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***2012 Annual Northern Pine Snake Monitoring and Radio-tracking
Report, Conducted at the Stafford Business Park,
Stafford Township, Ocean County, New Jersey***



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To

The Walters Group

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INTRODUCTION

This is the sixth annual report submitted by Herpetological Associates, Inc. (hereafter HA), on the monitoring of northern pine snakes (*Pituophis m. melanoleucus*) at a commercial and residential development site known as the Stafford Park Redevelopment property (hereafter SPR property), in Stafford Township, Ocean County, New Jersey. The SPR property is 370-acres in size (**Figure 1**).

This is a 7-year investigation that will terminate in the fall of 2013. The framework for this project is guided by the June 28, 2006 Memorandum of Agreement (hereafter MOA) which was made between Walters Homes, Inc. (hereafter Walters), Ocean County, Stafford Township, and the New Jersey Pinelands Commission (hereafter the Commission). As part of its responsibilities, Walters closed and excavated the old unlicensed landfill on site and used the excavated materials to properly close and cap the new licensed landfill located on the redevelopment property. This action was taken because the unlicensed landfill was contaminating ground water and the nearby Mill Creek.

BACKGROUND INFORMATION

Threatened and endangered species surveys were initiated at the SPR property in April of 2004. These surveys, which were conducted by EcolSciences, Inc., revealed the presence of four state-listed plant and wildlife species, one of which is the northern pine snake, a state-threatened species listed by the New Jersey Department of Environmental Protection. It occurs on and in the vicinity of the SPR property. Considerable effort was expended surveying the SPR property site for pine snakes during the 2004, 2005 and 2006 activity seasons.

In keeping with the agenda of the MOA, HA was asked to assist with the ongoing plant and wildlife species research in May of 2006. Through these intensive surveys, it was learned that the SPR property provided critical foraging, nesting and overwintering habitat for northern pine snakes. It was determined that the pine snake population required a long-term management and conservation study plan.

Walters funded the planning and writing of specific management plans regarding the mitigation and direct impacts to pine snakes, southern gray treefrogs (*Hyla chrysoscelis* - endangered), and two rare plant species, Knieskern's Beaked Rush (*Rhynchospora knieskernii*), a federally-threatened and state-endangered sedge, and Little Ladies'-tresses (*Spiranthes tuberosa*), an orchid on the Commission's list of protected plants. Final progress reports for southern gray treefrogs and rare plants were provided to the Commission by HA in 2008. HA and Dave Golden, Senior Zoologist with the New Jersey Department of Environmental Protection's Endangered and Nongame Species Program (hereafter the Department), designed and wrote the conservation, mitigation and management plan for pine snakes as outlined in the June 28, 2006 MOA. In accordance with the MOA, all funding for the conservation plans and on-going radio-tracking monitoring are provided by the Walters Group.



Figure 1. A 2009 aerial photograph showing a western view of the study site and the various commercial, township and county buildings that were constructed on the eastern and central portions of the SPR property. The licensed landfill is centered on the western portion of the property (the open grassy fields at the top left of the photo), and retention basin D is located in the extreme western portion of the site. The three pine snake mitigation and management fields are due west from the edge of the site. The perimeter exclusion drift fence and traps that surrounded the SPR property were removed in the winter of 2010/2011, because the trapping study was completed. Source: Walters, Inc.

On December 4, 2006, HA and the Department submitted the final Plan to the Commission entitled: “A Northern Pine Snake Management and Conservation Plan, and Radio-tracking and Monitoring Plan for Stafford Business Park and Stafford Forge WMA.” The pine snake plan consisted of two parts, a Relocation and Management Plan (**Part I**), and a Radio-tracking and Monitoring Plan (**Part II**). The Plan was fashioned after similar snake conservation studies in the literature (Griffith et al., 1989; King et al., 2004; King and Stanford, 2006). The Plan was approved by the Commission in the fall of 2006, and Walters was allowed to proceed with redevelopment and new landfill construction, provided the research and conservation plans were followed.

Three pine snake management fields with 6 artificial snake hibernacula were built in Stafford Forge WMA for the shifted portion of the population (**Figures 2 and 3**). Walters began residential and commercial development in 2007 and various stages of building and reconstruction have been ongoing through 2012. The monitoring program evaluates whether the pine snakes shifted from the old landfill at the Stafford Business Park will continue to use the artificial dens and management fields in Stafford Forge WMA. The manipulated habitat and the management fields were provided as additional alternative habitat to replace the lost landfill landscape within the Stafford Business Park Redevelopment site back in 2006.



Figure 2. Google Earth aerial photo showing the 3 pine snake management fields at Stafford Forge WMA. There are two artificial dens on the west side of each field. Notice the elongated circles coming from each field in a westerly direction; these were the former 3-acre summer holding corrals that were burned by a forest fire on May 16, 2007, rendering them unusable while killing four of our study snakes. The southern gray treefrog breeding pond is on the western edge of the SPR property.

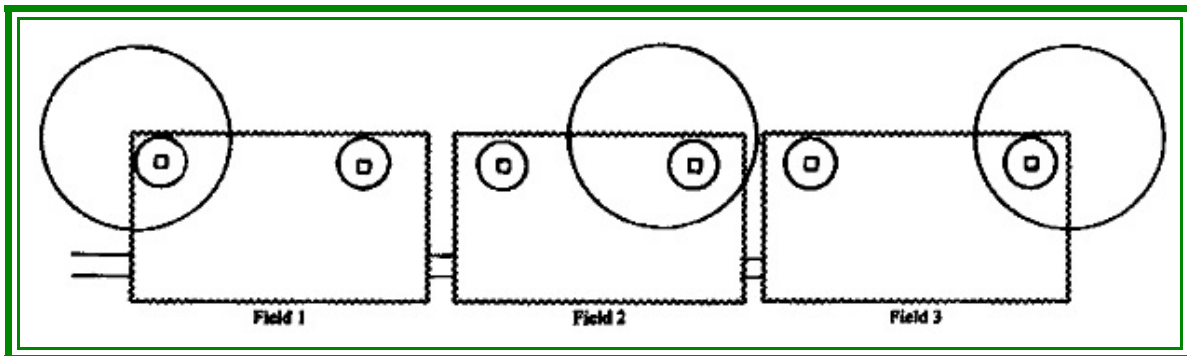


Figure 3. Diagrammatic drawing of the three Pinelands Commission approved snake management fields that were constructed on Stafford Forge WMA in the Fall of 2006 (see Legend for more details). Source: Zappalorti and Golden 2006).

Figure Legend: □ = Artificial Hibernaculum, ○ = Small Winter Fence, ○ = Large Summer Holding Corral.

Note: Diagrammatic drawing is not to scale. See description in the section below for the size details under the heading titled “Creation of Management Fields and Artificial Dens.”

According to Zappalorti and Golden's 2006 Management and Conservation Plan, the long-term field studies and radio-tracking monitoring program would address and possibly answer the following six research questions:

1. Can adult and hatchling northern pine snakes establish themselves and overwinter successfully in constructed artificial hibernacula after being shifted to a different area within their known activity range?
2. Will non-shifted northern pine snakes (or other snake species) from the existing Stafford Forge Wildlife Management Area population begin to use the artificial hibernacula constructed at the three management fields on their own?
3. How do the spatial movements and other behaviors (*e.g.*, habitat use, foraging, mating, nesting, and denning) of the shifted pine snakes differ from the non-shifted pine snakes?
4. Do pine snakes from this population (both those shifted to the management fields and others) attempt to move back onto the redevelopment area of Stafford Township Business Park during the construction period, and if so, does this tendency diminish over time?
5. Will a higher percentage of northern pine snakes (adults and juveniles) return to, and overwinter in, the artificial hibernacula when they are kept in an enclosed area around the hibernacula and fed for two winters versus only a single winter?
6. Will shifted and non-shifted gravid (carrying developing eggs) female northern pine snakes from this population begin using the three management fields as nesting habitat in future years?

MATERIALS AND METHODS

HA Staff and NJDEP Researchers

There were numerous tasks to be performed and data to be collected during the 2012 field season at Stafford Forge WMA and the SPR property. The following HA staff members were present during some, or all of the wildlife monitoring and surveys: David Burkett, Robert Hamilton, Matthew McCort, David Schneider, and Robert Zappalorti. Additionally, Division of Fish and Wildlife staff, Dave Golden and Kim Korth advised and assisted with various tasks throughout the 2012 field season.

CREATION OF MANAGEMENT FIELDS AND ARTIFICIAL DENS

The relocation and management phase of the conservation plan included habitat manipulation for pine snakes that were collected and shifted from the SPR property (Kingsbury and Gibson 2002). HA and the Division supervised the creation of three pine snake management fields (hereafter MF 1 through 3), at preselected suitable sites within Stafford Forge WMA. Each cleared field measures approximately 300 feet wide by 800 feet long in size (or a total of 5.5-acres, see **Figures 2 and 3**).

These three 5.5-acre fields were meant to replace the open grassland habitat that was lost on the old SPR property (*e.g.*, the two winter dens, the foraging habitat and nesting areas on the old unlicensed landfill). Two snake dens (artificial hibernacula), were constructed on each management field, approximately 350 feet from one another (**Figure 4**) (Gillingham and Carpenter, 1978; Frier and Zappalorti, 1983; Zappalorti and Reinert, 1994; Zappalorti and Golden, 2006).

Each hibernaculum was encircled with a one-acre fence to keep the snakes within the den enclosures. The circular fences stood 5 feet in height and had black landscape fabric attached on the inside. The fabric was intended to protect the snakes from rubbing their noses raw. Three of the dens (AH 1, 4, and 6) had a larger, 3-acre perimeter fence for holding the pine snakes over a twenty month period (1.5 years). As part of this experiment, a total of 100 pine snakes were released into the dens in the fall of 2006 (25 adults, 4 sub-adults, and 71 hatchlings (**Table 1**).

Table 1. Random Distribution of the 2006 Shifted Pine Snakes that were Released into Six Artificial Dens (Treatments A and B), and Non-random Assignment into Treatment C.

Winter Treatments	Den Number	Adult Males	Adult Females	Juveniles	Hatchlings	Totals
B = Two Winters	1	1	1	1	11	14
A = One Winter	2	2	2	0	13	17
A = One Winter	3	2	1	1	11	15
B = Two Winters	4	2	1	0	12	15
A = One Winter	5	1	1	2	11	15
B = Two Winters	6	2	1	0	13	16
C = One Winter in HA's Laboratory		3	5	0	0	8
Three Treatments		13	12	4	71	100

These snakes were randomly selected for distribution into Treatments A and B (**A** = one-winter treatment and/or **B** = two-winter treatment). The third treatment, Treatment **C** (the laboratory treatment), was not originally planned, but was created out of necessity after it was determined that 8 of the pine snakes were not healthy enough to be released in the fall of 2006. Unlike Treatments A and B, these snakes were not randomly assigned to the third treatment, because they suffered from poor health and were held in HA's laboratory for the first winter (2006-2007). All 8 snakes placed in Treatment C were cared for and fed during the winter and were deemed healthy enough to be released into the two-winter treatments in the spring of 2007. They too were monitored via radio-telemetry over the last six 6 seasons.

