late-February-March), the wood frog is an explosive breeder. Often a large percentage of a population migrates to ponds synchonously, laying eggs together in large floating masses. They breed in greatest abundance at vernal ponds with short to intermediate hydro-periods (Egan and Paton 2004).

Historically, Noble (1927) considered wood frogs widespread and common although Ditmars (1905) considered them abundant but limited in occurrence. Wood frogs were widespread on Long Island and although most records are from the glacial moraines (Schlauch and Burnley 1968), their occurrence at Patchogue (Overton 1914) indicates they also occurred on the outwash plain. Outside of the breeding season, wood frogs range far from their breeding ponds (Berven and Grudzien 1990). Consequently, wood frog abundance is now positively correlated with unfragmented and roadless forested landscapes with vernal ponds (Egan and Paton 2004) and wood frogs are not well adapted to urbanization (Klemens 1993; Gibbs 1998; Rubbo and Kiesecker 2005), particularly since vernal ponds are often filled in during urbanization (Campbell 1974). Latham (1971c) describes how a very large population of wood frogs, once so common on eastern Long Island that he made no effort to record them, declined dramatically after a wetland was drained after World War I. Thus, by the 1950's, wood frogs were limited to scattered patches of woodland habitat on western Long Island (Kieran 1959) and by the 1970's they had declined throughout much of Long Island (Schlauch 1978a). Current records are limited, but some populations still persist in Nassau and Suffolk Counties (Breisch and Ozard, in prep.).

Although wood frogs were historically present (Nichols 1904-1958), none were recorded in the current survey, nor have any been encountered in recent decades (R. Stavdal, pers. Comm.). In contrast, wood frogs were readily detected during our surveys at Sagamore Hill NHS in Oyster Bay. Although recently recorded in Bellport and Moriches (Breisch and Ozard, in prep.) and fairly common at Wertheim NWR (Chmielewski, pers. comm.), wood frogs appear to have been extirpated from WFE, with a combination of pesticides and surrounding development and habitat fragmentation the likely causes. Despite this loss, WFE may have sufficient habitat to support a population of wood frogs and this species should be considered for restoration. Sexton et al.

(1998) established a Wood Frog population by transplanting 11 egg masses, though only one of four attempts succeeded.

Southern Leopard Frog (*Rana sphenocephala*)

The southern leopard frog is widespread through the south central and southeast United States, except for Appalachia, and ranges northward along the Atlantic coastal plain to the lower Hudson River valley and Long Island (Conant and Collins 1998). Considered to be one of the most common frogs throughout most of its range, southern leopard frogs breed in shallow marshes and open grass meadows in a broad range of riverine and wetland habitats, including salt marshes (Butterfield et al. 2005; Gibbs et al. 2007). They venture away from wetlands outside of the breeding season (Conant and Collins 1998).

Although southern New York State is the northern limit of their distribution, southern leopard frogs were abundant historically along the coastal marshes of the New York Metropolitan area (Ditmars 1905; Noble 1927). Overton (1914) considered this species to be especially common on the salt marshes of Long Island's south shore and abundant on Fire Island. At WFE, Nichols (1904-1958) identified southern leopard frogs calling from Home Creek in 1916, 1919, and 1930 and they were commonly observed in O'Dell creek in the late 1960's (R. Frey *fide* R. Stavdal, pers. comm.). Yeaton (1968) also noted they were common at Old Mastic and a number of other sites along the south shore west to Islip and they were still abundant in Bridgehampton in the 1980's (Nelson 2005).

Southern leopard frogs are now listed as a Special Concern Species in New York State and recent efforts to locate extant populations on Long Island have not been successful (J. Feinberg, pers. comm.). Their decline on Long Island occurred "over the past 30 to 50 years" (Feinberg et al. 2007), essentially beginning in the late 1950's. Even though our searches included the same stretch of O'Dell Creek where southern leopard frogs were observed in the late 1960's, none were recorded anywhere at WFE in 2002 and this species appears extirpated. The exact time of extirpation is uncertain, but considering that Stavdal (pers. comm.) spent many hours afield in and around O'Dell Creek beginning in 1980, it appears that extirpation occurred in the 1970's.

Reasons for the apparent extirpation of southern leopard frogs on Long Island are uncertain, but likely include the cumulative effects of habitat loss and fragmentation, invasion by *Phragmites*, environmental contaminants, and disease (J. Feinberg, pers. comm.). WFE has been subject to many of these same stressors, e.g. the application of DDT in the 1950's and being surrounded by residential development over the years, plus increased salinity in Moriches Bay and its tributaries following the hurricane of 1938 (R. Stavdal pers. comm.). It is hard to attribute the extirpation of leopard frogs to any one stressor, particularly since their persistence into the late 1960's suggests they survived salinity changes and the DDT era. Although speculative, given that southern leopard frogs are a wide ranging species outside of the breeding season, the cumulative loss of individuals into the intense development surrounding WFE may have been one too many stressors.

Snapping Turtle (*Chelydra serpentina*)

The snapping turtle occurs from southern Canada, south through the mid-west and east coast, down to Florida and the Gulf of Mexico (Ernst et al. 1994). It is abundant and widespread in

New York State (Gibbs et al. 2007) and New England (Klemens 1993), and is the largest freshwater turtle in the northeastern United States. Although snapping turtles occur in nearly all freshwater habitats and also in brackish marshes, adults tend to occur more frequently in permanent water bodies and are most abundant in shallow, muddy ones (Klemens 1993; Cook et al. 2007). Typical of all turtles, eggs are laid on land. Female snapping turtles must emerge from wetlands and travel overland in search of nesting areas, generally open, sandy, sparsely vegetated patches (Gibbs et al. 2007). They are often seen crossing roads in late spring-early summer. Females dig nests and deposit eggs in loose sand or soil, and the hatchlings emerge in the late summer or early fall (Ernst et al. 1994).

Historically, snapping turtles were considered widespread and common throughout the NYC Metropolitan area (Engelhardt 1913; Murphy 1916; Noble 1927). Because urbanization has created additional permanent ponds in this region (Schlauch 1976) and snapping turtles are largely aquatic, primarily nocturnal, and relatively tolerant of water pollution and pesticides, they are able to survive urbanization (Klemens 1985) and are widespread in and around New York City (Kieran 1959) and Long Island (Breisch and Ozard in prep), including a nearby population at Werthheim NWR (Kinneary 1993).

Snapping turtles were fairly common in this survey, with a total of 16 records of individuals from Home Creek (58% of individuals), O’Dell Creek, Teal Hole Bog, and Teal Hole (Table 2, 4). Both adults and juveniles were found (Appendix D). In concert with prior records indicating that snapping turtles are common at WFE (Nichols 1904-1958; Lynch 1986), the current survey suggests it continues to be common in the park, with the majority utilizing Home Creek, a spring fed, freshwater stream and marsh.

Eastern Mud Turtle (*Kinosternon subrubrum subrubrum*)

The eastern mud turtle is a small aquatic turtle with a smooth, dark olive to black oval carapace, a double-hinged plastron, and 11 marginal scutes rather than the 12 found on most turtles. Its diet includes crayfish, mollusks, beetles, insects, and amphibians. Mud turtles are typically found in shallow muddy wetlands with soft bottoms and abundant aquatic vegetation and, along the coast, are also found in salt marshes and brackish ponds dominated by *Phragmites* (Ernst et al. 1994; Gibbs et al. 2007). Mud turtles can be quite terrestrial and utilize uplands for both nesting and hibernation. The eastern mud turtle ranges from Mississippi eastward through the southeastern United States and northern Florida, and then northward through the coastal states, with its northern limit reached on Long Island, NY (Conant and Collins 1998). In the New York Metropolitan area, mud turtles occur on Long Island, Staten Island and along coastal New Jersey.

Historically, mud turtles were considered widespread and common in the region, especially on the coastal plain (Noble 1927). Engelhardt (1913) noted they were common in streams and ponds in Brooklyn, and they also occurred in the salt marshes on the south shore of Staten Island and Long Island (Murphy 1916; Leng and Davis 1930), including East Patchogue and Mastic, where it was frequently seen (Nichols 1914). Wetland alteration and development, road kill, industrial development and road construction have led to declines in New York mud turtle populations (Gibbs et al. 2007) and they are listed as *Endangered* in New York State. They are considered extinct in Nassau county (Schlauch 1978b) and only a handful of isolated populations (six known) now remain in New York state, one on Staten Island, and others in Patchogue, Fire Island and eastern Long Island (Breisch and Ozard, in prep).

Mud turtles were once common at WFE. Nichols (1904-1958) reported 20 observations of mud turtles from Mastic (3), Snipe Hole (1), Home Creek (9), Lund's Creek (1), and Indian Point (6) between 11 June 1913 and 11 November 1934, including one being attacked by a blue crab in Home Creek (Nichols 1914). None were recorded in 2002 nor have there been any records since those of Nichols (R. Stavdal, pers. comm.). The decline and apparent extirpation of mud turtles at WFE is likely the result of several factors. The Moriches inlet, created by storms in the 1930's and artificially maintained through dredging since the 1950's, has led to increased salinity in Moriches Bay and eastern Great South Bay (Moskowitz 1976). Nichols (1947) states that mud turtles were common in the bordering creeks prior to this event, implying a decline afterwards. Moreover, because mud turtles make extensive use of upland habitats for nesting and hibernation, the development and habitat fragmentation adjacent to WFE has also likely been a significant factor. The extensive use of DDT at WFE, and particularly the high residual concentrations in the Home Creek system (Sprenger et al. 1987), which was the prime spot for mud turtles here (Nichols 1905-1958), has probably also contributed.

Although mud turtles appear extirpated from WFE, there are nearby populations in the Otis Pike Wilderness Area on Fire Island National Seashore (Cook et al., 2010) and in the Carmen's River (Meyer 1988; J. Feinberg, pers. comm.; A. Chmeilewski, pers. comm.), ca. six kilometers west of WFE. Both these sites have been exposed to some of the same stressors present at WFE (i.e. salinity changes in Moriches Bay, spraying of DDT), but differ in other significant ways. First, in addition to broad scale aerial spraying at all three, DDT at WFE appears to have been "mis-applied", resulting in localized hot spots (Sprenger et al. 1987). However, the most significant differences between WFE and these two other sites are probably the amount of available habitat and extent of adjacent urbanization. Mud turtles on Fire Island are able to move around on a largely undeveloped landscape, of which 1381 acres are designated wilderness. For this population, loss of nesting and hibernation sites to development and potential for road kill are minimal. The Carmen's River is the largest undeveloped estuary system remaining on Long Island (USFWS 2006). In addition to county parks and private campgrounds further upstream, Wertheim NWR (at its mouth) and South Haven County park (directly above Wertheim) preserve ca. 6.6 miles of river, and 3928 acres of adjacent upland and wetland habitat along this New York State designated Wild and Scenic River. Mud turtles utilizing the Carmen's River and adjacent wetlands are able to move about and meet their needs largely within the confines of this much larger protected area. Thus, an insufficient amount of habitat due to the relatively small size of Home Creek and the loss of adjacent uplands to urbanization, possibly in combination with impacts from DDT "mis-application", are the probable cause of mud turtle extirpation at WFE.

Painted Turtle (*Chrysemys picta*)

The painted turtle is the only North American turtle that ranges across the continent, from southern Canada down through the Pacific northwest, midwest, and the northeast coast to Louisiana, Georgia, and the Carolinas (Ernst et al. 1994). There are four subspecies, with English names that describe eachs' distribution. In the Northeast, including the Long Island region, the Eastern painted turtle (*C. p. picta*) and the Midland painted turtle (*C. p. marginata*) intergrade, forming a hybrid swarm (Pough and Pough 1968). Whereas the eastern painted turtle has an unmarked yellow plastron and the seams of the central and lateral carapace scutes are aligned and the midland painted turtle has a variable dark marking on the plastron and alternating seams on the carapacial scutes (Ernst et al. 1994), Long Island painted turtles are intermediate in these characters and are highly variable both within and among populations (Pough and Pough 1968).

In addition to a wide geographic distribution, painted turtles are widespread ecologically, occurring in a broad range of freshwater habitats, including vernal ponds. However, they prefer permanent, shallow, standing or slow-moving water bodies with soft bottoms and an abundance of aquatic vegetation (Ernst et al. 1994; Cook et al. 2007; Gibbs et al. 2007). Because of their abundance and habit of basking on rocks, logs, and clumps of vegetation, painted turtles are the region's most familiar and conspicuous turtle (Klemens 1993). Painted turtles are highly aquatic, feeding and hibernating in ponds. However, they lay their eggs on land and, as with all aquatic turtles, must leave the relative safety of the wetland and travel overland to patches of open habitat with well drained soils to nest.