Another portion of the relocation and management phase of the conservation plan involved enhancing existing habitat within Stafford Forge WMA for pine snakes. This included the construction of 6 foot high earthen berms along the edges of the three fields and large earthen and wood debris piles within the center of the fields. These earthen berms were constructed out of A-horizon sand, stumps, logs and brush. The fields provide pine snakes with forest-edge habitat suitable for basking and resting (Burger and Zappalorti, 1988a; Zappalorti and Burger, 1985). The fields are also open, with sandy areas that provide potential nesting habitat for female pine snakes (Burger and Zappalorti, 1991). As part of the habitat enhancement, HA and the Department planted grasses on the fields to replicate the lost landfill field habitat. Open grassy fields have been shown to be good nesting and foraging habitat for northern pine snakes (Burger and Zappalorti, 1986 and 1991). For greater detail on the success of the habitat enhancement, please refer to the results and discussion sections of this report.

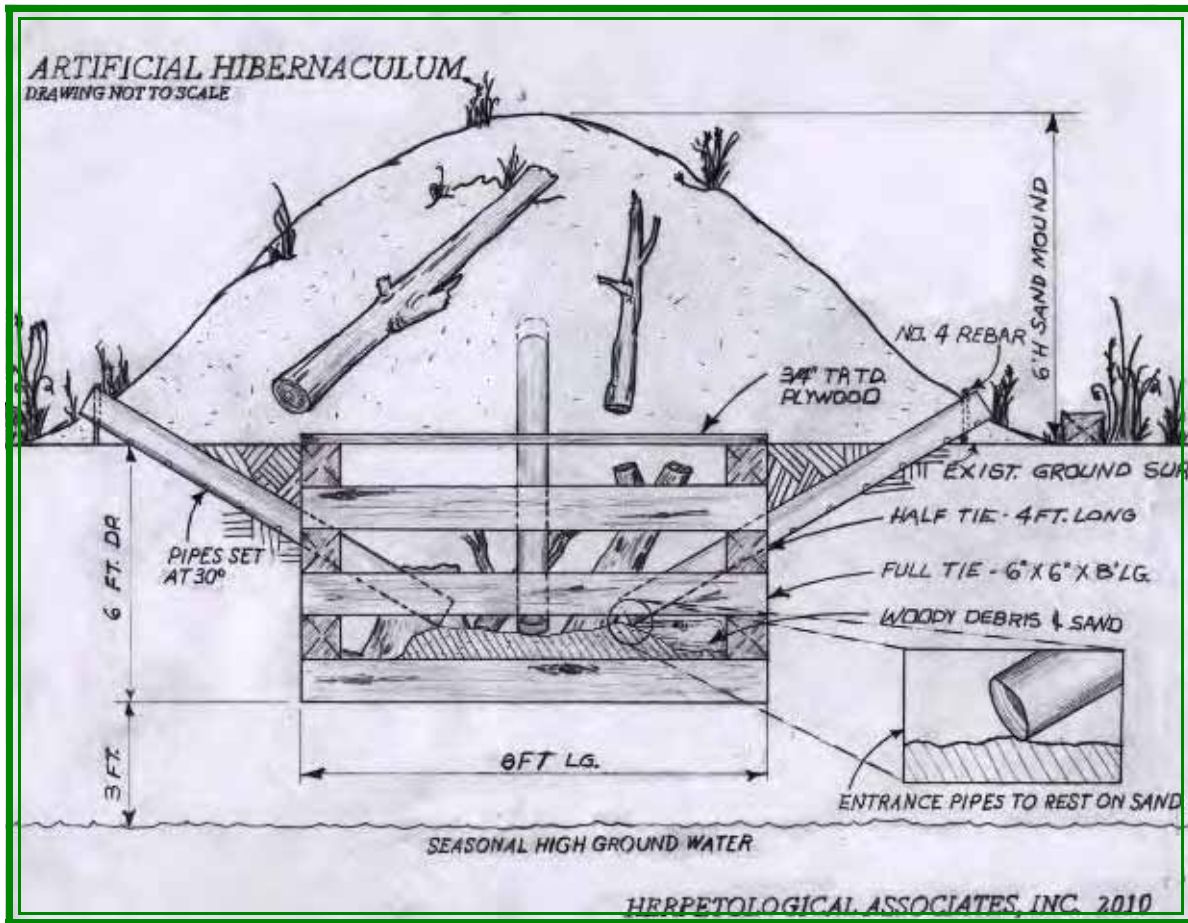


Figure 4. Diagrammatic drawing of an artificial snake hibernaculum designed by Zappalorti and Reinert (1998). This type of snake den has been used successfully for pine snakes and corn snakes at the Crossley Preserve and at the New Jersey Audubon, Hovnanian Preserve. Timber rattlesnakes have used this type of den at Greenwood Forest WMA.

After emerging from the artificial dens, snakes in the two-winter treatments were all released into the 3-acre corrals (see **Figure 2**). On May 16, 2007, a severe forest fire devastated the entire pine snake study area and the three management fields, burning all the fabric off the fences and all the vegetative cover in the forest. The fire also killed four of our radio-tracked study snakes and an unknown number of the PIT tagged hatchlings.

Due to damage related to the May 16, 2007 forest fire and the lack of vegetative ground cover to protect the snakes from hawk predation, these three corral fences could no longer be used. Instead, the two-winter treatment snakes were held within the 1 acre corrals for the duration of the treatment period (artificial dens 1, 4 and 6). After one winter of hibernation, snakes emerging from dens 2, 3, and 5 (the one-winter treatments) were allowed to disperse into the surrounding Stafford Forge WMA forest habitat.

ONSITE MONITORING

One of HA's tasks was to act as environmental monitors during various construction activities on the SPR property. During any habitat alteration, a qualified HA staff member was present to examine the area for any reptiles or amphibians that may have been present. Any animals found during these activities were collected, documented and released in the nearest section of protected Stafford Forge WMA forest.

The clearing of the forest within the SPR property boundaries was mostly completed in 2006 and 2007, however some additional clearing took place in 2011 along the southern portion of the SPR property. This area was cleared for the beginning development phase of the new Stafford Park Preserve Luxury Apartments. Pertinent data with respect to environmental monitoring is further explained in the results section of this report.

HABITAT EVALUATION

HA has three criteria for judging the potential value of the available habitat and its existing conditions for endangered, threatened or rare species (ETR species). These are:

1. Structure of Available Habitat: Both the biotic and abiotic components are considered. These are good indicators for the possible occurrence of particular ETR species within a specific study area (Burger and Zappalorti, 1986; Reinert and Zappalorti, 1988a and 1988b; and Heyer et al., 1994; Golden et al., 2009; Burger and Zappalorti, 2011).

2. Historic Evidence: Known sightings of the target ETR species in the State Natural Heritage Program database, and historic records on or in the vicinity of a study site, are important to the overall evaluation of a site as habitat for ETR species (Zappalorti and Johnson, 1982; Golden and Jenkins, 2003; Golden et al., 2009).

3. Indicator Species: The presence of plant and animal species that are often found in association with a target ETR species is highly informative when evaluating the suitability of a study site. Such indicator species may include food/prey organisms, or species that typically occur in similar or identical habitats as the target ETR species. The presence of associated or indicator species demonstrates the ecological value of the habitat within a particular study site (Frier and Zappalorti, 1983; Brown, 1993, Kingsbury and Gibson, 2002; Burger and Zappalorti, 2011).

REPTILE AND AMPHIBIAN SURVEY TECHNIQUES

Reptiles and amphibians are often difficult to census due to their highly secretive nature and ability to remain hidden for long periods of time. Environmental conditions such as ambient temperature, precipitation, soil moisture, relative humidity, light intensity, wind, and season have strong influences on reptile and amphibian activity patterns (Vogt and Hine, 1982). Unsuitable weather conditions may lead to increased fossorial behavior (burrowing), markedly reduced activity, shifts in habitat usage, and/or estivation (dormancy during hot and dry conditions) (Greene, 1997). Therefore, the use of several sampling techniques which take into account the various aspects of an animal's biology will often result in the best assessment of the target species relative abundance (Zappalorti and Torocco, 2002). The following visual search methods were performed.

Random Opportunistic Sampling (ROS)

A simple method used by the trained herpetologist, ROS was employed in conjunction with other sampling techniques on the study site. Habitat that showed potential for target species were searched. This search method is not constrained or standardized in time transects, but instead relied on the experience and professional judgement of the investigators. This method is effective if there are no time constraints, however detailed surveys were performed as a follow-up (Campbell and Christman, 1982; Karns, 1986). Qualitative impressions were determined as to the relative abundance and habitat use of certain species during ROS. All wildlife encountered was recorded to supplement the species list generated by other field methods (Zappalorti and Torocco, 2002).

Time-constrained Searching (TCS)

A specific habitat (e.g., oak/pine forest, pine/oak forest, wetland corridor) was selected, and all potential hiding places for reptiles and amphibians were searched. Fallen logs, stones, leaf-litter, artificial cover objects (discarded sheets of wood or metal, rugs, and furniture), were overturned. Open, sunny areas were searched for surface activity or basking snakes. Spatial boundaries for each search were limited to the selected habitat. Time limits ensured that each habitat was adequately, but not excessively, examined. When target species congregate in particular habitats (e.g., nesting area, hibernacula) for important life history events, TCS is highly productive and superior to other types of surveys methods (Campbell and Christman, 1982; Karns, 1986).

Diurnal and Nocturnal Road Cruising

Roads which border potential habitat often yield both living and road-killed animals (referred to as Dead On Road or DOR), reptiles, amphibians and other animals. Identification of species found while “road cruising” can provide useful information on migration routes, activity patterns, and habitat utilization/partitioning. The basic presence or absence of a species in a particular area can also be determined by the identification of their remains alone. Road cruising was used passively, such as while driving to and from the site or while driving/walking to and from areas on the site, or it was initiated as a specific surveying technique. This method involved driving a vehicle at slow speed along sand trails and paved roads at various times of the day and/or night. Road cruising is often highly productive on warm, humid or rainy spring nights, or during other periods of high activity. Animals moving across roads and those killed were collected and/or identified (Campbell and Christman, 1982; Karns, 1986; Zappalorti and Torocco, 2002).

Pine Snake Nest Survey

Surveys for nests were conducted visually. Typical pine snake nesting habitat consists of open sandy uplands with characteristic plants such as Pennsylvania sedge (*Carex pennsylvanica*) and golden heather (*Hudsonia ericoides*) (Burger and Zappalorti, 1986). Pine snake nests can be located by a sand dump pile left by the female excavating (Burger and Zappalorti, 1991). Nesting areas can also be found by locating hatchlings (or their fresh shed skins), in early September, when the physical evidence of nesting has long since diminished (Burger and Zappalorti, 1991; Burger and Zappalorti, 2011; and Zappalorti, personal observations). The primary goal of these surveys was to delineate critical pine snake nesting habitat. All potential pine snake nesting habitat was carefully walked by HA staff members parallel to each other and spaced 3 meters apart. Surveys were conducted during the nesting period (late June-early July), and in early September.

PROTOCOL FOR RELEASING PINE SNAKES FOUND ON THE SPR PROPERTY

As stated on Page 10 of the June 28, 2006 Memorandum of Agreement, one of the goals of the Species Management Plan was the protection of threatened and endangered species on the SPR property from adverse impacts and direct harm during the redevelopment process. This includes, but is not limited to, the reestablishment of threatened and endangered species at appropriate habitat areas designated by the Pinelands Commission and the NJDEP. Furthermore, the MOA mandates that measures be taken to preclude such species from returning to the disturbed SPR site.

RADIO-TELEMETRY

Radio-tracking is a method used to monitor the movements, habitat use and behavior of free-ranging pine snakes. Advanced Telemetry Systems, Inc. R1535 or R1520 transmitter units were used. Transmitters were designed so that their mass represents less than 5% of the snake's body weight. The typical reception range of the transmitters was 400 to 1000 meters. Transmitters were surgically implanted in the coelomic cavity following the general procedure of Reinert and Cundall (1982), with improvements and modifications (Mech, 1983; Reinert, 1992; Lutterschmidt, 1994). All snakes captured prior to 2007 were surgically implanted by a veterinarian hired by EcolSciences, Inc. All surgeries performed on snakes captured in 2007-2012 were conducted by qualified HA staff members (e.g., Bob Zappalorti, Mike Torocco, Matt McCort and/or Dave Schneider) in HA's laboratory in Jackson, New Jersey.

Radio-tracked pine snakes were located once every 48 hours using a Wildlife Materials International (Model TRX-2000S) receiver, unless unfavorable weather conditions (rain storms) or equipment problems (either transmitter or receiver) forced changes to the tracking schedule. Each relocation was recorded in the field using a Trimble GeoExplorer 3 GPS unit. The snake's activity, behavior and habitat-use data were also noted along with temperature, humidity and weather.

Transmitter Surgeries in 2012

All snake surgeries were completed before August 15, 2012 (Lutterschmidt, 1994; Rudolph et al, 1998). Snakes that had their old transmitters replaced in 2010, were due for new transmitters in 2012. A total of six pine snakes were pulled from the field for re-implantation surgery in 2012. Time frames for snake re-implantation and eventual release varied with the condition of each specimen as HA staff assessed the overall health of each snake. Five of the six snakes successfully had their old transmitters removed and replaced. Unfortunately, study snake 2006.19 died due to an enlarged heart condition (refer to Snake Synopses and Home Range Maps).

Activity Range Analysis

Radio-telemetry and GPS plotted points provided the data necessary for the calculation of activity ranges for all radio-tracked pine snakes with a sufficient number of relocation points. Activity range is defined as the area each snake used for all life history activities over the course of a season, which includes emergence from hibernation until winter ingress back into its den (Gregory et al, 1987). Two methods were used to arrive at the activity range for each snake: 100% Minimum Convex Polygon and Kernel Activity Range (Samuel et al, 1985; Tiebout and Carey, 1987; Tufto et al, 1996; Seaman and Powell, 1996).

Minimum Convex Polygon Activity Range

The Minimum Convex Polygon (MCP) method of activity range analysis has historic prominence in the literature due to its relative ease of use. This MCP method uses the outer most points plotted on a map which includes 100% of the relocation points to calculate activity ranges for each snake. The outermost points on the map are connected to form a polygon. The area of the polygon is then calculated to arrive at the MCP activity range. Activity ranges maps were produced using ArcMap 10.0 (Environmental Systems Research Institute, ESRI, Inc., 1999-2010) and activity range maps/calculations were done with XTools Pro for ArcGIS desktop (Copyright 2003-2010 Data East Soft, LLC).

Kernel Activity Range

HA used this additional method to estimate core activity centers of habitat use by the monitored pine snakes. The formula for the Kernel Activity Range is calculated via a fixed range of animal habitat utilization distributed equally within the 50% and 90% isopleth (Worton, 1989). The Kernel method's grid coverage matches the minimum convex polygon and 95% isopleth to determine the smoothing factor (H) (Row and Blouin-Demers, 2006). The bivariate normal density kernel was used as suggested by Worton (1989). In other words, Kernel Activity Range uses non-parametric statistical procedures to calculate probabilities of an animal being in various locations in two-dimensional space and adjusts the activity range boundaries for local variation in frequency.

Two different measures of activity range were calculated at 90% and 50% respectively. Each percentage is displayed on a base map of the study site as an area, representing the probability (90% and 50%) of each study animal occurring in that area at any given time based on the existing 2012 radio-telemetry data. Kernel Activity Range was calculated using Geospatial Modeling Environment (GME) (Copyright 2001-2011, Hawthorne L. Beyer, Ph.D., Spatial Ecology LLC).

RESULTS OF THE 2012 INVESTIGATION

Description of Existing Conditions and Habitats

The 370-acre SPR property consists of a mixture of habitats, comprised mostly of upland pine forest and disturbed open field. The property is bordered to the west and the south by the Division's Stafford Forge Wildlife Management Area and the north and east by Route 72 and the Garden State Parkway, respectively (**Figures 1 and 2**). The northern portion of the property is comprised of three areas: the buffer zone for the Mill Creek wetland corridor, the Ocean County facilities (public works, maintenance, mulching center, etc.), and the capped licensed landfill. A variety of wetland habitats exist within the Mill Creek wetland corridor, such as Atlantic white cedar (*Chamaecyparis thyoides*) swamps, deciduous hardwood swamps, and emergent wetlands.

The ecotone or transition area to the upland pine forest, and the oak/pine forest, still partially exists and will remain intact, as it is protected within the wetland buffer. The southern portion of the site was formerly a large tract of upland pine forest. This forest was cleared and graded to the property line in 2007. The western portion of the site consists mainly of the licensed, capped landfill and an area temporarily stabilized with vegetation awaiting residential development. Storm water basins and Ocean County municipal property comprise the remainder. The eastern portion of the site is now a new shopping center with chain stores such as Dicks, Best Buy, Pet Smart, Costco and Target.

There are two storm water basins and an irrigation pond associated with the shopping mall. The center of the site was cleared and prepared for commercial and residential development in October and November 2008. In 2009, affordable residential housing units were completed on the central portion of the site, opened to the public and are now fully occupied. Throughout 2012, construction has continued on the Stafford Park Preserve Luxury Apartment complex along the southern edge of the SPR property.

Selective Forest Thinning on Hay and Micaja Roads

In hopes of reducing damage caused by unexpected forest fires in the future, the New Jersey Forest Service selectively cut trees within prescribed areas of forest along Hay and Micaja Roads. This forestry procedure is a method used to reduce the risk of accelerated canopy burn during an uncontrolled forest fire (Graham et al, 2004). The majority of the forest was essentially cleared of all standing dead or clustered overstory trees approximately 200 meters into the forest from the edge of the sand roads within portions of Stafford Forge WMA. As a result of the clearing operations, large mounds consisting of sandy soil, stumps, logs, brush, sticks and twigs were left behind in the areas where the forest was thinned.

This action created habitat which can be very beneficial to pine snakes and other wildlife. The open canopy provides essential basking habitat for the snakes while the stump, log and earth mounds provide needed cover and shelter during the course of their activity season (Friar and Zappalorti, 1983). The open forest also attracts a variety of small mammal and bird species which provide important prey items for the snakes. Indeed, a few of the study snakes were relocated using the areas that had been thinned by the forest service on a regular basis during the 2012 field season (refer to Snake Synopses and Home Range Maps).

REPTILE AND AMPHIBIAN SURVEYS

Visual Survey Results

In 2012, random searching and visual surveys resulted in the observation, capture and identification of 19 different reptile and amphibian species in and around the SPR property and the adjacent Stafford Forge WMA. **Table 2** lists the 19 assorted species captured or observed during the field season. Several reptile and amphibian species were found while conducting radio-tracking monitoring of pine snakes, such as fence lizards and black racers (**Figures 5, 6, 7, 8, 9, 10, and 11**).

Table 2. Reptile and Amphibian Species Captured or Observed in and around the SPR Property and the adjacent Stafford Forge WMA in 2012.

Number of Species	Common Name	Scientific Name
1	Eastern Box Turtle	<i>(Terrapene c. carolina)</i>
2	Eastern Painted Turtle	<i>(Chrysemys p. picta)</i>
3	Redbelly Turtle	<i>(Pseudemys rubriventris)</i>
4	Red-eared Slider	<i>(Trachemys scripta elegans)</i>
5	Northern Fence Lizard*	<i>(Sceloporus undulatus hyacinthinus)</i>
6	Eastern Garter Snake*	<i>(Thamnophis s. sirtalis)</i>
7	Eastern Ribbon Snake	<i>(Thamnophis s. sauritus)</i>
8	Northern Water Snake	<i>(Nerodia s. sipedon)</i>
9	Rough Green Snake	<i>(Opheodrys aestivus)</i>
10	Eastern Hognose Snake*	<i>(Heterodon platirhinos)</i>
11	Northern Black Racer*	<i>(Coluber c. constrictor)</i>
12	Northern Pine Snake*	<i>(Pituophis m. melanoleucus)</i>
13	Fowler's Toad	<i>(Anaxyrus fowleri)</i>
14	Northern Spring Peeper (Vocalizing)*	<i>(Pseudacris c. crucifer)</i>
15	Pine Barrens Treefrog (vocalizing)*	<i>(Hyla andersonii)</i>
16	Southern Gray Treefrog (Vocalizing)*	<i>(Hyla chrysoscelis)</i>
17	Southern Leopard Frog	<i>(Lithobates sphenoccephalus)</i>
18	Green Frog*	<i>(Lithobates clamitans melanotus)</i>
19	Bullfrog	<i>(Lithobates catesbeiana)</i>

Note: * = Photographs of these various species of reptiles and amphibians are illustrated in this report.



Figure 5. Male northern fence lizard.



Figure 6. Gravid female fence lizard.



Figure 7. A northern black racer found basking at a natural den in the fall of 2012. Photo by David Burkett, HA staff.



Figure 8. A calling male southern gray treefrog, perched on a white cedar tree branch.



Figure 9. Male Pine Barrens treefrog resting on a pitch pine tree branch.



Figure 10. Northern spring peeper resting on a tree trunk.



Figure 11. Adult female green frog foraging for insects on the pond edge.

ARTIFICIAL AND NATURAL DENS

As a result of our intensive radio-tracking studies, HA discovered a large number of natural pine snake dens over the past 6 field seasons, including one new den in 2012 (**Figure 12**). HA's definition of a "Natural Hibernacula," is any underground structure in the forest that a free roaming pine snake selected as its winter refugia. In order to prevent confusion, all artificial dens in the management fields are referred to as "Artificial Hibernacula" (AH 1 through 6). Whereas, all natural dens are designated as "Natural Hibernacula" (NH 1 through NH 45). **Appendix I**, chronicles each natural and artificial hibernacula and the corresponding snakes that used them during each winter of the study. The 2007-2008 winter was the last winter that snakes were forced to hibernate in the two-winter treatments (AH 1, AH 4, and AH 6), completing the experimental habitat imprinting portion of the study. Therefore, all overwintering sites used by radio-tracked snakes in the 2012 - 2013 winter season were selected by the snakes themselves, without any influence from HA staff.

RESULTS OF RADIO-TRACKING

In 2012, a total of 12 pine snakes were radio-tracked during the active field season (April through October) (refer to Snake Synopses and Home Range Maps). These included 4 original "shifted snakes," 6 "non-shifted" snakes, and two recaptured 2006 hatchlings. Of the four "shifted" pine snakes tracked by HA at the start of 2012, two snakes (both males) remain alive and healthy. Of the six non-shifted snakes, four (3 males and 1 female) remain alive and healthy and two are currently missing and unaccounted for due to unexpected transmitter failures. The two radio-tracked 2006 hatchlings (1 male and 1 female) remain alive and healthy.



Figure 12. Radio-tracked pine snake 2007.10 coiled on top of a fallen pitch pine near it's den. Photo by David Burkett, HA staff.