Historically, painted turtles were considered widespread and very abundant in the New York City-Long Island region (Engelhardt 1913; Murphy 1916; Noble 1927). Because permanent water bodies tend to survive urbanization and have increased in some instances through the damming of streams, painted turtles in the NYC-Long Island region survived 20th century urbanization (Mathewson 1955; Kieran 1959; Schlauch 1978a) and remain widespread today. They occur in most any natural area with a permanent pond or lake (Breisch and Ozard, in prep).

Painted turtles were once common at WFE. Nichols (1904-1958) writes of painted turtles being numerous and plentiful in upper Home Creek and he reported a minimum of 63 observations of painted turtles from Mastic, Home Creek, O'Dell Creek, Indian Point Road, Great Lot, Lon's Creek, Poospatuck Creek, and Great Boat Place between 8 July 1911 and 5 July 1947. In spite of their widespread present occurrence on Long Island, including the Patchogue River (R. Stavdal, pers. comm.) and tidal creeks of the Carmen's River (J. Kinneary, pers. comm.), none were found at WFE in 2002. However, a single juvenile painted turtle (ca. 100 mm CL) was found on the road next to the curatorial building on July 10, 2008 by MaryLaura Lamont (pers. comm.), suggesting that a small population may still persist. Regardless, it is clear that the painted turtle population at WFE has declined dramatically, probably in response to a combination of factors: increased salinity in Home Creek (Nichols 1947); high levels of DDT in the freshwater remnants of upper Home Creek (Sprenger et al. 1987); impacts from adjacent urbanization, such as loss of nesting habitat, increased road kill of females on nesting forays, and increased populations of subsidized predators such as raccoons. Whether the population will recover on its own is uncertain, but painted turtle populations can be successfully established through translocation (Zweifel 1989; Cook 1996) and the potential for restoring them at WFE should be explored.

Spotted Turtle (*Clemmys guttata*)
A small semi-aquatic turtle with distinct yellow spots on a black carapace, the spotted turtle occurs along the Atlantic coastal plain, from Maine to Florida, including lower elevation areas of southern New England (Klemens 1993), and westward into Ohio, Indiana, Illinois, Michigan, and southeastern Canada (Ernst et al. 1994). In New York, spotted turtles occur in western New York, south of Lake Erie, in the Hudson River Valley, and on Long Island and Staten Island

(Gibbs et al. 2007). Although spotted turtles are widespread, they primarily occur in a broad range of shallow habitats, both freshwater and slightly saline and are considered semi-aquatic, because they may spend a lot of time on land when temporary wetlands dry (Ernst et al. 1994).

Historically, spotted turtles were common and widespread in coastal New York, occurring in ponds, streams and salt marshes (Smith 1899; Murphy 1916; Noble 1927). Nichols (1914) noted that spotted turtles were abundant in the salt meadow creeks of Mastic, opposite Fire Island. By mid-20th century, the negative impacts of urbanization on them were becoming apparent (Kieran 1959). This decline was due to the loss of preferred wetland habitats to urbanization (Schlauch 1976), exacerbated by their complex patterns of seasonal habitat shifts and large home ranges, which make them very susceptible to the negative impacts of habitat fragmentation (Klemens 1993). In addition, given the extensive use of DDT on the south shore of Long Island (Jankowski 2004), and its negative effects on reptiles via direct mortality and endocrine disruption (Guillette 2000), it is likely that pesticides have also contributed to the spotted turtle's decline on Long Island. They are currently listed by New York State as a species of *Special Concern*. They are rare and very limited in NYC, but a bit more common eastward on Long Island, with one site in Nassau County and several in Suffolk County (Breisch and Ozard, in prep).

Spotted turtles were once common at WFE (Nichols 1914) and between 11 June 1913 and 24 March 1928 he reported 19 observations of spotted turtles from Mastic (2), Home Creek (6), O'Dell Creek (1), meadow bog (2), West Road (1), meadow path (5), and Pattersquash Creek (1) (Nichols 1904-1958). They were present but seemingly rare in the 1980's. Stavdal (pers. comm.) marked a total of three individuals from 1984 through 1986, one each in Teal Hole Bog, near Rye Pond, and in Vista Marsh, and Lynch (1986) reported one from woodland habitat. One accidentally killed spotted turtle at WFE was collected for DDT analysis (Sprenger et al. 1987). This analysis found DDT residues at a concentration (204 μg/kg), higher than in a box turtle from the park (10μg/kg). This was expected given the spotted turtle spends considerably more time within the marshes where DDT was biologically available.

No spotted turtles were recorded during this survey, and it has been 15 years since the last records. However, rainfall in 2002 was low, as were wetland water levels, and spotted turtle activity and detectability was likely diminished. Home Creek begins as a spring fed, shallow, mucky, deciduous forest marsh and appears to be suitable habitat for spotted turtles, as do sections of O'Dell Creek (also spring fed) and all of Teal Hole Bog. Populations of spotted turtles still persist nearby on Fire Island (Cook et al., 2010) and in the Carmen's River (A. Chmielwewski, pers. comm.; P. Warny, pers. comm.), but these sites are larger and/or less surrounded by development. Although it is uncertain if spotted turtles have been extirpated from WFE, they are very rare at best, and have declined dramatically in the last half of the 20th century. Reasons for this decline are probably similar to those responsible for the decline of eastern mud turtle here; salinity changes in Moriches bay, impacts of DDT, and loss of habitat to adjacent development.

Northern Diamond-backed Terrapin (*Malaclemys terrapin terrapin*)

The northern diamond-backed terrapin is a sub-species of the diamond-backed terrapin, a species that ranges along the coast from Texas to Cape Cod, Massachusetts. Northern diamond-backed terrapins range from Cape Hatteras, North Carolina to Cape Cod (Conant and Collins 1998). In

New York, diamond-backed terrapins occur primarily along the coast of Long Island, both north and south shore (Morreale 1992). Terrapins are unique in that they are the only species of turtle restricted to estuaries (Morreale 1992), and they are typically found wherever extensive salt marsh habitat has developed, such as behind barrier beaches and within deep embayments. Although they spend most of their time in salt marshes, where they forage primarily on mollusks and crabs, female diamond-backed terrapins must emerge onto land to lay eggs, nesting in dunes, along roads and trails, and other open situations, often several hundred meters from water (Brennessel 2006). On western Long Island, terrapins nest from the first week of June through the third week of July (Cook 1989; Feinberg and Burke 2003).

Historically, diamond-backed terrapins were widespread and abundant on Long Island. However, they were highly valued as a delicacy (Smith 1899) and by the late 19th-early 20th century they had declined due to overharvesting (Engelhardt 1913; Murphy 1916). Terrapins remained rare to uncommon in the region during the first half of the 20th century, but appeared to be rebounding by the second half (Yeaton 1972; Morreale 1992). By the late 20th century, diamond-backed terrapins had recovered in many areas, including Long Island, although it was noted that the continuation of this recovery was threatened by renewed loss of habitat, commercial take, drowning in crab pots, and roadkill (Cook 1989; Wood and Herlands 1997). In addition, where raccoons are present, particularly as subsidized predators, nest predation can be a significant problem. At Jamaica Bay Wildlife Refuge on western Long Island, where there was a large increase in the raccoon population at the end of the 20th century, nest depredation by raccoons went from none in the early 1980's (Cook 1989) to 92.2% by the late 1990's (Feinberg and Burke 2003).

Diamondback terrapins appear to have been common in the waters of Moriches Bay near Mastic in the early part of the 20th century (Nichols 1914) and to have remained common into the latter part of the century. Lynch (1986) noted they are observed on a regular basis by park staff in WFE wetlands and Morreale (1992) captured three individuals at WFE, but observed as many as 19 individuals. The single record of a diamondback terrapin in this survey, one captured during turtle trapping at Floyd Pond (Tables 2 and 3, Appendix D) suggests that terrapins are uncommon here, but it may also reflect the difficulty of capturing this species (they are much easier to spot with binoculars at high tide) and/or a preference for the more open waters of Moriches Bay and its tributaries. Most of our sampling effort was concentrated in freshwater wetlands and uplands (with some trapping in ditches), and our results likely under-represent the local population. Park staff have observed terrapins basking in the bay near Floyd Pond and they occur in the Carmen's River (Kinneary 2008), on Fire Island (Cook et al., 2010), and throughout Moriches Bay. Although common in the salt marshes and main ditches of WFE, Stavdal (pers. comm.) never observed any evidence of terrapins in upland habitats at WFE over the course of 26 years, suggesting there is little nesting taking place here. Because terrapins are an estuarine species and may move about within this larger system, the salt marshes of the Floyd Estate are probably best viewed as a small part of a much larger system supporting a regional population of this species. Radiotelemetry studies would be needed to determine the range and movement of terrapins observed at WFE.

Eastern Box Turtle (*Terrapene carolina carolina*)

Eastern box turtles occur from Georgia and northern Alabama and Mississippi northward into southern Illinois and eastward (Conant and Collins 1998). In the northeast, box turtles are largely restricted to the coastal plain and major river valleys and extend northward into southern New England and up to Albany, NY (Klemens 1993). The eastern box turtle is a terrestrial species that typically occurs in areas that are a mix of woodland and open habitat. The habitat diversity provides the ability to shift habitats seasonally in response to changes in temperature and humidity (Reagan 1974), and, as with all turtles, well drained open habitats are needed for nesting. Eastern box turtles are frequently found foraging following spring and summer rains, and they will feed on slugs, fruits, vegetation, and carrion.

Historically, box turtles were widespread in the New York metropolitan area and considered abundant on Long Island (Smith 1899; Engelhardt 1913; Murphy 1916; Noble 1927). However, as urbanization progressed they began to decline. Citing automobiles as a cause, Kieran (1959) noted the decline of box turtles on western Long Island. The terrestrial nature of box turtles results in their being more widely dispersed across the landscape than aquatic amphibians and reptiles. Box turtles often engage in seasonal movements for nesting, hibernation, or feeding, and some individuals are transients that do not establish home ranges (Dodd 2001). All this movement across the landscape places box turtles at relatively greater risk of becoming road kill (Gibbs and Shriver 2002) or being collected for a pet in urban areas, which, in conjunction with their late maturity and low rate of reproduction, make their populations unable to sustain the heavy adult mortality that typically occurs in urban areas. Thus, box turtle populations do not fare well on the highly fragmented landscapes found in urban/suburban areas (Schlauch 1976; Mitchell and Klemens 2000) and are declining in many parts of their range (Dodd 2001). Box turtles are a species of *Special Concern* in New York State and although there are still many widespread records from Long Island (Breisch and Ozard, in prep) they are found primarily in parks and habitat remnants (Klemens 1993). Moreover, box turtles are frequently moved around and released by people, and because they are very long lived, many of these recent records, especially on western Long Island, do not necessarily mean that a viable population exists.

Much is known about the natural history of box turtles at WFE from the journals of J. T. Nichols. Box turtles were abundant here and Nichols (1904-1958) marked approximately one thousand five hundred of them. Some of the most significant early publications on this species were based on studies conducted here (Nichols 1917b, 1939a, 1939b, 1939c, 1940). Continuing this work, NPS employee Richard Stavdal marked over 700 box turtles here from 1980 to 2002, including 18 originally marked by Nichols (R. Stavdal pers. comm.). Although some of these recent data have been analyzed vis-à-vis longevity and population structure (Klemens 1993), much more analysis is possible.