SNAKE SYNOPSES AND HOME RANGE MAPS

ABOUT THE HOME RANGE MAPS

The Division's, Endangered and Nongame Species Program reviewed and approved the pine snake's activity range maps that are provided in this report. These pine snake home range maps were generated by collecting relocation GPS coordinates while radio-tracking. Each base map shows the land boundaries of the SPR property, the Department's Stafford Forge Wildlife Management Area, along with plotted GPS snake relocation points. The activity/home range information is shown graphically by plotting the land area used by each radio-tracked pine snake. Two methods were used to arrive at the activity range size for each snake: 100% Minimum Convex Polygon, and 50% and 90% Kernel Activity Range (Samuel et al., 1985; Tiebout and Carey, 1987; Tufto et al., 1996; Seaman and Powell 1996, Hooge et al., 1997, USGS, Alaska Biological Science Center).

LOSS OF RADIO-TRACKING DATA IN 2012

One of HA's former researchers, Robert Hamilton was responsible for monitoring the following pine snakes via radio-telemetry in 2012: Numbers 2006.19, 2006.46, 2007.07, 2007.14, 2008.03 and 2009.13. The GPS relocation point data collected throughout the 2012 season (April to October), was uploaded and kept on Mr. Hamilton's personal laptop computer. Likewise, all the paper field data sheets were in a binder that was also in his possession. Typically, all GPS relocation points are backed-up onto HA's main server on a regular basis throughout the year, but during 2012, Mr. Hamilton failed to back-up his GPS relocation points on HA's server.

Mr. Hamilton had both his laptop and binder with all the paper snake data sheets stored in his garage. His garage was flooded and all the paper data sheets and his laptop were inundated with water. All the GPS files stored on his laptop computer and the paper data sheets were destroyed from water damage. All the GPS relocation points and data he collected throughout the 2012 season were also lost and unretrievable (Bob Hamilton, personal communication). Therefore, no home range analysis is presented for these snakes. Only the few recoverable behavioral and habitat use observations are included in the analysis for 2012. A short history of the snake's activities is provided below, but there are no home range maps for snakes with missing data.

SNAKE SYNOPSES

A brief activity and behavior synopsis is provided along with a home range map of each adult pine snake with full season radio-telemetry data. This activity information was collected during the 2012 field season (whether a snake is currently alive or deceased), and is chronicled below. These maps are included within the synopsis for each snake. Refer to the individual maps for information on each pine snake's activity range size during 2012. **Appendix II** provides a brief explanation for each snake that died, prior to and during the 2012 radio-telemetry season. Additionally, a home range analysis map of all radio-tracked pine snake relocations for 2012 (the combined movements and home range sizes) is provided.

N. Pine Snake No. 2006.16 (σ). (Shifted Snake, Treatment C/Lab) Current status = Alive and healthy. This snake was originally captured by EcolSciences, Inc. in trap number 27 along the perimeter drift fence on 05/18/06.

This snake egressed from AH 1 on 04/30/2012. It was relocated 84 times during the 2012 field season. Upon leaving the hibernaculum, this snake moved into the earth berm along the western side of MF 1. It remained there for a few days before making a large move south/southeast into pine/oak and oak/pine forest near the landmark known as the “glass pile” (see **Appendix IV**). This habitat has been identified as part of the snake’s home range in prior field seasons. It was relocated in this area for approximately two weeks before making a brief return to the pine forest along the edge of MF 1. This snake only spent a few days along the edge of the management fields before once again being relocated in the pine/oak forest south/southwest of the management fields for the rest of May. During this period of time the snake was often observed on the move, since the temperatures were still mild.

On 06/04/2012, this snake was relocated concealed inside a fallen pitch pine near the landmark known as the “turtle pond” (see **Appendix IV**). This snake had never been relocated here before, however a previous study snake (study snake 2006.41 which is now deceased) was often found in the same location for extended periods of time. The snake then spent the majority of the remainder of June in an area of pine/oak forest southwest of the management fields. On 06/16/2012, it was found in this section of forest concealed in a fallen log. Next to this log was a large pile of pine chips indicative of small mammal feeding activity. It is possible the snake may have found a meal at this location.

On 07/02/2012, this snake again moved into the berm along MF 1. Interestingly, this snake moved back into almost the same location on July 6th of 2011. The snake remained in the berm for approximately one week. During the middle of July it was consistently relocated in the same pine/oak forest as previously mentioned. The snake was observed moving during the early morning hours when temperatures were cooler and was relocated underground or concealed amongst the understory shrub and duff layer during the hotter periods of the day. On 07/23/2012, it was found basking along the edge of MF 1 and was removed from the field for transmitter replacement.

After successful transmitter replacement surgery it was released back into the field along the edge of MF 1 where it had been caught and it immediately moved back into the pine/oak forest southwest of the management fields. Once again, due to the hot temperatures, it was often relocated concealed under vegetation, the duff layer, or underground. On 08/20/2012, it moved back into the berm along MF 1 and stayed there for the remainder of August.

This snake’s activity in September mimicked that of August, with the first portion of the month being spent in the pine/oak forest southwest of the management fields and the last portion in the berms along the edge of MF 1. During October, this snake remained near the management fields, except for one relocation, when it made a large move approximately 600 meters south of the management fields. From October 15th to the 20th, it was found in NH 42, before being located in a trap attached to AH 1. It was removed from the trap and released into AH 1 where it is currently overwintering for the sixth year in a row. This snake was never observed mating during the 2012 field season. The full activity season home range for this adult male pine snake is illustrated in **Figure 13** on the next page.

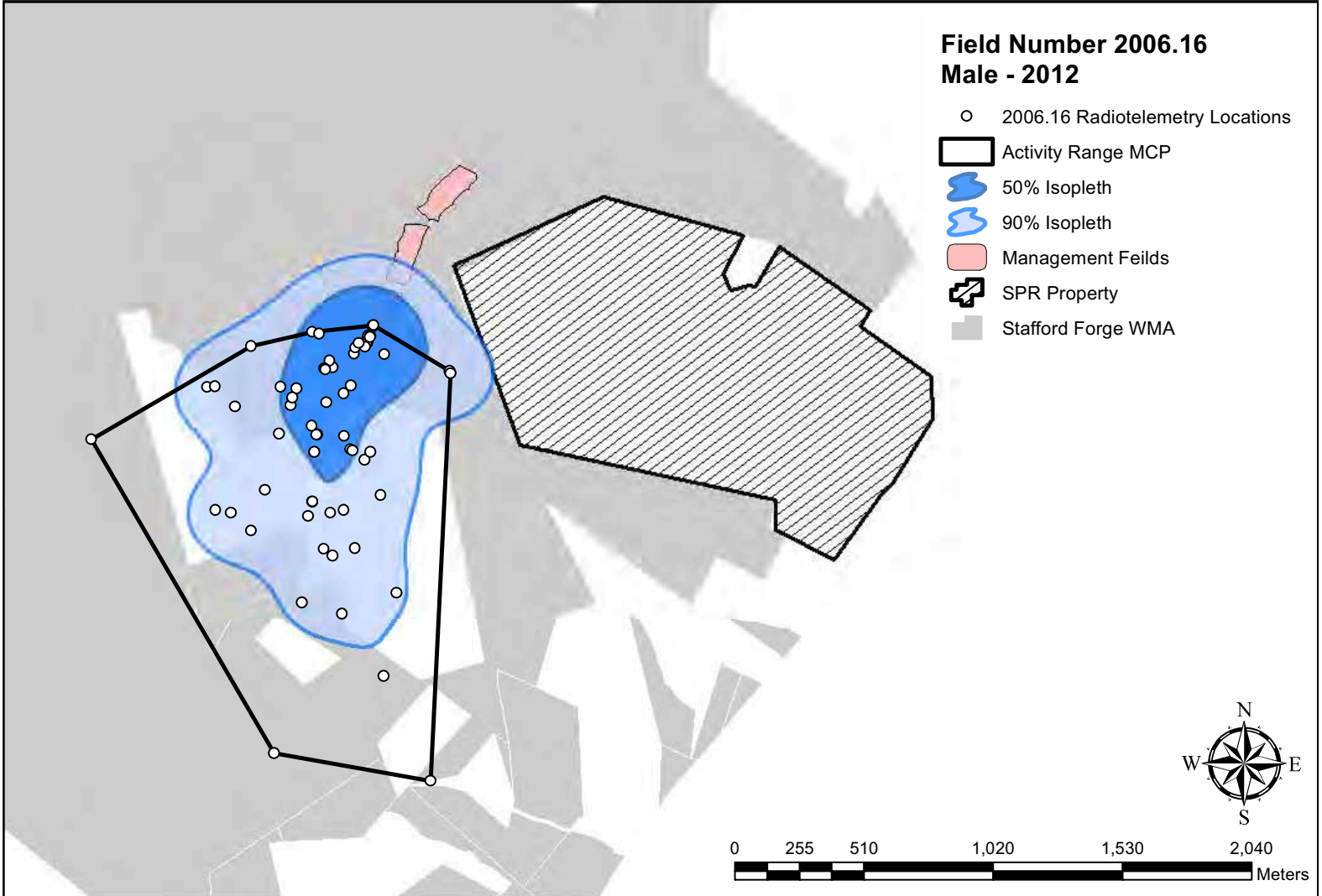


Figure 13. 2012 activity range of pine snake 2006.16, showing 100% minimum convex polygon (MCP), and 50% and 90% kernel density estimator isopleths (KDE).

	Acres	Hectares
MCP	424.2	171.7
KDE 50%	68.9	27.9
KDE 90%	302.9	122.6

N. Pine Snake No. 2006.19 (♀) (**Figure 14**). (Shifted Snake, Treatment C/Lab) Current status = Deceased. This snake was originally captured by EcolSciences, Inc. on 05/24/06 in the NW corner of the former Stafford Township Police firearms shooting range, which no longer exists.

This snake emerged from AH 1 on 04/30/2012. Similar to previous years, the majority of this snake's activity range was concentrated in the pine forest bordering the edge of MF 1 and just to the west of it. It made occasional forays into pine/oak forest approximately 350-meters southwest of the management fields in search of prey.

This snake was often observed breeding in previous field seasons, sometimes with study snake 2006.16. However, no mating or courtship behavior was observed between this snake and any male pine snakes in 2012. The snake never appeared gravid and did not lay eggs in June.

This snake was pulled from the field in late July for transmitter replacement surgery. Unfortunately, unknown to HA staff at the time, this snake was suffering from an enlarged heart and the snake died during surgery as a result (this was revealed by a necropsy). A home range map is not provided because there were not enough relocation points available to generate a complete season due to lost data.



Figure 14. Female Pine Snake 2006.19, basking under a blackberry bush. Photo by R.T. Zappalorti.

N. Pine Snake No. 2006.34 (♂) (**Figure 15**). (Shifted Snake, Treatment A/1 Winter) Current status = Deceased. This snake was originally caught in trap number 85 in the perimeter drift fence by EcolSciences, Inc. on 08/31/06.

This snake had already egressed from its den prior to the commencement of radio-tracking activities on 03/19/2012. It was relocated 31 times during the 2012 field season. At the beginning of the activity period, this snake moved into pine/oak forest approximately 400-meters east of the landmark known as the “glass pile”(see **Appendix IV**). It remained in this area for about a month. It was relocated basking on the surface during the middle of the day and underground during the cooler morning and evening hours. On 04/16/2012, this snake made a large move north into pine/oak forest, near the Costco shopping complex, where it was observed breeding with an unknown female on 04/20/2012. It remained in this same general area of forest for the next week. On 04/28/2012, it moved north along the edge of the landfill. It was relocated along a small cleared path, where study snake 2006.49 was often relocated during last field season and this field season. For the next week, this snake was relocated right along the southern edge of the landfill, in areas of forest with very little canopy cover.

On 05/07/2012, this snake made a large move back towards the “glass pile”, where it was relocated mating with another unknown female on 05/10/2012. The snake remained in the vicinity of the “glass pile” where it was relocated concealed in, or under, familiar discarded debris it had been found in during all prior field seasons. This included an old abandoned metal gas tank and a rubber tire, both of which another study snake (pine snake 2007.11) would also be found concealed in later during the 2012 field season.

On 05/26/2012, this snake was found dead along the edge of the “glass pile”. During the week prior to it being found deceased, this snake was always relocated concealed in the previously mentioned rubber tire. It is not known what caused the death of this snake. There was an injury on the snake along the bottom left side of the body and insects had begun to feed on the snake’s remains. A truncated home range map for this adult male pine snake is illustrated in **Figure 16**, on the next page.



Figure 15. Study snake 2006.34 coiled under fallen log. Photo by David Burkett, HA staff.

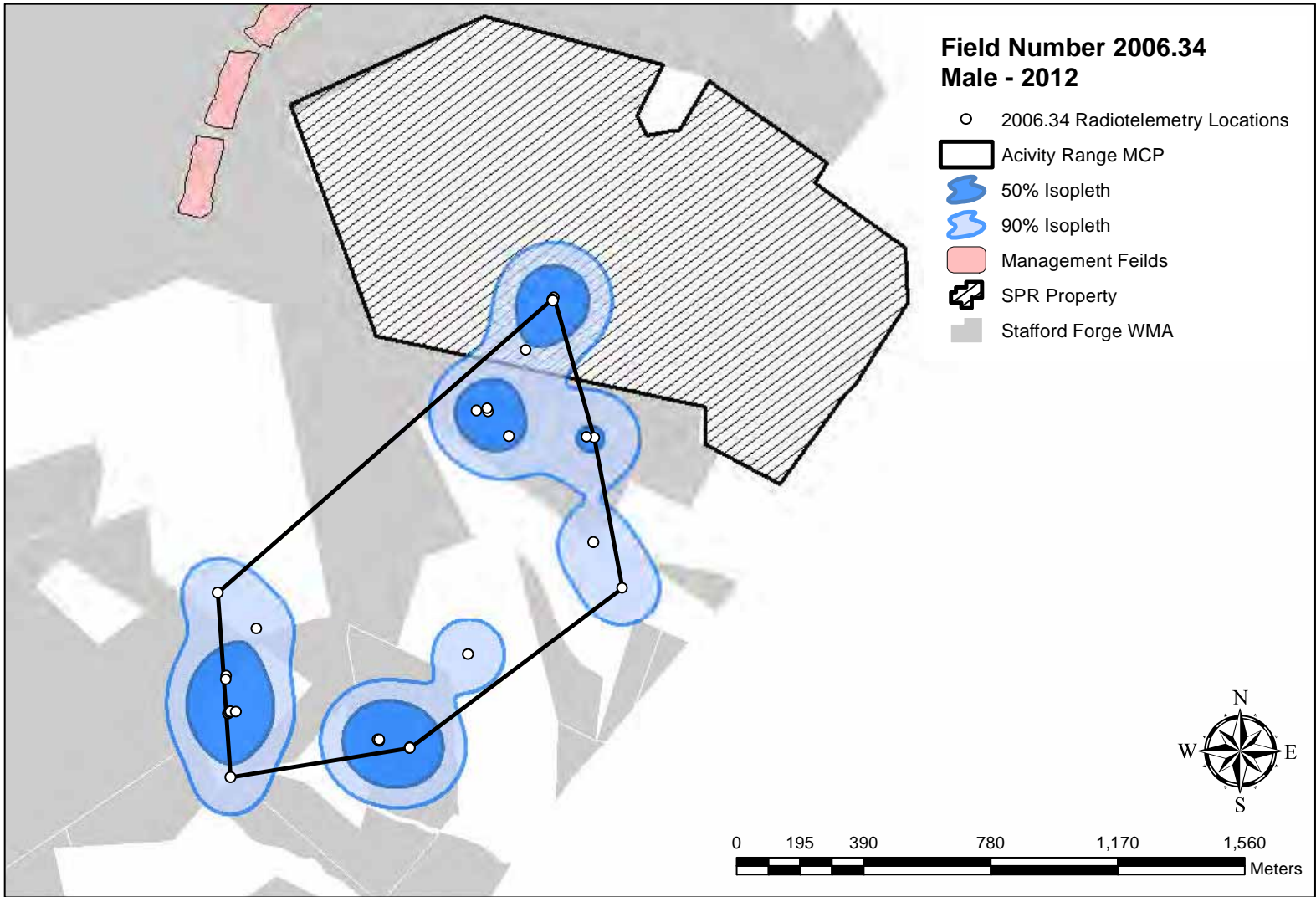


Figure 16. 2012 activity range of pine snake 2006.34, showing 100% minimum convex polygon (MCP), and 50% and 90% kernel density estimator isopleths (KDE).

	Acres	Hectares
MCP	252.7	102.3
KDE 50%	54.7	22.1
KDE 90%	201.2	81.5

N. Pine Snake 2006.46 (♀). (2006 Hatchling, Treatment A/1 Winter) Current status = Alive and healthy. This snake was originally hatched in HA's laboratory in 2006 and released into AH 1.

This snake was found basking near the entrance to NH 2 on 03/19/2012. When it was scanned for a PIT tag, it was found to be from the 2006 cohort hatched in the laboratory. It was originally released into AH 3, a one winter treatment, in the fall of 2006. It had been recaptured twice in the past, once in 2008 in a trap attached to AH 1, and again in 2009 in a trap attached to AH 3. On both occasions it was considered too small to be implanted with a radio-transmitter. However, when recaptured at the beginning of the 2012 activity season, it had grown considerably, and was of suitable length and weight to be surgically implanted and introduced into the radio-tracking study.

Upon being released after transmitter implantation surgery this snake immediately moved to the east side of MF 3. For the majority of the 2012 field season, this snake was most often recorded in the habitat surrounding MF 3. It would make small moves away from the field to forage in the surrounding pine and pine/oak forest and then return to the management field berms to shed.

During April, there were three different observations of mating or courtship involving this snake and male snakes. The first occurred on 04/13/2012, when this snake was relocated being scent trailed by an unknown male pine snake. The second observation was on 04/19/2012, when it was observed mating with another unknown male snake. Finally, on 04/21/2012, it was again found being scent trailed by an unknown male. Although this snake was observed mating, it was never observed excavating a nest. It is possible it nested in the berm along MF 3, since it was relocated inside the berm during the nesting season. There have been many observations of snakes nesting within the interior of the earth berms, instead of in the open areas of the management fields.

An interesting observation occurred with this snake on 10/02/2012, when it was relocated on the capped landfill. It was found concealed in the grass at the end of a drainage culvert between the compost area and the raised portion of the landfill. Prior to the end of the season, this snake was found basking next to the entrance to NH 2, however, the snake did not overwinter in NH 2 this year. Instead, it moved to a previously unknown hibernaculum. This den is a large mammal burrow located in upland pine forest approximately 250 meters northeast of MF 3. A home range map is not provided for this snake because there were not enough relocation points available due to lost data.

N. Pine Snake 2006.49 (♂). (2006 Hatchling, Treatment A/1 Winter) Current status = Alive and healthy. This snake was originally hatched out in HA's lab in 2006 and released into AH 1.

This snake was found in a trap on the corral around NH 42 in late March. It was removed from the field for transmitter replacement surgery and released at NH 42 on 04/05/2012. It was relocated 101 times during the 2012 field season. Upon release, this snake made a large move away from its den into pine/oak forest approximately 830 meters southeast of its hibernaculum, where it remained for the first half of April. It then made a large move back to the northwest and was found basking next to a small mammal burrow that was located directly under a scrub oak. This is a mammal burrow that this snake was found in, or next to, for an extended period of time towards the end of the 2011 field season. This snake then proceeded to spend the rest of April concealed inside the burrow. When it finally was located above ground again on 05/02/2012, it appeared to have recently shed.

This snake then moved into pine forest south of the landfill for the first two weeks of May. The majority of observations during this time consisted of the snake being concealed amongst the shrub and duff layers. The snake then moved closer to the landfill and was relocated in, and next to, a series of earth mounds created when some clearing was done along the southern portion of the landfill. On 05/24/2012, this snake was observed being mobbed by two chipping sparrows (*Spizella passerina*) and a northern mockingbird (*Mimus polyglottos*). Interestingly, it once again appeared to have recently shed, suggesting that this snake went into a shed cycle twice in the period of a month.

On 05/31/2012, this snake was observed mating with a female. The observer waited for the snakes to finish copulating and then scanned the female to see if it had been identified and inserted with a PIT tag earlier in the study. The female was identified as pine snake 2009.11, which was a young of the year snake captured in an AH 3 trap on 05/01/2009.

For the majority of June, July, and August this snake moved back and forth between the pine/oak forest south of Slocum Road and the pine forest immediately adjacent to the south side of the landfill. This is all habitat previously identified as part of this snakes home range in 2011. During 2012 this snake was the most likely snake to be located very near to the SPR property on a regular basis. In fact, on 08/22/2012, this snake was relocated traveling within less than 50-meters of new construction occurring on the SPR property.

From the end of August until the middle of September, this snake was consistently relocated, in or near, the earth mounds mentioned previously in this synopsis. During this period of time, it was also observed to be opaque. It is highly likely this snake uses these earth mounds as a shedding station, due to the number of times it was observed in a pre-shed or post-shed condition when in the vicinity of these mounds. On 09/13/2012, it returned to the small mammal burrow under the scrub oak where it had been earlier in the field season and remained there for the rest of September. This snake was also located in this burrow at the end of the 2011 field season.

This snake was found in a trap attached to AH 3 on 10/06/2012. It was removed from the trap and released into the den. However, after spending approximately two weeks in AH 3, it moved out of the den and returned to NH 42, where it is currently overwintering. The full activity season home range of this adult male pine snake is illustrated in **Figure 17** on the next page.