In 2002, the eastern box turtle was the most frequently recorded reptile and the most widespread species at WFE. Among the 65 records were 35 individuals captured once each, five individuals captured twice, plus 15 shells and 6 nests (Tables 2, 3, 4). The majority of box turtles were found in woodlands (54%) and fields (35%), but some were also found in stream and marsh habitats, feeding on mushrooms and berries, and mating. Based on Chapman's modification of the Lincoln-Petersen method (Thomson et al. 1998) in which the field season is divided into two equal sampling periods (Menkens and Andersen 1988), the estimated population size and 95%

confidence interval is 118 ± 98 individuals. Of the 39 unique individuals recorded, 26 were marked for the first time in 2002 and 13 were recaptures of individuals marked prior to 2002 (Appendix C, Figure 6). Among these 13 were 12 individuals initially marked by Stavdal prior to 2002, plus one found on 16 September 2002 in Woodlot 6, originally marked by Nichols. Nichols marked this turtle JN 21/21 (Appendix C) on July 3, 1921 and described it as having "about 19 rings on a scale of plastron, about 22 on one at side of carapace" (Nichols 1904-1958 - journal Vol. VII, p.131). Based on this description the turtle was mature (at least 20 years old) in 1921, making it at least one hundred years old in 2002. Park staff first found this turtle in 1991 and it was assigned carapace notches at the time to replace the penknife engravings carved into the plastron by Nichols. Although centenarian box turtles are known (Oliver 1955; Graham and Hutchison 1969), there are few such well documented cases.

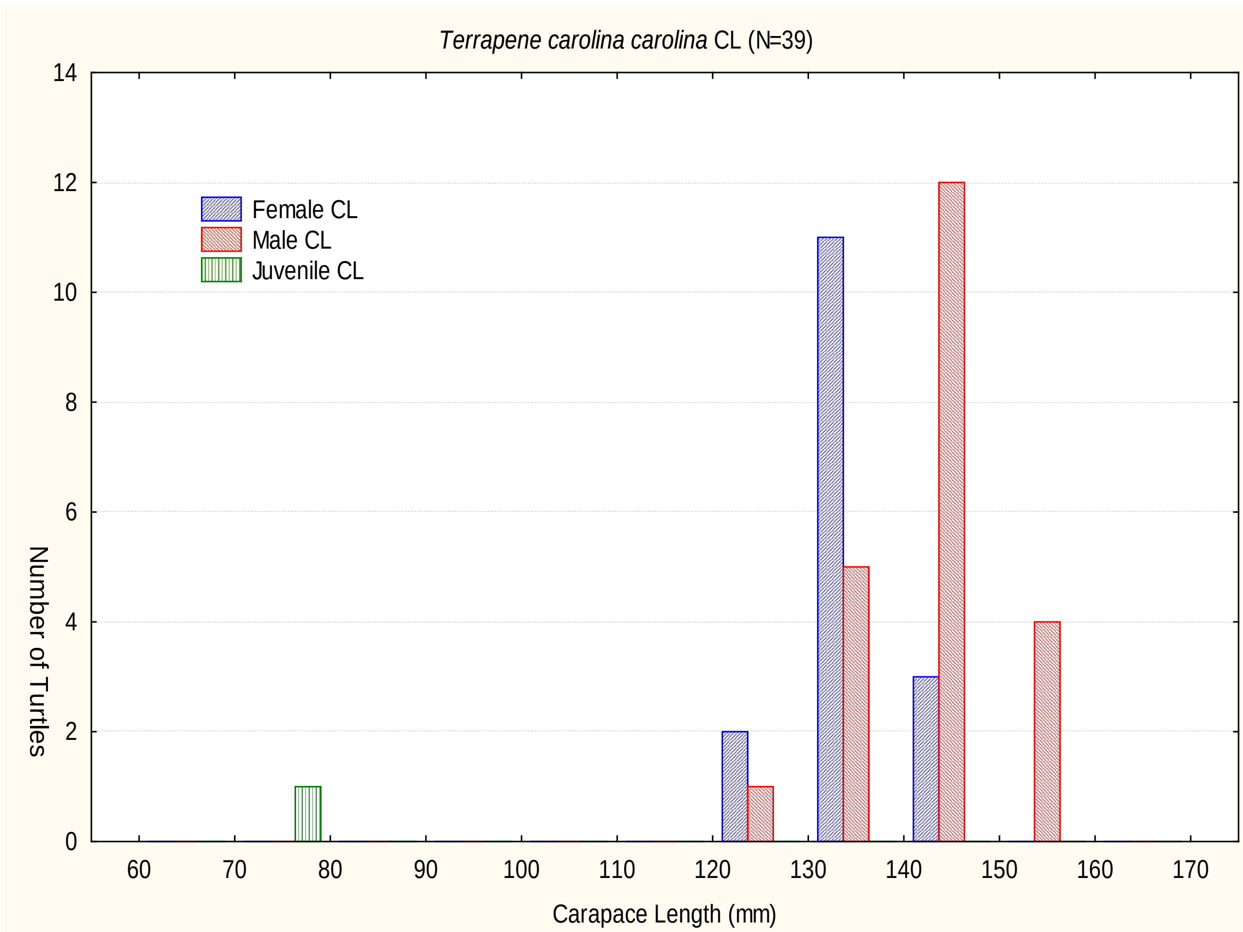

Figure 6. Frequency distribution of the eastern box turtle (*Terrapene c. carolina*) by size and sex at the William Floyd Estate, 2002.

Given the large numbers of box turtles marked here prior to this survey, the fact that 67% (26/39) of all individuals encountered during the survey were unmarked suggests that the population here is large. However, the estimated population of 118 inds (± 98) is not very large, nor is the density estimate of 0.48 inds/ha. Density estimates reported in the literature (reviewed in Dodd 2001) run roughly 10 to 20 times greater, and Madden (1975) estimated the population density of box turtles at the former Kalbfleisch Field Research Station in western Suffolk county to be 3.71 inds/ha. In the current survey, 38 of 39 individuals recorded were adults. Because young box turtles are more vulnerable to predation and tend to be less conspicuous, most studies of box turtle populations record primarily adults (Dodd 2001). However, the proportion of adults recorded at WFE in this study (97.4%) is significantly greater than the 80.5% recorded here during the early 20th century (Nichols 1939a; Fisher's Exact Test p=0.01), and non-significantly greater than the 82% recently recorded on Fire Island (Cook et al., 2010; Fisher's Exact Test p=0.08). Although mating behavior and six nests were observed in the course of this survey, the increasing proportion of adults at WFE suggests that recruitment of young into the population may be declining, perhaps due to increased populations of subsidized predators in response to urbanization (Mitchell and Klemens 2000).

Based on the historic record and results from this study, the eastern box turtle was abundant at WFE and still appears to be so. However, this historic population now faces a number of potential stressors, including genetic isolation, illegal collection, and introduction of disease via release of other box turtles by visitors. Given the current population structure, i.e. decreasing proportion of young, its future viability should not be taken for granted. The current Floyd Estate is much smaller than the original, and is a habitat "island" surrounded by development. The lands adjacent to WFE are probably now more of a "population sink", with the likelihood of loss to road kill and collection greater than previously. Thus, the long term survival of this population will depend on the ability of WFE's 613 acres to support it. One critical aspect of this is to maintain the patchwork of woodlots and fields that provide the edge habitats favored by box turtles (Klemens 1993). Box turtles spend much of their time at the edge between fields and woodlands (Reagan 1974) and many at WFE were found in fields in 2002. Although maintaining fields at WFE is critical to the long-term viability of box turtles here, it must be done in a way that minimizes the risk of mower blades and/or tractors killing them. Ideally, mowing of fields should be done outside the box turtle activity season, which, on average, extends from 21 April until 24 October on western Long Island (Cook 1996). Thus, mowing fields from November until mid-April would pose minimal risks to box turtles. The worst times of year to mow would be June-early July, which is generally when turtles nest, and in mid to late spring and late summer-early fall, when they often bask at field edges. If mowing must occur in summer, it should be done during the hottest months (July-August) to reduce the risk of mower/turtle encounters. Turtles tend to avoid open areas during times of drought and high heat intensity, making the heat of day on hot dry, days the best time to mow during the active season. Mowers with rotary blades or sickle bars are preferable to reel or flail mowers. Rotary blades and sickle bars are oriented horizontally and, if set to cut at least seven inches above ground, they will safely pass over many small animals and wear more slowly (MA NHESP 2007).

Although box turtles are generalists in terms of the habitat they occur in, as long as it is a mix of woody and herbaceous types, they are specialists in requiring relatively large habitat patches to sustain a population. The present-day WFE, surrounded by residential development, presents today's box turtle population with a much more challenging landscape than the one they occupied 50 to 100 years ago. Given the growing body of evidence that populations of long-lived turtles cannot sustain themselves in the face of elevated, anthropogenic mortality (Gibbs and Amato 2000; Budischak 2006), the continued persistence of box turtles at WFE will require vigilance and effective management. The box turtle population at WFE is a unique resource for the National Park Service, one with both natural and historic significance. It is one of only a handful of box turtle populations with such a long term data set associated with it. Considering the stressors acting on it, and data that suggest recruitment may be declining, a detailed demographic study is called for, preferably supplemented with fresh data. Estimates of population size, structure, and other parameters such as survival and recruitment are needed as are telemetry studies to determine the extent to which animals move beyond WFE's boundaries.

Northern Black Racer (*Coluber constrictor constrictor*)

The northern black racer is subspecies of the eastern racer, which is widespread throughout most of the United States, except for the desert southwest (Ernst and Ernst 2003). The northern black racer occurs from the southern Appalachian Mountains northward, extending to the coastal plain in the mid-Atlantic states and into southern New York and New England (Conant and Collins 1998). The black racer is widespread in New Jersey, southern New York and New England, but occurs primarily at relatively low elevations along the coast and in river valleys (Trapido 1937; Klemens, 1993; Gibbs et al. 2007). It is found in open, dry woodlands, fields, grasslands, along the borders of wetlands, and on barrier islands (Ernst and Ernst 2003). Large sheets of corrugated sheet metal and plywood are a favorite cover type of this species, along with other debris at the edge of woodlands (Klemens 1993). Juvenile northern black racers have distinct gray/brown or reddish/brown patterning down their bluish/gray back that will disappear as they mature. Adults are satiny black in color with a white throat patch and can reach five to six feet in length (Conant and Collins 1998). An opportunistic feeder, the racer diet includes a variety of animals such as shrews, voles, birds, small turtles, lizards, anurans, salamanders, and snakes (including hog-nosed snake *Herterdon platirhinos*) (Ernst and Ernst 2003).

Historically, the black racer was common and widespread in the New York City region (Noble 1927) and on Long Island it was especially common along the sandy south shore (Engelhardt et al. 1915). Black racers occur primarily in landscapes with open habitats and are a large, conspicuously active species with a large home range (Ernst and Ernst 2003; Kjoss and Litvaitis, 2001). As the flat, open habitats in the region were easily developed, the behaviors and large home range of black racers lead to greater mortality in landscapes fragmented by urbanization (Schlauch 1976; Gibbs et al. 2007). Intentional killing by humans was also a factor (Mathewson 1955). By mid-20th century, black racers had declined through much of western Long Island (Kieran 1959; Schlauch 1978b) and Latham (1972) noted they were common on eastern Long Island prior to 1940, implying a decline thereafter. Its current distribution on Long Island is primarily in wilder sections of Suffolk County (Breisch and Ozard in prep).

Nichols (1904-1958) recorded black racers from this area in his journal five times from 1911 through 1927, suggesting they were fairly common then. They remained present into the 1980's (Lynch 1986) and were observed periodically by park staff during the past couple of decades (R. Stavdal, pers. comm.). In 2002, one juvenile northern black racer was found under a coverboard in Field H9 (Tables 4 and 11, Appendix E). Considering how readily observable this large, active, and conspicuous species can be, this single record suggests that black racers have declined and are now uncommon at WFE. In contrast, they are still common nearby at Wertheim NWR (P. Warny, pers. comm.) and on Fire Island (Cook et al., 2010). As noted above, the large home range of black racers leads to high mortality in landscapes fragmented by urbanization and although a generalist in many ways, black racers are specialists in requiring relatively large tracts of land. As is the case for other species that have declined or disappeared from WFE, Wertheim NWR and Fire Island provide much larger habitat patches and less exposure to road kill and human-related mortality. However, two sites on Western Long Island that support populations of black racer, Floyd Bennett Field in Brooklyn and Rulers Bar Hassock in Queens contain ca. 1130 acres and 460 acres of upland habitat respectively (Cook, in prep., 2008). Populations at these sites are also subjected to road kill and/or loss of individuals into the adjacent urbanized. That black racers have been successfully translocated to these sites, both part of Gateway NRA, suggests that habitat quality can compensate to some extent for relatively small patch size.