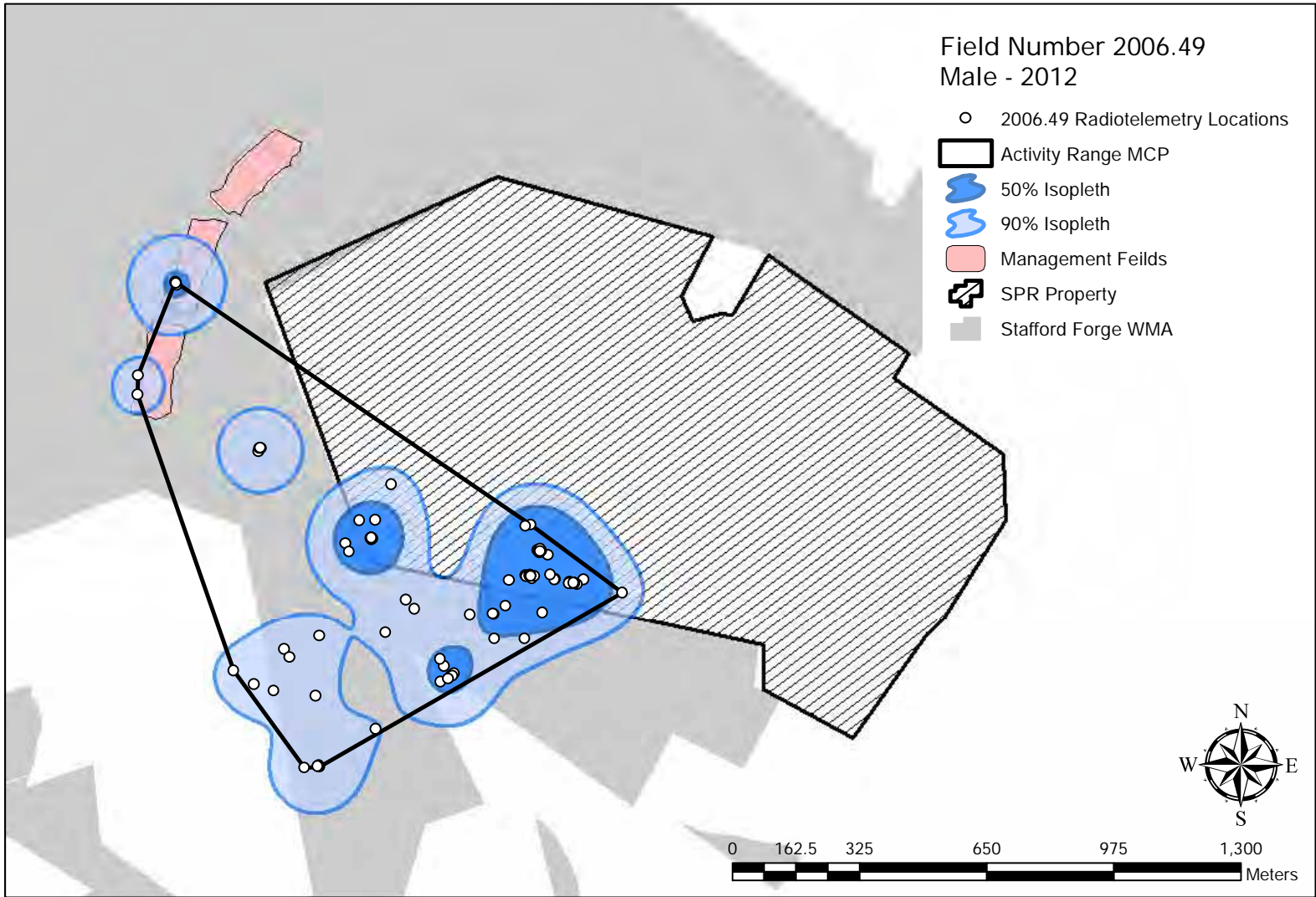


Figure 17. 2012 activity range of pine snake 2006.49, showing 100% minimum convex polygon (MCP), and 50% and 90% kernel density estimator isopleths (KDE).

	Acres	Hectares
MCP	181.8	73.6
KDE 50%	30.8	12.5
KDE 90%	142.5	57.7

N. Pine Snake No. 2006.108 (♂) (Shifted Snake, Treatment A/1 winter) Current status = Alive and healthy. This snake was originally caught in trap 10 on the perimeter drift fence by EcolSciences, Inc. on 10/05/06.

This snake egressed from its den on 04/04/2012 and was immediately pulled for transmitter replacement surgery. It was released back into the field on 04/06/2012 and relocated 100 times during the 2012 field season. When this snake was originally pulled on 04/04/2012, its left eye was completely clouded over, but, this condition healed and improved as the field season progressed.

Upon being released back into the field, this snake spent a small portion of time basking in the upland pine forest along the western edge of Micaja Road before making a large move to the east/northeast into upland pine/oak forest. This is habitat that has been previously established as part of its home range during prior field seasons. This relocation found the snake either concealed in or under a fallen log that it has also been found at over the past years. The snake virtually remained in this location for the entire month of April and first week of May. It is possible the snake was trying to heal from transmitter surgery and the injury to its left eye.

Upon leaving the confines of the fallen log, this snake made a quick foray to the management fields where it was observed foraging along the edge of MF 1. It then once again returned to the aforementioned fallen log and spent the rest of May there. This snake then spent the first half of June in the upland pine forest near the landmark known as the “beach pond” (see **Appendix IV**) where it was often relocated basking on top of, or concealed among, the pine needles on the forest floor before again returning to the fallen log.

The snake then returned to the management fields on 07/08/2012. For the next month and a half, it was consistently relocated concealed in or basking nearby the earth berms along the western edge of MF 1, or in the earth mounds lining the outer corral path of AH 1. Then on 08/20/2012, it made a large move of almost two kilometers into the upland pine forest west of Micaja Road in the vicinity of its den. It remained here for a few days before again returning to the berms along the west edge of MF 1.

On 09/11/2012, this snake was observed approximately three quarters of the way up a dead pitch pine. Portions of the snakes body were protruding from two different cavity holes in the sides of the tree. The observer noted that the snake could be seen constricting and contracting its body and there was a large portion of what appeared to be some kind of nesting material pushed outside of one of the cavities. It was apparent to the observer that the snake was feeding on some prey item, but the snake never showed itself with the prey in its mouth.

In late September, this snake returned to the isolated tract of upland pine forest west of Micaja where it had hibernated last winter. A few relocations found the snake up basking or concealed in the leaf litter near the opening of its den (NH 27). On 09/27/2012 it entered its den, the very first snake to do so this year, and is currently overwintering there. The full activity season home range of this adult male pine snake is illustrated in **Figure 18** on the next page.

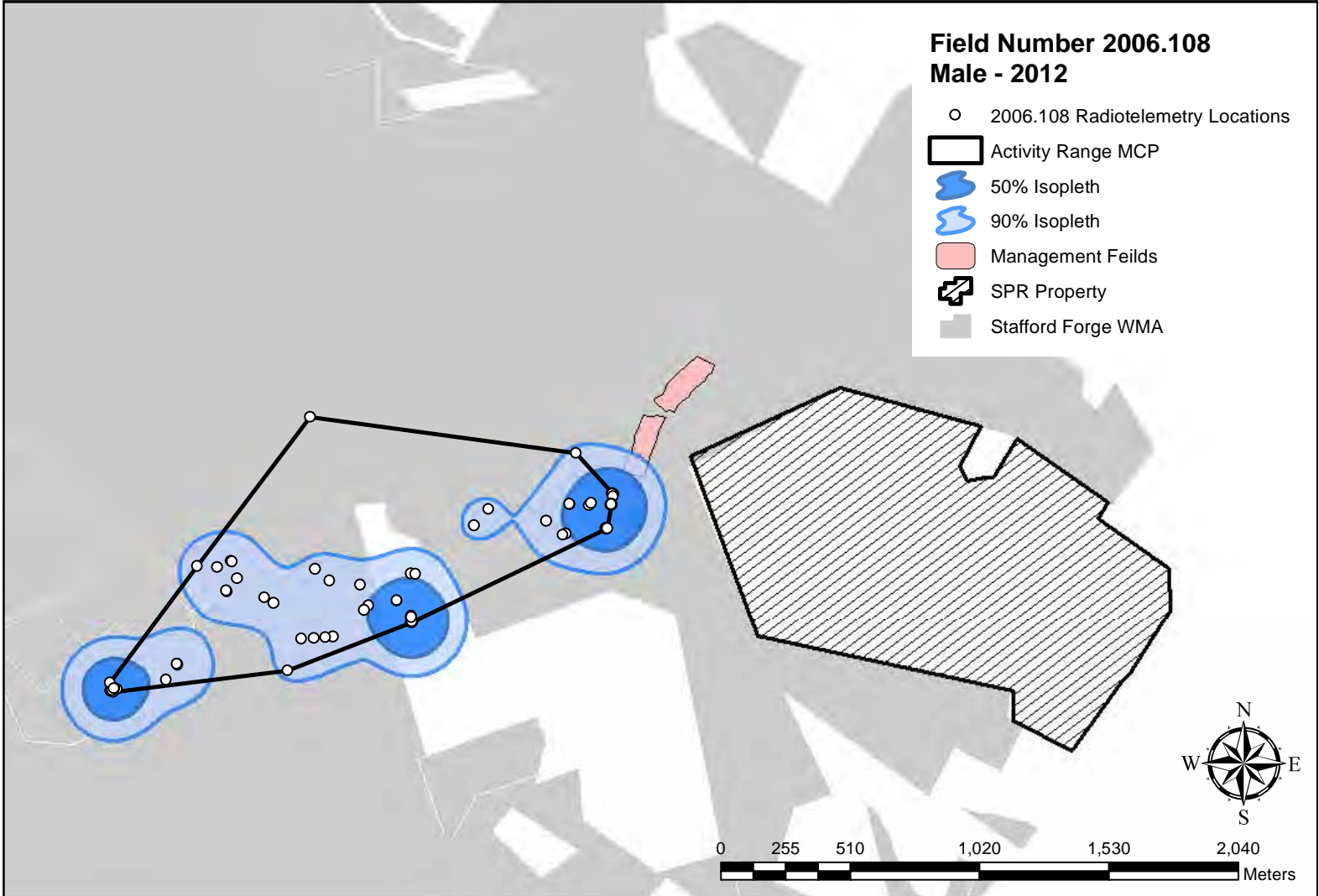


Figure 18. 2012 activity range of pine snake 206.108, showing 100% minimum convex polygon (MCP), and 50% and 90% kernel density estimator isopleths (KDE).

	Acres	Hectares
MCP	283.0	114.5
KDE 50%	51.0	20.6
KDE 90%	218.9	88.6

Pine Snake No. 2007.07 (♀). Current status = Alive and healthy. This snake was originally captured on 06/03/07 by HA staff as it was crossing Hay Road.

This snake egressed from NH 33 on 03/29/2012. Similar to previous years this snake would split its time between pine/oak forest approximately 1.8 kilometers north of the management fields near Route 72 and the pine and pine/oak habitat bordering the edges of Hay Road further in the interior of Stafford Forge Wildlife Management Area.

In past field seasons, this snake was observed mating multiple times, including with male study snake 2007.10. However, it was never observed mating in 2012, nor did it appear gravid. On 08/16/2012, it was observed consuming a nest of white-footed mice (**Figure 19**).

At the end of the field season, this snake made a large move southwest to the vicinity of the Hay Road Pond and an old hibernaculum it had used in the past. However, the snake did not return to its old hibernaculum, rather, it made a large move into the interior of the upland pine forest northwest of the management fields. It is currently overwintering in a previously identified hibernaculum (NH 20) in this tract of pine forest. A home range map is not provided for this snake because there were not enough relocation points available due to lost data.



Figure 19. Female pine snake 2007.07 constricting a white-footed mouse in a small hole on the forest floor. Photo by R.T. Zappalorti, Herpetological Associates, Inc.

N. Pine Snake No. 2007.09 (♂) (Figure 20). Current status = Deceased. This snake was originally captured by HA staff on 06/04/07, and was found by random searching. It was concealed in a trash pile under discarded plywood and was of suitable length and weight to be surgically implanted with a radio-transmitter.

Pine snake 2007.09 was found dead in early March when HA staff went to check on the snakes due to an unseasonably warm spell. It was found dead outside of its hibernaculum. The cause of death is unknown, but, we suspect it froze to death. HA has found other pine snakes that emerged from their dens during winter thaws to bask on the surface. It is possible that sudden cold weather made the snake too cold and it could not crawl back down into the den, and froze on the surface (Burger and Zappalorti 2011).