Northern Ring-necked Snake (*Diadophis punctuatus edwardsii*)

As a species, the ring-necked snake ranges throughout the northeast United States and southern Canada southward through the mid-west and south-central states and northward along the Pacific coast (Ernst and Ernst 2003). The northern sub-species occupies the northeastern and Appalachian Mountain portion of that range (Conant and Collins 1998), is widespread in New York State, and often abundant as well (Gibbs et al. 2007). The northern ring-necked snake is a small, inconspicuous, primarily nocturnal species, typically found in moist woodlands with abundant cover where it feeds on small salamanders and worms (Conant and Collins 1998; Ernst and Ernst 2003).

Historic accounts suggest that the ring-necked snake was not encountered very often in the New York City and Long Island area. Ditmars (1896) considered it somewhat rare and Noble (1927) considered it widespread, but desired habitat records. Engelhardt et al. (1915) noted only two locations, one of which was a “colony” limited to the woods bordering a cranberry bog in Yaphank, ca. 10 km from WFE, whereas Latham (1971b) considered it generally distributed on the east end of Long Island, but very secretive. Yeaton (1938) considered it probably the rarest snake on Long Island. Although “Historic” assessments of a species’ abundance and/or distribution can sometimes turn out to be incorrect, especially for inconspicuous or “retiring” species, data collected through the late 1960’s (including those of Latham) show that although ring-necked snakes occur the entire length of Long Island, on both the moraines and outwash plains (Schlauch 1974), they do not appear to be very common in occurrence or abundance. Nichols (1904-1958) did not record any ring-necked snakes at WFE, but three were recorded from a yard in Mastic Beach in 1970 (Leary 1971), ca. two kilometers west of WFE and a young one was found in a cobweb inside the Floyd estate house (Lynch 1986). Considering their “secretive” nature and the fact that WFE contains large areas of woodland with woody debris and red-backed salamanders, an important prey species in the northeast, it is likely that ring-necked snakes have been present at WFE all along. However, none were recorded during this survey, nor have there been any other records here since 1986.

Ring-necked snakes may truly be rare at WFE or they may simply have gone undetected due to a relative lack of searching. As noted earlier, it is unclear how much J.T. Nichols searched under woody debris, but Stavdal (pers. comm.) rolled logs over the course of 26 years without encountering any. At Cape Cod National Seashore, ring-necked snakes represented 74% of all snake captures under coverboards during a three year period, with a capture rate of 0.0121 captures/board check (81 captures/6674 boardchecks)(R. Cook, unpublished data). During this survey at WFE, coverboards identical to those used at Cape Cod and deployed in the same fashion were checked 704 times without producing any ring-necked snakes. Had the capture rate at WFE equaled that of Cape Cod, the sampling effort at WFE would have lead to 8.5 captures. Given these efforts, plus all the log rolling that lead to 100 captures of red-backed salamanders, there does not appear to be a lack of sampling effort. Thus, even though we did not encounter any in 2002, as best as can be determined, the northern ring-necked snake is rare at WFE and has been for some time.

Eastern Hog-nosed Snake (*Heterodon platirhinos*)

The eastern hog-nosed snake, a species of *Special Concern* in New York, occurs throughout most of the central and eastern U.S. and into southern Canada (Ernst and Ernst 2003). In the northeast, hog-nosed snakes are limited to southern New York and southern New England, and much of their occurrence in this region is linked to the presence of sandy habitat: it prefers sandy, well-drained soils in woodlands, fields, and on barrier beaches (Klemens 1993; Ernst and Ernst 2003; Gibbs et al. 2007). Historically, hog-nosed snakes were widespread and common in the New York metropolitan region (Ditmars 1896; Noble 1927) and were considered particularly abundant along the south shore of Long Island (Engelhardt et al. 1915). Smith (1963) details their abundance on the barrier beaches of Long Island from Coney Island eastward to Fire Island, and Engelhardt et al. (1915) described an encounter with campers who had collected a barrel full of hog-nosed snakes in 1908 at Rockaway Beach in Queens. Yeaton (1972) also recounted stories of “barrels of adders being collected under Fire Island boardwalks in the olden days”

Hog-nosed snakes have a number of specialized attributes that make them both readily identifiable and especially vulnerable. Their upturned rostral scale at the tip of the snout and their bizarre defensive behaviors are unique among local species. When threatened, the eastern hog-nosed snake will puff up and hiss loudly, flatten the head into a “hood”, and sometimes attempt to strike with a closed mouth. The snake will regurgitate its last meal, turn on its back with its mouth open, and feign death. Although harmless to humans, this behavior often leads people to kill hog-nosed snakes, thinking they are a threat. In addition, hog-nosed snakes feed almost exclusively on toads and their distribution and abundance is greatly influenced by variation in toad abundance. Hog-nosed snakes do not survive urbanization nor co-exist with humans very well. By the 1930’s they were declining on Staten Island, in part due to a decline in Fowler’s toad (Leng and Davis 1930). By the 1940’s they were declining throughout most of Long Island, with both Murphy (1950) and Smith (1963) attributing their decline to direct killing by humans unfamiliar with their defensive displays. Kieran (1959) also noted their decline in NYC and Schlauch (1978b) considered the hog-nosed snaked extremely endangered in Nassau County. They are somewhat more common on eastern Long Island (Breisch and Ozard, in prep.) but still, relatively few are recorded there (J. Feinberg, pers. comm.). They are extremely rare on Fire Island, and one observed in 2007 by Mary Laura Lamont is the only record since the 1970’s (Cook et al., 2010).

Hog-nosed snakes were once moderately common at WFE and Nichols (1904-1958) reported a total of seven observations: at Mastic (3), Indian Point (2), Home Creek (1), and swimming near the Home Meadows (1) between 15 June 1919 and 7 September 1936. None were recorded in this survey nor have there been any records here since those of Nichols (R. Stavdal, pers. comm.). The decline of hog-nosed snakes on Long Island is the result of habitat destruction and fragmentation, road-kill, indiscriminant killing, and pesticides, and these factors have also likely contributed to its extirpation at WFE as well. However, considering that eastern hog-nosed snakes thrived in the 331 acres of Gateway NRA's Breezy Point Tip in Queens prior to the near-extirpation of the Fowler's toad population there (Cook, in prep), it is probable that WFE is large enough to support a population of hog-nosed snakes, if Fowler's toads were sufficiently abundant. Given the history of DDT use and "mis-application" here (Jankowski 2004), it is likely that hog-nosed snakes were extirpated due to the pesticide-caused decline and extirpation of Fowler's toad, their primary food source, long before patch size would have had much effect.

Eastern Milk Snake (*Lampropeltis triangulum triangulum*)

The eastern milk snake is a subspecies of the milk snake, which is one of the most widespread species of snakes, ranging from the east and mid-western U.S.A. down to Ecuador in South America (Ernst and Ernst 2003). The eastern milk snake occurs from northern Georgia and Alabama northward to Wisconsin and through the northeastern states into southern Canada (Conant and Collins 1998). Identifying characters include a "Y" shaped, cream-colored patch on the nape, and a black and white checkerboard pattern on the belly (Conant and Collins 1998). Eastern milk snakes are widespread in the northeast U.S. and occur both inland and along the coast in habitats ranging from woods, meadows, bogs, streams, and farmland. They are frequently associated with old farm fields, dilapidated structures, and trash piles, and thrive in such human altered habitats (Klemens, 1993; Gibbs et al., 2007).

Historically, Ditmars (1896) and Engelhardt et al. (1915) considered milk snakes widespread but not common in the NYC and Long Island area whereas Noble (1927) considered them common. Records through the 1960's show they occurred the entire length and breadth of Long Island (Schlauch 1974). Milk snakes are similar to black racers in eating a wide range of prey items and having a large home range, but differ in being primarily nocturnal and far less conspicuous (Ernst and Ernst 2003; Kjoss and Litvaitis 2001). Their large home range makes them vulnerable to habitat fragmentation, and although still common in rural areas, they are absent from the most urbanized areas (Klemens 1993). Prior to 1950 they were not uncommon on the south side of eastern Long Island (Latham 1971a), implying a decline thereafter, and by the 1970's they were rare and endangered on western Long Island (Kieran 1959; Schlauch 1978b). Current records (Breich and Ozard in prep.) show they are widespread on Long Island, but mostly restricted to large habitat remnants.

Nichols (1904-1958) recorded milk snakes at Mastic twice, on 3 June 1917 and 29 June 1930. One was killed on the park entrance road in the 1980's (Lynch 1986) and, during his tenure at WFE from 1980 to 2006, Stavdal (pers. comm.) often encountered them within the historic core. Although none were found in 2002, an individual found in the maintenance yard on 24 July 2004 (R. Stavdal pers. comm.) indicates that milk snakes are still extant at WFE. Given their secretive nature, milk snakes were probably more common at WFE than the record suggests, but they nonetheless were probably uncommon and remain so today. In contrast, milk snakes are common on Ruler's Bar Hassock, an island with 460 acres of upland habitat in Jamaica Bay on western Long Island (Cook, in prep), but the habitats there are more open. Milk snakes in New York State may be declining as farmland reverts back to forest (Gibbs et al. 2007), and the current rarity of milk snakes at WFE may be due, at least in part, to the re-growth and maturity of woodlands at WFE.

Common Water Snake (*Nerodia sipedon sipedon*)

The common water snake is a sub-species of the Northern water snake, and occurs from the northeastern United States and southeastern Canada westward into the mid-west (Conant and Collins 1998). In New York and New England, the common water snake is widespread and common, occurring both along the coastal plain and inland, although they do not range into high elevations (Klemens 1993; Gibbs et al. 2007). Common water snakes are primarily aquatic and occur in a broad range of freshwater wetlands, provided that they contain an abundance of cover and food, primarily fish and secondarily amphibians (Ernst and Ernst 2003). They are frequently observed basking on the shore, on rocks, and on branches overhanging the water and occasionally enter brackish waters (Conant and Collins 1998; Ernst and Ernst 2003).

Historically, water snakes were widespread in the New York City - Long Island area and common in and near stream and ponds (Ditmars 1896; Engelhardt 1913; Engelhardt et al. 1915; Noble 1927), particularly shallow ponds along the south shore (Yeaton 1938). Although the water snake appears to persist well on suburbanized landscapes (Klemens 1993) and it was still common regionally in parkland lakes and ponds in the 1950's (Mathewson 1955; Kieran 1959), water snakes have not persisted well as urbanization intensified. By the 1970's they were extremely endangered on western Long Island (Schlauch 1978b) and although still widespread geographically on eastern Long Island (Breisch and Ozard, in prep.), they are largely restricted to large habitat remnants.

Historically, water snakes appear to have been moderately common at WFE and Nichols (1904-1958) recorded northern water snakes at Mastic (1), Augustus Floyd Beach (1), and at Indian Point (2) between 17 June 1911 and 15 July 1923, plus two individuals along Home Creek on 9 May, 1915 (Nichols 1916). None have been recorded or observed since. The decline and apparent extirpation of water snakes at WFE is likely the result of several factors. These include increased salinity in WFE salt marshes and tidal creeks following the Hurricane of 1938; development and habitat fragmentation adjacent to WFE; and direct and food-chain related effects from the extensive use of DDT at WFE, and particularly in light of the high residual concentrations in the Home Creek system (Sprenger et al. 1987), which appears to have been the prime spot for water snakes here (Nichols 1904-1958, 1916).

Although common water snakes appear to be extirpated from WFE, they are still common in the nearby Carmen's river, including some tidal areas (Kinneary pers. comm.; Warny, pers. comm.). As discussed above in the eastern mud turtle account, although WFE and the Carmen's river system have been subjected to many of the same stressor's, the intensity of these stressors, particularly DDT contamination and loss of habitat is much greater at WFE and likely explains why water snakes persist in the Carmen's river and not at WFE.

Northern Brown Snake (*Storeria dekayii dekayii*)

The brown snake is a species that ranges throughout most of the eastern half of the United States and into eastern Mexico (Ernst and Ernst 2003). The sub-species found at WFE, the northern brown snake, occurs from South Carolina northward into central New England, southern Canada, and westward to lower Michigan and Ohio (Conant and Collins 1998). Formerly called "DeKay's snake", the northern brown snake was named after New York naturalist James Edward Dekay (Conant and Collins 1998). It is widespread throughout New York and New England

(Klemens 1993; Gibbs et al. 2007). Historically, brown snakes were widespread and common throughout the New York City region (Ditmars 1896; Noble 1927), abundant in Brooklyn, and generally distributed over Long Island (Engelhardt et al. 1915). However, there are few published historic records from eastern Long Island, and those few are limited to the North Fork (Schlauch 1974).

Brown snakes are relatively small and sedentary, feed heavily on slugs and worms (Lazell 1976) and are well known for their ability to persist on small, disturbed patches of habitat, sometimes becoming more abundant in these settings than in undisturbed patches (Schlauch 1978a). Consequently, brown snakes are considered very urban tolerant (Klemens 1985). Latham (1968) noted that during the 20^{th} century, the relative abundance of brown snakes on Long Island's North Fork increased as populations of other snake species declined. However, there are limits to their ability to survive intense urbanization (Klemens 1993) and by the late 1960's they were disappearing from some parts of western Long Island (Ziminski 1970). They remain somewhat common today on western Long Island within parks and large habitat remnants, but still appear to be limited to the east (Breisch and Ozard, in prep.). This, however, may reflect this species' sedentary and retiring habits rather than actual rarity because most brown snakes are observed under cover objects rather than out in the open (R. Cook, pers. obs.).

The only historic record of northern brown snake at WFE is of two individuals observed by J.T. Nichols and his boys on 26 March 1929 (Nichols 1904-1958). In 2002, there were a total of five northern brown snakes records (four live, one shed skin) from under coverboards in Fields J12 and M11 (Tables 2, 3, 4, Appendix E). Although it is impossible to know, given this species' behavior and Nichol's inconsistency in recording observations, it appears that brown snakes were and continue to be uncommon at WFE.

Common Ribbon Snake (*Thamnophis sauritus sauritus*)

The common ribbon snake is a subspecies of the eastern ribbon snake, which ranges throughout most of the eastern United States, except for most of Appalachia (Ernst and Ernst 2003). The common ribbon snake occurs primarily from southern New England and southeastern New York state southward through South Carolina and then west into Mississippi and up the Mississippi River valley into southern Illinois (Conant and Collins 1998). Ribbon snakes feed primarily on amphibians, especially frogs, and are mostly found in freshwater wetlands, particularly grassy or shrubby ones with an open canopy that allows them to bask (Gibbs et al. 2007). They are closely related to, and look very similar to garter snakes, and specimens must be captured and examined carefully to identify correctly (Klemens 1993).

Ribbon snakes were historically considered widespread and common in the New York City – Long Island area (Noble 1927). It occurred on both terminal moraine and outwash plain, all the way east to Montauk (Schlauch 1974). Although it was relatively uncommon on the North Fork (Latham 1968), it was common in the freshwater lowlands of the south shore (Yeaton 1938) and was considered more common than garter snakes at Mastic (Engelhardt et al. 1915). Because they are habitat specialists, tied to freshwater swamps and marshes with an abundance of anurans, and these habitats are often the first to disappear during urbanization, ribbon snakes are relatively urban sensitive (Schlauch 1976). However, observations in southern New England, where they appear to have declined or become extirpated in many areas, suggest that successional “reforestation” may also be a factor in their decline (Klemens 1993). Ribbon snakes were considered extinct on Staten Island by the 1950’s (Mathewson 1955) and extremely endangered in Nassau county by the 1970’s (Schlauch 1978b). On Long Island, ribbon snakes are currently limited to a couple of sites on the north shore of Nassau county, and several sites in central and eastern Suffolk County (Breisch and Ozard, in prep.).

Although Nichols (1904-1958) only recorded common ribbon snakes twice at Mastic, on 11 June 1911 and 16 July 1916, they were reportedly more common there than eastern garter snakes (Engelhardt et al., 1915). Considering that J. T. Nichols was the second author of Engelhardt et al. (1915), this suggests that he observed more ribbon snakes at WFE than he recorded. Since then, the only report of a ribbon snake at WFE is that of Lynch (1986), but it lacks details or documentation. We consider this report problematic at best for the following reasons: 1-Lynch (1986) provides detail about a garter snake encountered but only lists ribbon snake; 2-Stavdal (pers. comm.) is uncertain whether he observed garter snakes or ribbon snakes at WFE; 3-the anuran populations which would have been the foodbase for ribbon snakes were extirpated sometime in the 1960’s and/or 1970’s; 4-all 17 *Thamnophis* sp. encountered during this survey were garter snakes. In spite of the uncertainty about this particular report, it is clear that the ribbon snake population has declined dramatically at WFE and, considering that WFE has lacked an anuran foodbase for the last 20-30 years, it appears that the ribbon snake population here is extirpated.

Eastern Garter Snake (*Thamnophis sirtalis sirtalis*)

The eastern garter snake is a sub-species of the common garter snake, which ranges throughout the United States, except for Texas and the southwest, and all of southern Canada (Ernst and Ernst 2003). The eastern garter snake occurs primarily east of the Mississippi River from Florida northward into New York and southern New England into Canada (Conant and Collins 1998). In New York and southern New England, garter snakes are widespread and common, both inland and along the coast, and are the most conspicuous and well known snake in this area (Klemens 1993; Gibbs et al. 2007). Garter snakes are found in a variety of habitats including meadows, marshes, woodlands, and cultivated and developed areas (Behler and King 1979). Historically they were considered the most common and widespread snake around New York City (Ditmars 1896) and Long Island (Engelhardt 1913). Although garter snakes are relatively urban tolerant because of their generalized habits (Schlauch 1976), as urbanization continued into the late 20^{th} century, they have become less common and widespread (Ziminski 1970). However, data from the New York State Herp Atlas (Breisch and Ozard, in prep), show they still remain the most common and widespread snake locally.

The eastern garter snake was common and widespread in WFE with 17 records from 10 sites encompassing stream, woodland, and field habitats (Tables 2, 3, 4, Appendix E). Although the historic record is limited (Nichols 1904-1958; Lynch 1986), the eastern garter snake appears to have been common at WFE, and our results indicate this to still be the case, especially in woodlands and fields. Nichols (1904-1958) noted that a small garter snake captured on July 5, 1915 regurgitated a toad. Although garter snakes are well known toad eaters, they are also well known to be extremely broad in their diet (Ernst and Ernst 2003). Thus, in spite of the loss of WFE’s amphibian food base, the generalized diet of garter snakes has allowed this species to persist.

Literature Cited

Bank, M. S., J. B. Crocker, S. Davis, D. K. Brotherton, R. Cook, J. Behler, and B. Connery. 2006. Population decline of northern dusky salamanders at Acadia National Park, Maine, USA. Biological Conservation 130:230-238.

Behler, J. L. 2003. A 100-year-old Turtle. Curator's Report, Spring 2003. Wildlife Conservation Society, Bronx, NY.

Behler, J. L., and F. W. King. 1979. The Audubon Society Field Guide to North American Reptiles and Amphibians. Alfred A. Knopf, New York, 719 pp.

Berven, K. A., and T. A. Grudzien. 1990. Dispersal in the wood frog (*Rana sylvatica*): implications for genetic population structure. Evolution 44: 2047-2056.

Blanchard, F. N. 1934. The spring migration of the four-toed salamander (*Hemidactylium scutatum*). Copeia 1934 (1):50.

Blaustein, A. R. 1994. Chicken little or Nero's fiddle? A perspective on declining amphibian populations. Herpetologica 50:85-97.

Blaustein, A. R., P. D. Hoffman, D. G. Hokit, J. M. Kiesecker, S. C. Walls, and J. B. Hays. 1994. UV repair and resistance to solar UV-B in amphibian eggs: a link to population declines? Proceedings of the National Academy of Sciences. 91:1791-1795.

Bishop, S. C. 1941. Salamanders of New York. Bulletin New York State Museum 324:1-365.

Breden, F. 1988. The natural history and ecology of Fowler's toad, *Bufo woodhousei fowleri* (Amphibia: Bufonidae) in the Indiana Dunes National Lakeshore. Fieldiana Zoology 49:l-16.

Breisch, A. R. and J. W. Ozard. in prep. The New York State Amphibian and Reptile Atlas 1990-1999. New York State Department of Environmental Conservation.

Brennessel, B. 2006. Diamonds in the marsh: a natural history of the diamondback terrapin. University Press of New England. Lebanon, NH.

Bridges, C. M. and R. D. Semlitsch. 2005. Xenobiotics. pages 89-92 *in* M. Lanoo, editor. Amphibian declines: The conservation status of United States species. University of California Press. Berkeley and Los Angeles.

Budischak, S. A., J. M. Hester, S. J. Price, and M. E. Dorcas. 2006. Natural history of *Terrapene carolina* (box turtles) in an urbanized landscape. Southeastern Naturalist 5:191-204.

Burton, T. M. and G. E. Likens. 1975. Salamander populations and biomass in the Hubbard Brook Experimental Forest, New Hampshire. Copeia 1975:541-546.

Bury, R. B., and M. G. Raphael. 1983. Inventory methods for amphibians and reptiles. *In* J. F. Bell and T. Atterbury (eds.), Renewable Resources Inventories for Monitoring Changes and Trends, pp. 416-419. Oregon State University, Corvallis, Oregon.

Butterfield, B. P., M. J. Lanoo, and P. Nanjappa. 2005. *Rana spenocephala*. pages 586-587 i*n* M. J. Lanoo, ed., Amphibian Declines; The Conservation Status of United States Species. University of California Press. Berkeley, CA.

Byers, D. L. and J. C. Mitchell. 2005. Sprawl and species with limited dispersal abilities. *In* E. A. Johnson and M. W. Klemens (eds.), Nature in Fragments: The Legacy of Sprawl, pp. 157-180. Columbia University Press, New York, NY.

Cagle, F. R. 1939. A system of marking turtles for future identification. Copeia 1939:170-173.

Campbell, C. A. 1974. Survival of amphibians and reptiles in urban environments. *In* J. H. Noyes and D. R. Progulske (eds.), A Symposium on Wildlife in an Urbanizing Environment, pp. 61-66. Planning and Resource Development Series No. 28, Holdsworth Natural Resource Center, University of Massachusetts, Amherst.

Chalmers, R. J. 2004. Wetland and nest scale habitat use by the four-toed salamander (*Hemidactylium scutatum*) in Maine, and a comparison of survey methods. M.S. thesis, University of Maine, Orono.

Conant, R. and J. T. Collins. 1998. A Field Guide to Reptile and Amphibians: Eastern and Central North America. 3rd Edition Expanded. Boston: Houghton Mifflin Co.

Congdon, J. D., G. L. Breitenbach, R. C. van Loben Sels, and D. W. Tinkle. 1987. Reproduction and nesting ecology of snapping turtles (*Chelydra serpentina*) in southeastern Michigan. Herpetologica 43:39-54.

Congdon, J. D., S. W. Gotte, and R. W. McDiarmid. 1992. Ontogenetic changes in habitat use by juvenile turtles, *Chelydra serpentina* and *Chrysemys picta*. Canadian Field Naturalist 106:241-248.

Cook, B. 1989. A natural history of the diamondback terrapin. Underwater Naturalist 18:25-31.

Cook, R. P. 1996. Movement and ecology of eastern box and painted turtles repatriated to human-created habitat. Ph.D. disseration, City University of New York.

Cook, R. P**.** 2005. Monitoring leads to enhanced protection of spadefoot toads at Cape Cod National Seashore. Park Science 23(2):10-11.

Cook, R. P. 2008. Potential and limitations of herpetofaunal restoration in an urban landscape. *In* Mitchell J. C. and R.E. Jung (eds.), Urban Herpetology. pp 465-478. Herpetological Conservation Vol. 3. Society for the Study of Amphibians and Reptiles. Salt Lake City, Utah.

Cook, R. P. in prep. Amphibians and reptiles of Gateway NRA: Impacts of urbanization and restoration. Technical Report NPS/NER/NRTR-XXXX/xxx. National Park Service, Boston, Massachusetts..

Cook, R. P. and K. M Boland. 2005. A comparison of approaches to counting egg masses of spotted salamander (*Ambystoma maculatum*). Herpetological Review (36):272-274.

Cook, R. P. and C. A. Pinnock. 1987. Recreating a herpetofaunal community at Gateway National Recreation Area. pp. 151-154 *In* L. W. Adams and D. L. Leedy (eds.) Integrating man and nature in the urban environment. National Institute for Urban Wildlife, Columbia, Maryland. 249 pp.

Cook, R. P., K. M. Boland, S. J. Kot, J. Borgmeyer, and M. Schult. 2007. Inventory of aquatic turtles at Cape Cod National Seashore with recommendations for long term monitoring. Technical Report NPS/NER/NRTR-2007/091. National Park Service, Boston, Massachusetts.