Figure 20. Adult male Pine Snake 2007.09 basking at its den in the spring of 2011. Notice the orange sand on its head and body dorsal scales. Photo by R.T. Zappalorti, Herpetological Associates, Inc.

N. Pine Snake No. 2007.10 (♂). Current status = Alive and healthy. This snake was originally captured by HA staff on 06/05/07 traveling near the radio tower along the northern portion of the SPR construction site.

This snake had emerged from its winter hibernaculum by 03/29/2012, when it was located basking approximately 600 meters southwest of its NH 43. During the month of April, this snake continuously moved about the large tract of pine/oak and oak/pine forest sandwiched between the Mill Creek wetland corridor and Route 72. This section of forest has been identified as part of this snake's home range in previous years and is referred to as the "powercut" (see **Appendix IV**) in previous reports. It is located approximately 1.5 kilometers northwest of the management fields. It was often observed foraging or coiled up next to small mammal burrows that appeared to be active due to large amounts of pine chips scattered around the entrances. There was one feeding observation on 04/20/2012 when the snake was located feeding on a nest of young eastern cottontails.

On 04/30/2012, this snake moved deep into the interior of the Mill Creek wetland corridor. It spent a few days in a large open canopied cedar swamp that had been decimated by the fire in 2007. There was little to no overstory at the snakes location, but there was a large amount of dense understory in which the snake had concealed itself. After leaving Mill Creek, it returned to the "powercut".

In May, this snake made a few forays across the Mill Creek wetland into the unburned forest along the northeastern edge of Hay Road. In the past, when this snake moved west across the wetland, it was often observed mating with former study snake 2006.29. However, study snake 2006.29 died in 2011. In 2012, this snake was never observed mating with any female pine snakes when it would cross over into habitat west of Mill Creek. Also, in prior years, this snake was observed mating with female study snake 2007.07. Even though female study snake 2007.07 is still currently alive, it was never observed mating with 2007.10 in 2012. In fact, 2007.10 was never observed mating this season.

For the majority of the 2012 field season, this snake was consistently located in the previously mentioned pine/oak and oak/pine habitat. Many times it was relocated at fallen logs, mammal burrows and stump holes that it had been recorded at in prior field seasons. Often, when at these locations, the snake would be in shed, indicating these features are "shedding stations" that the snake has used for many years. One other interesting observation of this snake occurred on 07/12/2012, when it was again relocated in the Mill Creek wetland corridor. On this occasion, the snake was found inside a large standing dead Atlantic white cedar tree. However, there were no discernable entrances into the tree according to the observer; it is unknown how or why the snake was inside the tree.

In early October, this snake moved back into the area of forest where it hibernated last winter. Unfortunately, at this time the snake's transmitter began to fail. It is unknown why the transmitter began to fail since it was not due to be replaced until 2013. October 11th was the last day that the observer was able to relocate this snake. On that date, the signal was extremely weak even though the snake was not far from the observer's car. After the 11th, no signal was received on this snake despite numerous efforts. The full activity season home range of this snake is illustrated in **Figure 21** on the next page.

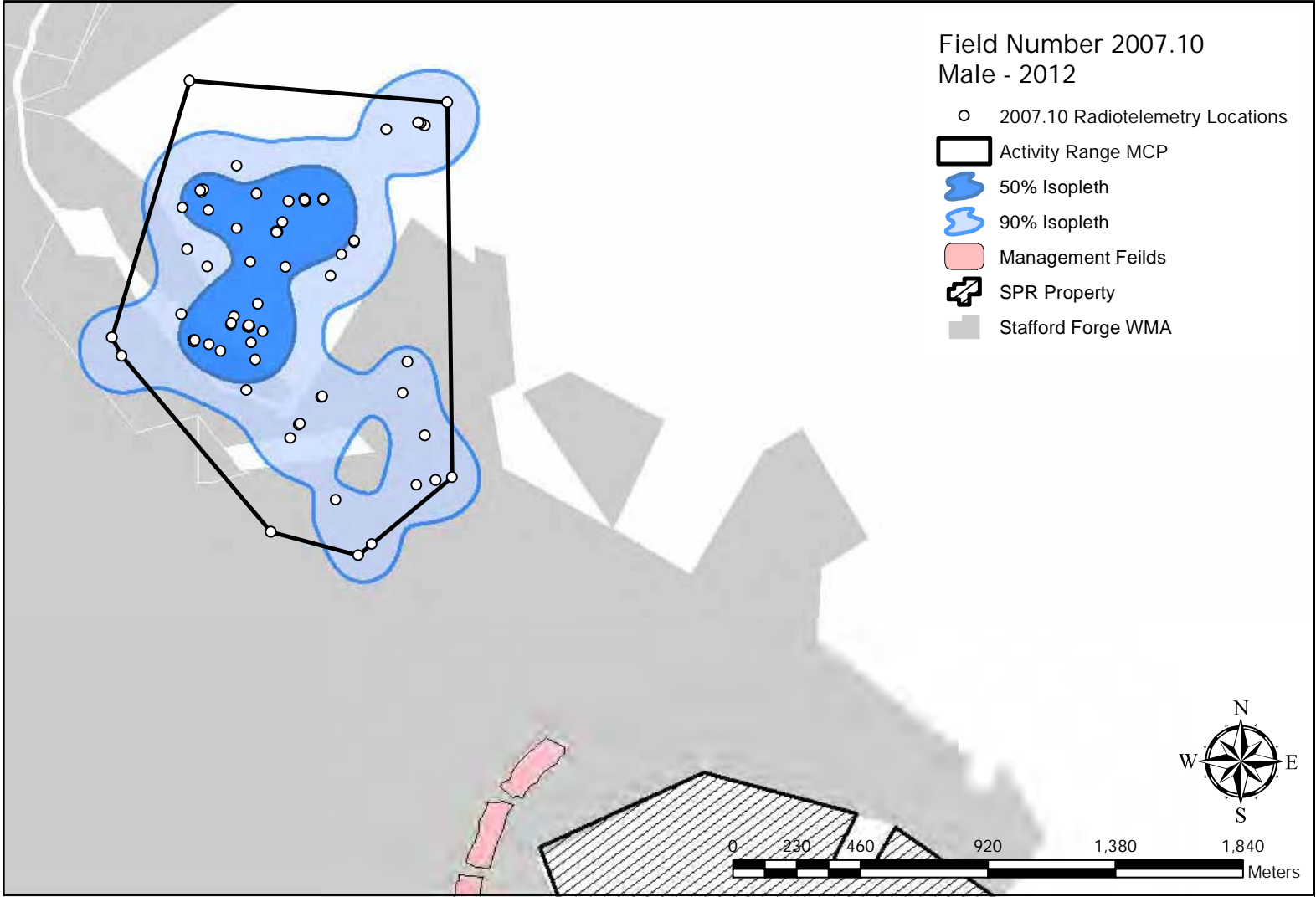


Figure 21. 2012 activity range of pine snake 2007.10, showing 100% minimum convex polygon (MCP), and 50% and 90% kernel density estimator isopleths (KDE).

	Acres	Hectares
MCP	400.5	162.1
KDE 50%	76.6	31.0
KDE 90%	318.3	128.8

N. Pine Snake No. 2007.11 (♂). Current status = Alive and healthy. This snake was captured by HA staff on 06/15/07, while radio-tracking pine snake 2006.34.

This snake had already emerged from NH 8 when staff went out to randomly check on the snakes on 03/19/2012. The snake was located basking in the disturbed pine forest habitat known as “the Stafford triangle” (see **Appendix IV**) for a few days before making a large move of approximately one kilometer to the northeast into pine/oak forest along the western edge of Micaja Road. This tract of forest has been previously identified as part of this snakes home range in prior years. During the month of April, this snake was relocated within the pine forest and oak/pine forest approximately 2.3 kilometers south of the management fields. All of these relocations occurred in habitat that has also been identified as part of this snakes home range in prior field seasons and was often observed near subterranean structures (mammal burrows and stump holes) that it has been at in earlier years.

This snake was observed on three separate occasions in May in the company of a female pine snake. The first observation occurred on 05/07/2012, when it was observed stretched out next to an unknown female. Unfortunately, the female spooked and moved off into the shrub layer. A second observation occurred on 05/14/2012, when this snake was again located next to an unknown female pine snake. On this occasion, the female did not spook; unfortunately, no actual mating or courtship behavior was observed. Finally, on 05/18/2012, this snake was observed mating and copulating with an unknown female pine snake. Since all three observations took place in the same general area, it is possible that it was always the same female with which this snake was observed. During the majority of June, this snake used the habitat previously mentioned above. On one occasion it was observed in the cavity of a tree being mobbed (harassed) by some eastern bluebirds (*Sialia sialis*) and a brown thrasher (*Toxostoma rufum*).

In fact, for the majority of the summer, this snake was found in the same habitat as prior field seasons. However, on two occasions, this snake made forays northeast across the Cedar Run wetland corridor. Both times, the snake was observed going into a shed cycle and was relocated at “shedding stations” that other study snakes had used. These two “stations” were the discarded tire on the “glass pile” (see **Appendix IV**) and an old metal motorcycle gas tank. Two other study snakes have been found in shed at these locations on different occasions throughout the study.

Usually, this snake is one of the first to enter its den for hibernation. In previous years, this snake would be found in its den by late September or early October, however, this year proved different. Indeed, this snake was found in its den on 09/17/2012, however, it only remained there for a week before making a large move northeast. Following this move, it was relocated concealed next to a stump hole that it used earlier in the field season. On 10/15/2012, it was relocated back in its den. However, it left the den again and moved to a large coyote burrow approximately 227 meters to the southeast. This snake, along with study snake 2007.14, had been found at this coyote burrow late in the year during prior field seasons. It stayed here for a couple of days before moving back to NH 8 where it is currently overwintering. The full activity season home range of this adult male pine snake is illustrated in **Figure 22** on the next page.