Cook, R. P., D. K. Brotherton, and J. L. Behler. 2010. Amphibian and reptile inventory of Fire Island National Seashore. Natural Resource Technical Report NPS/NCBN/NRTR—2010/378. National Park Service, Fort Collins, Colorado .

Corser, J. D., and C. K. Dodd. 2004. Fluctuations in a meta-population of nesting four-toed salamanders, *Hemidactylium scutatum*, in the Great Smoky Mountains National Park, USA, 1999-2003. Natural Areas Journal 24:135-140.

Cowman, D. F. and L. E. Mazanti. 2000. Ecotoxicology of “New Generation” pesticides to amphibians. *In* D. W. Sparling, G. Linder, and C. A. Bishop (eds.), Ecotoxicology of amphibians and reptiles, pp. 233-268. SETAC Press, Pensacola, Florida.

Crother, B. I. (ED.). 2000. Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in Our Understanding. Committee on Standard English and Scientific Names. Society for the Study of Amphibians and Reptiles Herpetological Circular No. 29. 82pp.

Crother, B. I., J. Boundy, J. A. Campbell, K. De Quieroz, D. Frost, D. M.Green, R. Highton, J. B. Iverson, R. W. McDiarmid, P. A. Meylan, T. W. Reeder, M. E. Seidel, J. W. Sites Jr., S. G. Tilley, and D. B. Wake. 2003. Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico: Update. Herpetological Review 34:196–203.

Crouch, W. B. and P. W. C. Paton. 2002. Assessing the use of call surveys to monitor breeding anurans in Rhode Island. Journal of Herpetology 36:185-192.

Crump, M. L. and N. J.Scott.1994. Visual Encounter Surveys. *In* Heyer, R. W., M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, M. S. Foster. 1994. Measuring and Monitoring Biological Diversity – Standard Methods for Amphibians. Pp 84-92. Smithsonian Institution Press. Washington, DC.

Daszak, P., L. Berger, A. A. Cunningham, A. D. Hyatt, D. E. Green, and R. Speare. 2000. Emerging Infectious Diseases and Amphibian Population Declines. Center for Disease Control Vol. 5, No. 6.

Ditmars, R. L. 1896. The snakes found within fifty miles of New York City. Abstract of Proceedings of the Linnaean Society of New York 8:9-24.

Ditmars, R. L. 1905. The batrachians of the vicinity of New York City. Guide Leaflet Series No. 20, American Museum of Natural History. New York, New York.

Dodd, C. K. 2001. North American Box Turtles: A Natural History. Norman, University of Oklahoma Press. 256pp.

Donaldson, B. M. and A. C. Echternacht. 2005. Aquatic habitat use relative to home range and seasonal movement of eastern box turtles (*Terrapene carolina carolina*: Emydidae) in eastern Tennessee. Journal of Herpetology 39:284-287.

Dunson, W. A., R. L. Wyman, and E. S. Corbett. 1992. A symposium on amphibian declines and habitat acidification. Journal of Herpetology 26:349-352.

Egan, R.S., and P. W. Paton. 2004. Within-pond parameters affecting oviposition by wood frogs and spotted salamanders. Wetlands 24:1-13.

Engelhardt, G. P. 1913. The reptiles of Long Island. Museum News 8:128-129.

Engelhardt, G. P., J. T. Nichols, R. Latham, and R. C. Murphy. 1915. Long Island Snakes. Copeia 17:1-4.

Ernst, C. H., J. E. Lovich, and R. W. Barbour. 1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington D. C. 578pp.

Ernst, C. H. and E. M. Ernst. 2003. Snakes of the United States and Canada. Smithsonian Institution Press, Washington D. C. 668pp.

Feinburg, J. A., and R. L. Burke. 2003. Nesting ecology and predation of diamondback terrapins, *Malaclemys terrapin*, at Gateway National Recreation Area, New York. Journal of Herpetology 37:517-526.

Feinburg, J. A, J. Burger, and T. M. Green. 2007. The decline of southern leopard frogs from Long Island: investigating causes and conservation strategies. Biodiversity Research Institute Grant, New York State Museum, Albany, NewYork.

Frazer, N. B., J. W. Gibbons, and J. L. Greene. 1991. Life history and demography of the common mud turtle *Kinosternon subrubrum* in South Carolina, USA. Ecology 72:2218-2231.

Germaine, S. S., and B. F. Wakeling. 2001. Lizard species distributions and habitat occupation along an urban gradient in Tucson, Arizona, USA. Biological Conservation 97:229-237.

Gibbs, J. P., 1998. Distribution of woodland amphibians along a forest fragmentation corridor. Landscape Ecology 13:263-268.

Gibbs, J. P. and G. D. Amato. 2000. Genetics and demography in turtle conservation. In: Turtle Conservation, p. 207-217. Klemens, M.W., Ed, Washington, Smithsonian Institution Press.

Gibbs, J. P., and W. G. Shriver. 2002. Estimating the effects of road mortality on turtle populations. Conservation Biology 16:1647-1652.

Gibbs, J. P., A. R. Breisch, P. K. Ducey, G. Johnson, J. L Behler, and R. C. Bothner. 2007. The amphibians and reptiles of New York State. Oxford University Press, New York.

Golet, W. J. and T. A. Haines. 2001. Snapping turtles (*Chelydra serpentina*) as monitors for mercury contamination of aquatic environments. Environmental Monitoring and Assessment 71:211-220.

Gosner, K. L. 1962. Reptiles of northern New Jersey. New Jersey Nature News, New Jersey Audubon Society 17(3):94-100.

Graham, T. E. 1995. Habitat use and population parameters of the spotted turtle, *Clemmys guttata*, a species of special concern in Massachusetts. Chelonian Conservation and Biology. 1:207-214.

Graham, T. E., and V. H. Hutchison. 1969. Centenarian box turtles. International Turtle and Tortoise Society Journal. 3(3):25-29.

Grant, B. W., A. D. Tucker, J. E. Lovich, A. M. Mills, P. M. Dixon and J. W. Gibbons. 1992. The use of coverboards in estimating patterns of reptile and amphibian biodiversity. *In* D. R. McCullough and R. H. Barrett (eds.). Wildlife 2002: Populations, pp. 379-403. Elsevier Science Publication, Inc. London, England.

Guillette, L. J., Jr. 2000. Contaminant-associated endocrine disruption in reptiles. *In* D. W. Sparling, G. Linder, and C. A. Bishop (eds.), Ecotoxicology of amphibians and reptiles, pp. 595-615. SETAC Press, Pensacola, Florida.

Hall, R. J. 1980. Effects of environmental contaminants on reptiles: a review. United States Department of the Interior, Fish and Wildlife Service. Special Scientific Report – Wildlife Number 228. Washington, D. C. pp. 1-12.

Hall, R. J., Henry, P. F. P., Bunck, C. M. 1999. Fifty-year trends in a box turtle population in Maryland. Biological Conservation 88:165-172.

Harless, M., and H. Morlock. 1989. Turtles: Perspectives and Research. Robert E. Krieger Publishing Company, Inc. Malabar, Florida.

Hayes, T. B., A. Collins, M. Lee, M. Mendozza, N. Noriega, A. A. Stuart, and A. Vonk. 2002. Hermaphroditic, demasculinized frogs after exposure to the herbicide atrazine at low ecologically relevant doses. Proceedings of the National Academy of Sciences 99:5476-5480.

Henry, P. F. P. 2000. Aspects of amphibian anatomy and physiology. *In* D. W. Sparling, G. Linder, and C. A. Bishop (eds.), Ecotoxicology of amphibians and reptiles, pp. 71-110. SETAC Press, Pensacola, Florida.

Henry, P. F. P. 2003. The eastern box turtle at the Patuxent Wildlife Research Center 1940's to the present: another view. Experimental Gerentology 38(7):773-776.

Heyer, R. W., M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, M. S. Foster. 1994. Measuring and Monitoring Biological Diversity – Standard Methods for Amphibians. Smithsonian Institution Press, Washington D.C.

Hinga, K. R. 2005. Water quality and ecology of Great South Bay (Fire Island National Seashore Science Synthesis Paper). Technical Report NPS/NER/NRTR—2005/019. National Park Service. Boston, MA.

Jankowski, P. 2004. An assessment of contaminant threats at Fire Island National Seashore DRAFT. Rutgers University School of Public Health.

Kieran, J. 1959. Natural History of New York City. Houghton-Mifflin Co. Boston, MA.

Kjoss, V. A. and J. A. Litvaitis. 2001. Community structure of snakes in a human-dominated landscape. Biological Conservation 98:285-292.

Kinneary, J. J. 1993. Salinity relations of *Chelydra serpentina* in a Long Island estuary. Journal of Herpetology 27:441-446.

Kinneary, J. J. 2008. Observations on terrestrial feeding behavior and growth in diamondback terrapin (*Malaclemys*) and snapping turtle (*Chelydra*) hatchlings. Chelonian Conservation and Biology 7:118-119.

Klemens, M. W. 1985. Survivors in megalopolis: Reptiles of the urban Northeast. Discovery 18:22-25.

Klemens, M. W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. State Geological and Natural History Survey of Connecticut, Bulletin 112. 318 pp

Klemens, M. W., editor. 2000. Turtle Conservation. Smithsonian Institution Press, Washington, D. C.

Klemens, M. W., R. Stavdal, and B. Stutz. 1988a. William Floyd Estate Field Notes. 27 January 1988. American Museum of Natural History Archive. Museum specimen AMNH 134464. New York, New York. P. 706.

Klemens, M. W., R. Stavdal, and B. Stutz. 1988b. William Floyd Estate Field Notes. 8 June 1988. American Museum of Natural History Archive. Museum specimen AMNH 134465. New York, New York. P. 861.

Knapp, R. A., and K. R. Matthews. 2000. Non-native fish introductions and the decline of the Mountain Yellow-legged Frog from within protected areas. Conservation Biology 14:428-438.

Kroenke, A. E., E. L. Shuster, R. F .Bopp, and M .D. Gastrich. 2003. Assessment of historical and current trends in mercury deposition to New Jersey aquatic systems through analysis of sediment/soil cores. Research Summary. New Jersey Department of Environmental Protection, Division of Science, Research, and Technology. Trenton, New Jersey.

Latham, R. 1968. Occurrence of the Eastern Ribbon Snake on eastern Long Island. Engelhardtia 1:15.

Latham, R. 1968. The Northern Brown Snake on the North Fork of Long Island. Engelhardtia 1:22.

Latham, R. 1970. The pickerel frog on eastern Long Island. Engelhardtia 3:11.

Latham, R. 1971a. The milk snake on eastern Long Island. Engelhardtia 4:9.

Latham, R. 1971b. Records of the ringneck snake on eastern Long Island. Engelhardtia 4:46.

Latham, R. 1971c. The wood frog on eastern Long Island. Engelhardtia 4:50.

Latham, R. 1972. The northern black racer on eastern Long Island. Engelhardtia 5:22.

Lazell, J. D. 1976. This Broken Archipelago: Cape Cod and the islands, amphibians and reptiles. New York: Demeter Press (Quadrangle: The New York Times Book Co.).

Leary, J. 1971. Ringneck snakes found at Mastic Beach, Long Island. Engelhardtia 4:35.

Lee, S. M. 2004. Repatriation and health assessment of eastern box turtles (*Terrapene c. carolina*) at Caumsett State park, New York. M. S. Thesis, Hofstra University.

Leng, C. W. and W. T. Davis. 1930. Staten Island and its people: A history. 1609-1929. Lewis Historical Publishing Company, New York.

Longcore, J. R, J. E. Longcore, A. P. Pessier, and W. A. Halteman. 2006. Chytridiomycosis widespread in anurans of northeastern United States. Journal of Wildlife Management 71:435-444.

Lykens, D. V. and D. C. Forester. 1987. Age structure in the spring peeper: do males advertise longevity? Herpetologica 43:216-223.

Lynch, P. 1986. Ecological Inventory William Floyd Estate Fire Island National Seashore. Department of the Interior, National Park Service. North Atlantic Region Office of Scientific Studies, Boston, Massachusetts. Unpublished in park records. 41 pp.

Madden, R. 1975. Home range, movements, and orientation in the eastern box turtle, *Terrapene c. carolina.* Ph.D. Dissertation, City University of New York.

Marsh, D. M., and P. C. Trenham. 2001. Metapopulation dynamics and amphibian conservation. Conservation Biology 15:40-49.

Massachusetts Natural Heritage and Endangered Species Program. 2007. Draft mowing advisory guidelines in turtle habitat: pastures, successional fields, and hayfields. http://www.mass.gov/dfwele/dfw/nhesp/conservation/pdf/mowing_guidelines.pdf

Mathewson, R. F. 1955. Reptiles and amphibians of Staten Island. Proceedings of the Staten Island Institute of Arts and Science Vol. XVIII: No.2.

Matthews, M. J., R. P. Cook, J. T. Tanacredi, and J. J. Pane. 1992. Interagency cooperation in restoring freshwater wetlands in an urban National Recreation Area. Pp. 151-155. *In* L. W. Adams and D. L. Leedy (eds.) Wildlife Conservation in Metropolitan Environments. National Institure for Urban Wildlife Symposium Series 2. National Institute for Urban Wildlife, Columbia, Maryland. 264 pp.

McCormick, J. 1975. Environmental Inventory of the Fire Island National Seashore and the William Floyd Estate, Suffolk County, New York. National Park Service, United States Department of the Interior Denver Service Center, Denver, Colorado. Contract # 2000-4-0010. 272 pp.

Menkens, G. E. Jr., and S. H. Anderson. 1988. Estimation of small-mammal population size. Ecology 69:1952-1959.

Meyer, M. E. 1988. Investigating the eastern mud turtle (*Kinosternon subrubrum subrubrum*). New York State Department of Environmental Conservation. Stony Brook, New York.

Mitchell, J. C., and M. W. Klemens. 2000. Primary and secondary effects of habitat alteration. In: Turtle Conservation, p. 5-32. Klemens, M. W., Ed, Smithsonian Institution Press. Washington, DC.

Morreale, S. J. 1992. The status and population ecology of the diamondback terrapin, *Malaclemys terrapin*, in New York. Okeanos Ocean Research Foundation, Hampton Bays, New York.

Moskowitz, P. D. 1976. An analysis of salinity variations within Great South Bay, New York. Limnology and Oceanography 21:740-742.

Murphy, R. C. 1916. Long Island Turtles. Copeia 33:56-60.

Murphy, R. C. 1950. August on Fire Island Beach. Science Guide No. 134, American Museum of Natural History, New York, New York.

Nelson, B. 2005. Leaping to frog's rescue: herpetologist plans last ditch effort to determine if species has disappeared from Long Island habitat. Newsday.com, http://www.newsday.com/news/printedition/health/ny-hsfrog014285284jun01,0,3815018.story accessed January 7, 2009

New York State Department of Environmental Conservation. 2000. Endangered Species Program. http://www.dec.state.ny.us/website/dfwmr/wildlife/endspec/

New York State Department of Environmental Conservation. 2008. Hydrogen ion concentration as pH (2006). Acid Deposition Monitoring Program. http://www.dec.ny.gov/chemical/38884.html

Nichols, J. T. 1904-1958. William Floyd Estate natural history journals of naturalist J. T. Nichols. American Museum of Natural History, New York, New York. Special Collections Archives Microfilm #60. 28 volumes.

Nichols, J. T. 1914. Mud turtle attacked by crab. Copeia 1914(12):3.

Nichols, J. T. 1916. Water-snakes swallowing fish. Copeia 1916(31):44.

Nichols, J. T. 1917a. Spadefoot toads at Mastic, Long Island. Copeia 1917(45):59-60

Nichols, J. T. 1917b. Stray notes on *Terrapene carolina*. Copeia 1917(46):66-68.

Nichols, J. T. 1933. Further notes on painted turtles. Copeia 1933(1):41-42.

Nichols, J. T. 1939a. Data on size, growth, and age in the box turtle, Terrapene carolina. Copeia 1939(1):14-20.

Nichols, J. T. 1939b. Disposition in the box turtle. Copeia 1939(2):107.

Nichols, J. T. 1939c. Range and homing of individual box turtles. Copeia 1939(3):125-127.

Nichols, J. T. 1940. Eye color in the box turtle, *Terrapene carolina*. Copeia 1940(2):130.

Nichols, J. T. 1947. Notes on the mud turtle. Herpetologica 3:147-148.

Noble, G. K. 1926. The Long Island newt: a contribution to the life history of *Triturus viridescens*. American Museum Novitates 228:l-11.

Noble, G. K. 1927. Distributional list of the reptiles and amphibians of the New York City region. Guide Leaflet Series No.69, American Museum of Natural History, New York.

Oliver, J. A. 1955. The natural history of North American amphibians and reptiles. D. Van Nostrand Company, Princeton, New Jersey.

Overton, F. 1914. Long Island flora and fauna III: the frogs and toads (Order Salientia). Museum of the Brooklyn Institute of Arts and Science, Science Bulletin 2(3):21-40.

Overton, F. 1915. Late-breeding spadefoot toads, etc. Copeia 24:52-53.

Palmer, B. D. 2000. Aspects of reptilian anatomy and physiology. *In* D. W. Sparling, G. Linder, and C. A. Bishop (eds.), Ecotoxicology of amphibians and reptiles, pp. 111-139. SETAC Press, Pensacola, Florida.

Pauli, B. D. and S. Money. 2000. Ecotoxicology of pesticides in reptiles. *In* D. W. Sparling, G. Linder, and C. A. Bishop (eds.), Ecotoxicology of amphibians and reptiles, pp. 269-324. SETAC Press, Pensacola, Florida.

Pechmann, J. H. K., and H. W. Wilbur. 1994. Putting declining amphibian populations in perspective: natural fluctuations and human impacts. Herpetologica 50:65-84.

Petranka, J. W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, D. C.

Pough, F. H., and M. B. Pough. 1968. The systematic status of painted turtles (*Chrysemys*) in the northeastern United States. *Copeia* 1968:612-618.

Pough, F. H., R. M. Andrews, J. E. Cadle, M. L. Crump, A. H. Savitsky, and K. D. Wells. 2004. Herpetology. Prentice Hall, Upper Saddle River, NJ.

Primack, R. B. 1993. Essentials of Conservation Biology. Sinauer Associates, Inc., Sunderland, Massachusetts.

Psuty, N. P., M. Grace, and J. P. Pace. 2005. The Coastal Geomorphology of Fire Island: A Portrait of Continuity and Change (Fire Island National Seashore Science Synthesis Paper). Technical Report NPS/NER/NRTR—2005/021. National Park Service. Boston, Massachusetts.

Reagan D. P. 1974. Habitat selection in the three-toed box turtle, *Terrapene carolina triunguis*. Copeia 1974:512-527.

Rubbo, M. J., and J. M. Kiesecker. 2005. Amphibian breeding distribution in an urbanized landscape. Conservation Biology 19:504-511.

Schlauch, F. C. 1967. The caudata of Long Island. Bulletin Maryland Herpetological Society 3(4):96-98.

Schlauch, F. C. 1974. The biogeography of the herpetofauna of Long Island, NY. Unpubl. Ms.

Schlauch, F. C. 1976. City snakes, suburban salamanders. Natural History 85:46-53.

Schlauch, F. C. 1978a. Urban geographical ecology of the amphibians and reptiles of Long Island. In C. M. Kirkpatrick (ed.), Wildlife and People, pp. 25-41. John S. Wright Forestry Conference Proceedings, Cooperative Extension Service, Purdue University, West Lafayette, Indiana.

Schlauch, F. C. 1978b. New methodologies for measuring species status and their application to the herpetofauna of a suburban region. Engelhardtia 6: 30-41.

Schlauch, F. C. and Burnley, J. M. 1968. An annotated list of the salientians of Suffolk County, Long Island, New York. Bulletin Maryland Herpetological Society 4(4):74-75.

Scott, T. A., W. Wehtje, and M. Wehtje. 2001. The need for strategic planning in passive restoration of wildlife populations. Restoration Ecology 9:262-271.

Sexton, O. J., C. A. Phillips, T. J. Bergman, E. B. Wattenberg, and R. E. Preston. 1998. Abandon hope not: status of repatriated populations of spotted salamanders and wood frogs at the Tyson Research Center, St. Louis County, MO. *In* M.J. Lanoo (ed.), Status and Conservation of Midwestern Amphibians, pp 340-344. University of Iowa Press, Iowa City, Iowa.

Sherwood, W. L. 1898. The frogs and toads found in the vicinity of New York City. Abstract of Proceedings of the Linnaean Society of New York 10: 9-24.

Smith, E. 1899. The turtles and lizards found in the vicinity of New York City. Abstract of Proceedings of the Linnaean Society of New York 11: 11-32.

Smith, J. D. 1963. Puff Adders. Long Island Forum 26:185-186.

Smith, C. K. and J. W. Petranka. 2000. Monitoring terrestrial salamanders: repeatability and validity of area-constrained cover object searches. Journal of Herpetology 34:547-557.

Sprenger, M. D., D. A. Adams, and A. W. McIntosh. 1987. DDT Distribution Study. Prepared for North Atlantic Region, National Park Service, Dr. Michael Soukup, Project Officer. No. 85 4-28201 DI NPS DDT Distribution Study.

Stickel, L. F. 1951. Wood mouse and box turtle populations in an area treated annually with DDT for five years. Journal of Wildlife Management 15(2):161-164.

Thomson, W. L., G. C. White, and C. Gowan. 1998. Monitoring Vertebrate Populations. San Diego, Academic Press.

Torres-Reyes, R. 1974. Historic resource study, the William Floyd Estate, Fire Island National Seashore, New York. Denver Service Center Historic Preservation Team, National Park Service, Denver, Colorado.

Trapido, H. 1937. The snakes of New Jersey, A guide. The Newark Museum. Newark New Jersey.

Tupper, T. A. and R. P. Cook. 2008. Habitat variables influencing breeding effort in northern clade *Bufo fowleri*: Implications for conservation. Applied Herpetology 5:101-119.

Tupper, T. A., R. P. Cook, B. C. Timm, and A. Goodstine. 2007. Improving call surveys for detecting Fowler's toad, *Bufo fowleri*, in Southern New England, USA. Applied Herpetology 4:245-259.

Unrine, J. M., C. H. Jagoe, W. A. Hopkins, and H. A. Brant. 2004. Adverse effects of ecologically relevant dietary mercury exposure in southern leopard frog (*Rana sphenocephala*) larvae. Environmental Toxicology and Chemistry 23:2964-2970.

USFWS. 2006. Long Island National Wildlife Refuge Complex: Comprehensive Conservation Plan. U. S. Fish and Wildlife Service, Shirley, New York.

Virag, I. 2003. Silent spring peeps up at last. Newsday.com, a nature journal. http://www.newsday.com/community/news/northshoresuffolk/huntington/ny-prjoun3272645may11,0,5905182.column. Last accessed 11 November 2008.

Williams, E. E., R. Highton, and D. M. Cooper. 1968. Breakdown of polymorphism of the red-backed salamander on Long Island. Evolution 22:76-86.

Wood, R. C., and R. Herlands. 1997. Turtles and tires: The impact of roadkills on Northern Diamondback Terrapin, *Malaclemys terrapin terrapin*, populations on the Cape May peninsiula, southern New Jersey, USA. In: Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles–an International Conference, p. 46-53i. Van Abbema, J. Ed., New York Turtle and Tortoise Society. New York, New York.

Wright, A. H. and A. A.Wright. 1949. Handbook of Frogs and Toads of the United States and Canada. Comstock Publishing Associates, Ithaca, New York.

Yeaton, S. C. 1938. The reptilia of Long Island. Long Island Forum 1: 4, 23-24.

Yeaton, S. C. 1968. The amphibians of Long Island. Sanctuary 1968 Summer:2-19. Long Island Chapter of the Nature Conservancy.

Yeaton, S. C. 1972. A natural history of Long Island. The Nature Conservancy, Long Island Chapter, Cold Spring Harbor, New York.

Ziminski, S. W. 1970. Notes on the decline of snakes at the Long Island Village of Hempstead and its vicinities. Engelhardtia 3:2.

Zweifel, R. G. 1989. Long-term ecological studies on a population of painted turtles, *Chrysemys picta*, on Long Island, New York. American Museum Novitates 2952:1-55.

Appendix A. Prior records of amphibians and reptiles from the William Floyd Estate and vicinity.

Records for species attributed to J.T. Nichols are from Nichols' journal (Nichols 1904-1958) and publications (Engelhardt et al. 1915; Nichols 1914, 1916, 1917, 1933, 1939abc, 1940, 1947). For McCormick (1975), X and x denote species "known" versus "expected" to occur at WFE, respectively. "Expected" species were not considered part of the "historic" herpetofauna of WFE.

Species	J. T. Nichols	Schlauch 1974	McCormick 1975	Lynch 1986	Sprenger et al. 1987	Klemens et al. 1988ab	Morreale 1992
Eastern red-backed salamander	X	X	X	X		X	
Spotted salamander			x				
Jefferson salamander			x				
Marbled salamander			x				
Eastern Tiger salamander			x				
Eastern spadefoot toad	X		X				
Fowler's toad	X	X	x	X			
Spring peeper	X		x				
Gray treefrog	X		x				
Northern green frog	X		x				
Southern leopard frog	X		x				
Wood frog	X		x				
Pickerel frog	X						
Painted turtle	X	X	x				
Snapping turtle	X	X	X	X			
Eastern box turtle	X		X	X	X	X	
Spotted turtle	X		x	X	X		
Eastern mud turtle	X	X	X				
Northern diamond-backed terrapin	X		x	X			X

Species	J. T. Nichols	Schlauch 1974	McCormick 1975	Lynch 1986	Sprenger et al. 1987	Klemens et al. 1988ab	Morreale 1992
Eastern garter snake	X		X	X			
Northern water snake	X	X	X				
Eastern milk snake	X		x	X			
Northern brown snake	X		x				
Northern ring-necked snake		X		X			
Eastern ribbon snake	X	X	X	X			
Eastern hog-nosed snake	X		x				
Northern black racer	X		x	X			

Appendix B. Habitat Categories.

Habitat Category	Habitat Type	Description
Stream	permanent stream	Narrow (<3m wide), flowing body of water with water flowing throughout the year.
Wetland	marsh	Body of water without well-defined borders, supporting abundant vegetation such as deciduous trees (i.e., Red Maple (*Acer rubrum*)), shrubs (i.e., Buttonbush (*Cephalanthus occidentalis*)), and emergent, herbaceous vegetation (i.e., Soft Rush (*Juncus effuses*); sedges (*Carex* spp.)). Water is usually shallow (<1m) and substrate mucky.
	brackish pond	Salt water influenced wetland, subject to changes in water depth during each tidal cycle. Swamp areas with low shrubs, *Phragmites*, and briar thickets (*Smilax* spp.) occur along the outer margins of the pond.
	temporary pond	Open or closed canopy, freshwater body of water that holds water for part of the year, drying during late summer months, and is void of fish. Identified by water stained leaves and buttressed tree trunks (i.e., Pin Oak (*Quercus palustris*); Black Gum (*Nyssa sylvatica*)). Invertebrates present include fairy shrimp, predacious diving beetles, copepods, cladocerans, and caddisfly larvae.
	permanent pond	Open canopy, freshwater body of water (<2 ha), holds water the entire year, and fish are usually present. Borders of the pond are well defined.
Upland	woodland	Forest dominated by deciduous and coniferous trees (i.e., oak (*Quercus* spp.); maple (*Acer* spp.); birch (*Betula* spp.); pine (*Pinus* spp).
	field	Open canopy, upland area dominated by grasses and sedges (i.e. *Poa* spp.; *Carex* spp.)

Appendix C. Measurements of eastern box turtles captured at the William Floyd Estate, 2002.

Date	Site	Sex	New/ Recap[1]	WCS Notch Code[2]			Stavdal Notch Code[3]					CL[4] (mm)	CW[4] (mm)	PL[4] (mm)	PW[4] (mm)	Wgt[4] (g)
				RT	LT	ID#	RF	RR	LF	LR	ID#					
27-Apr	Vista Marsh	male	new	3,4	10	4011	3,4	-	-	3	680	143.8	105.2	-	80.5	450
20-May	Home Creek	male	new	-	-	-	-	-	-	-	-	148.5	120.6	-	89.8	540
21-May	O'Dell Creek	female	new	-	-	-	-	-	-	-	-	137.5	99.2	126.4	76.6	355
22-May	Woodlot 3	male	new	1,2	2,10	4203	1,2	-	2	3	681	149.4	111.8	140.7	82.8	560
22-May	Field J10	female	new	4	3,10	4407	4	-	3	3	682	137.0	104.8	-	78.9	590
23-May	Woodlot 6	female	new	1	4,10	4701	1	-	4	3	683	130.2	103.2	-	78.1	470
24-May	O'Dell Creek	female	new	4	2,10	4207	4	-	2	3	684	131.5	107.4	129.1	78.6	510
16-Jun	Field G5	female	new	1,3	4,10	4705	1,3	-	4	3	690	131.8	101.5	-	82.2	495
16-Jun	Woodlot 2	male	new	-	-	-	-	-	-	-	-	149.5	113.4	140.9	91.0	530
17-Jun	Field G5	female	new	-	-	-	-	-	-	-	-	130.2	103.3	126.0	68.5	475
17-Jun	Field I14	female	new	-	-	-	-	-	-	-	-	121.6	101.9	-	73.5	410
18-Jun	Field I14	female	new	2	4,10	4702	2	-	4	3	685	132.9	103.3	-	71.5	535
18-Jun	Field H9	female	recap	4	2,12	10207	4	-	2	1	-	148.1	118.7	-	92.1	725
18-Jun	Field H9	male	new	2	1,2,10	4302	2	-	1,2	3	688	152.3	114.1	-	86.4	540
18-Jun	Field F7/G7	male	recap	3,4	3,11	7411	3,4	-	3	2	-	135.8	114.0	-	76.8	430
18-Jun	Field J12	female	new	1	1,2,10	4301	1	-	1,2	3	687	138.7	107.5	-	79.0	520
18-Jun	Field H9	male	recap	-	-	-	-	-	-	-	341	146.5	114.0	-	83.9	570
19-Jun	Field G5	female	new	3	4,10	4704	3	-	4	3	686	134.8	117.9	130.5	93.1	507
19-Jun	Field F12	male	new	1,2	3,10	4403	1,2	-	3	3	696	153.2	112.1	-	78.6	580
19-Jun	Field F12	female	recap	3	3,11	7404	3	-	3	2	-	144.1	108.2	139.5	78.0	625
19-Jun	Field F12	male	recap	1	3,4	1101	1	-	3,4	-	-	135.6	106.6	134.0	71.2	510
11-Jul	Woodlot 6	male	recap	2,4	12	10009	2,4	-	-	1	-	148.8	105.8	138.9	79.4	530
20-Aug	Woodlot 2	male	new	4	1,10	4107	4	-	1	3	691	136.3	117.5	-	81.6	525
20-Aug	Woodlot 3	female	recap	2	4	702	2	-	4	-	-	140.2	108.8	-	76.5	530
20-Aug	Woodlot 3	male	recap	1,2	4,10	4703	1,2	-	4	3	208	145.5	112.0	141.6	81.2	565
20-Aug	Woodlot 3	male	new	3	1,2,10	4304	3	-	1,2	3	693	146.5	116.9	-	82.4	510
21-Aug	Woodlot 6	female	new	4	1,2,10	4307	4	-	1,2	3	692	125.9	107.3	-	79.1	460

Date	Site	Sex	New/ Recap[1]	WCS Notch Code[2]			Stavdal Notch Code[3]					CL[4] (mm)	CW[4] (mm)	PL[4] (mm)	PW[4] (mm)	Wgt[4] (g)
				RT	LT	ID#	RF	RR	LF	LR	ID#					
21-Aug	Teal Hole Bog	male	new	2	1,3,10	4502	2	-	1,3	3	695	144.3	114.7	-	82.2	530
21-Aug	Woodlot 6	male	new	1,2	1,10	4103	1,2	-	1	3	694	148.6	110.3	-	78.4	500
22-Aug	Field M11	female	recap	-	1,2	300	-	-	1,2	-	384	133.7	106.9	-	79.6	510
22-Aug	Field H9	male	new	1	1,3,10	4501	1	-	1,3	3	697	135.4	102.8	127.4	74.5	420
16-Sep	Woodlot 6	male	recap	3	1,2,12	10304	3	-	1,2	1	-	139.7	109.7	132.4	85.8	510
17-Sep	Woodlot 3	female	recap	-	9,12	12000	-	-	-	1,4	223	133.3	107.7	134.3	78.3	555
18-Sep	Field F7/G7	male	recap	12	9,11	29000	-	1	-	2,4	-	148.5	111.4	-	83.4	510
18-Sep	Woodlot 1	juvenile	new	1,3	3,10	4405	1,3	-	3	3	700	76.6	64.5	74.5	50.5	81
18-Sep	Woodlot 2	male	new	1,3	2,10	4205	1,3	-	2	3	698	151.0	111.9	142.2	89.1	525
18-Sep	Woodlot 1	male	new	3	1,3,10	4504	3	-	1,3	3	701	159.0	122.0	-	94.0	555
18-Sep	Woodlot 1	male	recap	2,3	11	7006	2,3	-	-	2	-	129.7	105.2	123.9	78.2	420
18-Sep	Woodlot 1	male	new	1	2,3,10	4601	1	-	2,3	3	699	148.0	117.2	141.1	88.5	630

[1]New = turtles previously unmarked; Recap = turtles captured with existing notches or identification from capture prior to 2002.
[2]RT=right; LT=left; ID# refers to numbers assigned to each scute in Figure 2.
[3]RF=right front; RR=right rear; LF=left front; LR=left rear; ID# is the consecutive number assigned to a turtle based on the order of capture since 1980 to the present.
[4]CL=carapace length, CW=carapace width, PL=plastron length, PW=plastron width, Wgt=weight

Appendix D. Measurements of snapping turtles and northern diamond-backed terrapins captured at the William Floyd Estate, 2002.

				Notch Code[1]							
	Date	Site	Sex	RT	LT	ID#	CL[2] (mm)	CW[2] (mm)	PL[2] (mm)	PW[2] (mm)	Wgt[2] (g)
Snapping turtle	24-Apr	Home Creek	male	-	11	7000	265.3	226.1	194.7	203.8	5500
	24-May	O'Dell Creek	male	11	-	70	336	260	245.1	209.9	7500
	25-May	Home Creek	male	-	10	4000	254	196	177	168.1	3500
	16-Jun	Teal Hole	female	9	-	20	279.5	239.4	213.8	280.7	4800
	16-Jun	Home Creek	male	1	-	1	272	230	208	180	4600
	17-Jun	Teal Hole Bog	unknown	-	-	-	49.4	40	34.8	32.7	28.5
	17-Jun	Home Creek	female	10	-	40	227	196	169.5	162.8	2500
	18-Jun	Home Creek	unknown	-	-	-	31.4	30.1	21.8	22.8	9.3
	19-Jun	Teal Hole Bog	unknown	-	9	2000	50.4	42.4	34.9	32	31.5
	19-Aug	O'Dell Creek	female	11	11	7070	271	210	196	172	4200
	16-Sep	O'Dell Creek	male	12	-	20000	297	235	207	185	5500
N. diamond-backed terrapin	18-Jun	Floyd's Pond	unknown	1	-	1	104.5	77.8	98.2	70.8	225

[1]RT=right; LT=left; ID# refers to numbers assigned to each scute in Figure 2
[2]CL=carapace length, CW=carapace width, PL=plastron length, PW=plastron width, Wgt=weight

Appendix E. Measurements of snakes captured at the William Floyd Estate, 2002.

Species	Date	Location	SVL[1] (mm)	TL[1] (mm)	Weight (g)	Sex
Northern black racer	16-Sep	Field H9	310	410	15	juvenile
Northern brown snake	26-Apr	Field J12	117	145	1.5	juvenile
	21-May	Field J12	126	165	1.5	juvenile
	21-May	Field M11	282	346	12.2	female
Eastern garter snake	29-Mar	Woodlot 2	345	460	17.5	female
	29-Mar	Woodlot 2	420	520	27.5	female
	23-Apr	Woodlot 5	409	455	19.4	male
	23-May	Woodlot 2	392	506	18.5	female
	23-May	South Pond Woodlot	367	477	15.2	male
	17-Jun	Field M11	371	468	43	male
	18-Jun	Field M11	492	612	76	male
	19-Jun	Field F12	442	560	58	male
	20-Jun	Field J12	471	582	50	male
	19-Aug	Home Creek	353	453	20	female
	16-Sep	Woodlot 3	200	250	6.5	juvenile
	16-Sep	Home Creek	330	424	29	male

[1] SVL=snout-vent length, TL=total length

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