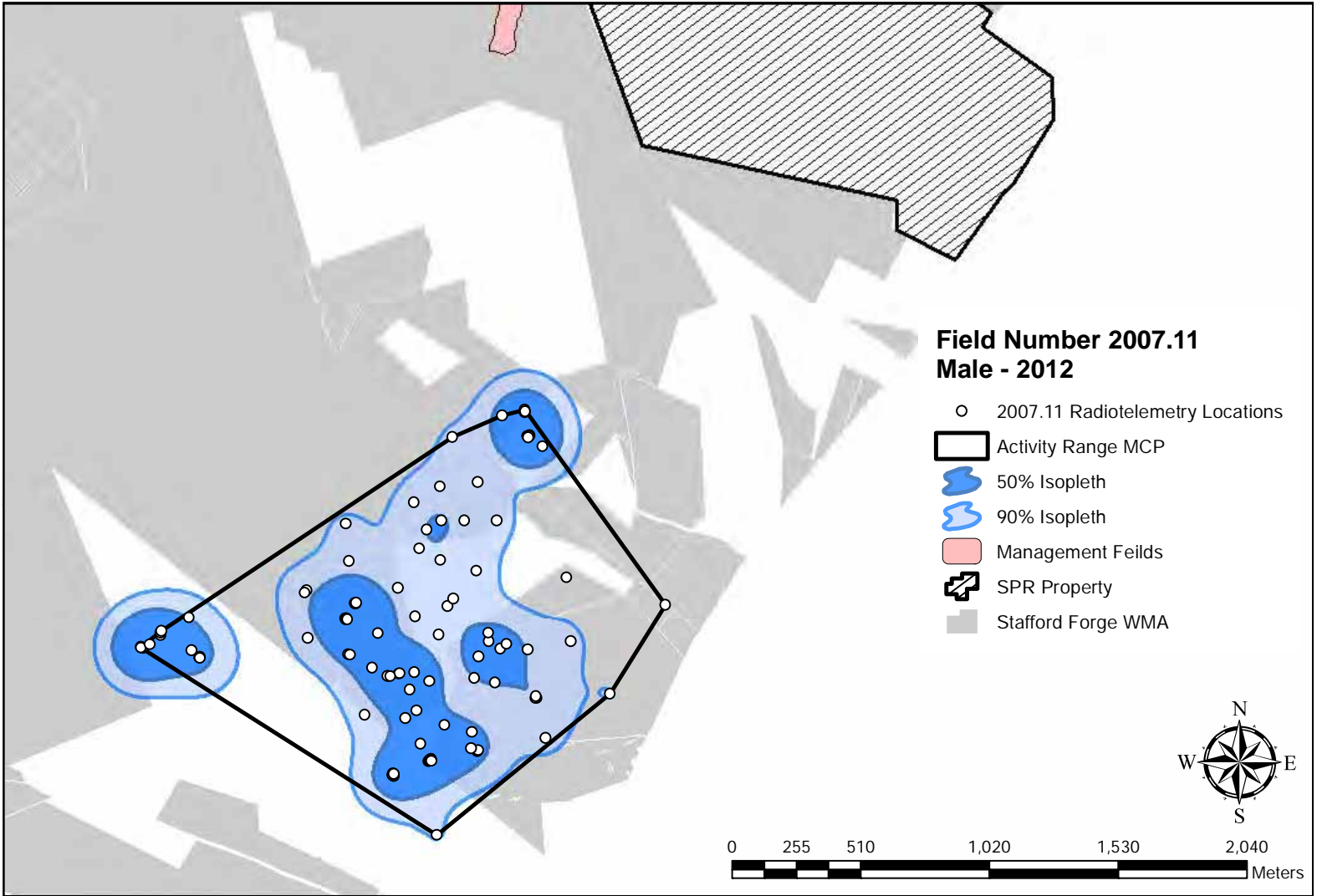


Figure 22. 2012 activity range of pine snake 2007.11, showing 100% minimum convex polygon (MCP), and 50% and 90% kernel density estimator isopleths (KDE).

	Acres	Hectares
MCP	455.9	184.5
KDE 50%	121.8	50.1
KDE 90%	370.2	149.8

N. Pine Snake 2007.14 (♂) (**Figure 23**). Current status = Alive and healthy. This snake was originally captured on 08/11/07 near the landmark known as the “glass pile,” which is located south of the SPR property.

This snake had egressed from its den by 04/10/2012, when it moved away and was subsequently relocated concealed in leaf litter in the upland pine forest west of Micaja Road. Similar to previous years, this snake was often relocated in the upland pine forest that borders Micaja Road in Stafford Forge WMA. It was also frequently observed foraging in the pine/oak forest that borders Slocum Road.

This snake was never observed mating in 2012. In the fall of 2012, it migrated back to NH 27. It is currently overwintering with another of our radio-tracked snakes (2006.108). A home range map is not provided for this snake because there were not enough relocation points available due to lost data.



Figure 23. Adult male pine snake 2007.14 basking on the forest floor. Photo by David Burkett, HA Staff.

N. Pine Snake No. 2008.03 (♀). Current status = Unknown. This snake was originally captured by HA staff attempting to egress from a corralled natural den (NH 5), on 04/16/08.

This snake had egressed from its den by the beginning of April (see **Figure 24**). During the 2012 field season it was often relocated in the pine/oak habitat northeast of Hay Road and in the selectively thinned forest that borders the western side of Hay Road.

The location status of this snake is currently unknown due to the sudden premature failure of its radio-transmitter during the middle of August. A home range map is not provided for this female snake because there were not enough relocation points available due to lost data.



Figure 24. Adult female Pine Snake 2008.03 basking near its den in the spring of 2012. Photo by David Burkett, HA staff.

N. Pine Snake No. 2009.13 (♂). Current status = Alive and healthy. This snake was originally captured by HA staff in trap number 16 of the perimeter drift fence line in early June 2009.

This snake had emerged from NH 40 by 04/02/2012. For the first few weeks, this snake was relocated not far from its den location in the selectively thinned forest along the south side of Hay Road. It was often found in brush piles, large woody debris, and the uprooted bases of pitch pines.

As in previous summers, this snake was relocated in the earth berm along the western edge of MF 3 at various times throughout the season. It was often found in the forest along the west and east sides of Hay Road, moving back and forth between the selectively thinned forest on the west side of the road and the non-thinned forest on the east side. On October 10th, this snake was located in NH 20 where study snake 2007.07 is currently overwintering. However, the snake only remained in this den for a few days before making a large move back into the selectively thinned forest along Hay Road. It remained in the thinned forest for three days before being located in NH 2 directly behind AH 6. The snake is currently overwintering in NH 2. A home range map is not provided for this female snake because there were not enough relocation points available due to lost data.

Home Range Analysis

Table 3 shows the Minimum Convex Polygon (MCP) home range, as well as, the 50% and 90% kernel activity range isopleths in acres and hectares for each individual snake radio-tracked during the 2012 field season (Samuel et al, 1985; Tiebout and Carey 1987; Seaman and Powell 1996). **Table 3** also shows the number of relocations for each northern pine snake with complete data sets for 2012.

Table 3. MCP and Kernel Activity Range (Both 50% and 90 % Isopleth) in Acres and Hectares for 13 Radio-tracked Pine Snakes in 2012.								
HA Snake Field ID Number	Sex	Number of Relocations	Minimum Convex Polygon		50% Kernel Home Range Isopleth		90% Kernel Home Range Isopleth	
			Acres	Hectares	Acres	Hectares	Acres	Hectares
2006.16	M	84	424.2	171.7	68.9	27.9	302.9	122.6
2006.34	M	31	252.7	102.3	54.7	22.1	201.2	81.5
2006.49	M	101	181.8	73.6	30.8	12.5	142.5	57.7
2006.108	M	100	283.0	114.5	51.0	20.6	218.9	88.6
2007.10	M	90	400.5	162.1	76.6	31.0	318.3	128.8
2007.11	M	103	455.9	184.5	121.8	50.1	370.2	149.8
N=13	6 Males							

Figure 25 on the next page, shows a composite map of all of the 2012 radio-tracked pine snake relocations with both MCP and Kernel analysis of all the points. This map depicts four areas within the 50% isopleths which suggest important activity centers for the radio-tracked snakes in 2012.

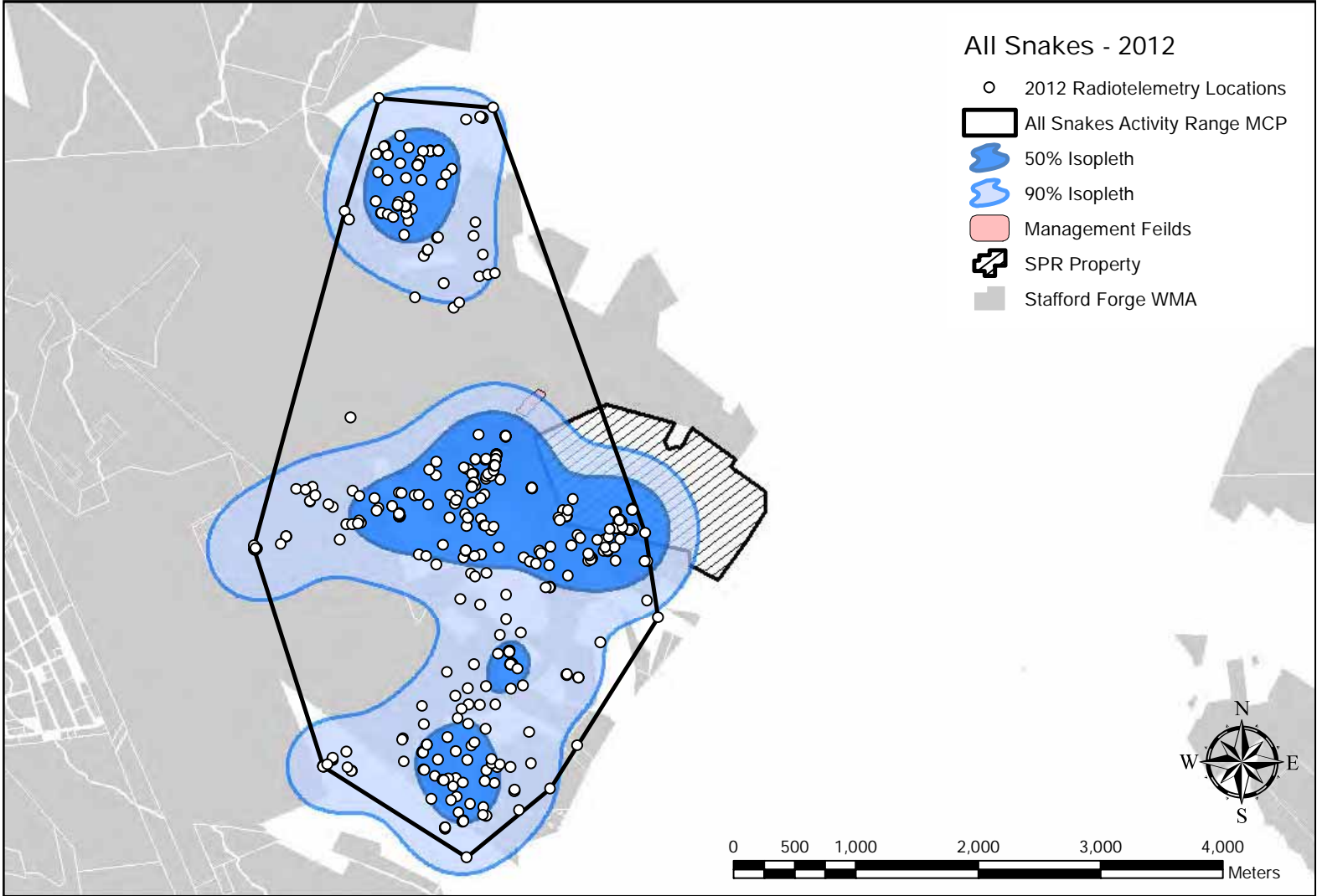


Figure 25. 2012 activity range of all radio-tracked pine snakes, showing 100% minimum convex polygon (MCP), and 50% and 90% kernel density estimator isopleths (KDE).

	Acres	Hectares
MCP	3,288.6	1,330.9
KDE 50%	844.5	341.7
KDE 90%	2,652.1	1,073.3

HABITAT USE AND BEHAVIORAL ANALYSIS

Radio-tracking and monitoring of northern pine snakes at the SPR property and the adjacent Stafford Forge WMA revealed some interesting habitat preferences by the study snakes. **Table 4** and **Figure 26** provide a comparison by percent of the habitat selected by the shifted, non-shifted, and radio-tracked 2006 hatchling pine snakes during the 2012 field season (McCormick 1970 and 1979, Burger and Zappalorti 1989a, Boyd 1991). **Figure 27** Shows a comparison by percent of the most frequent behaviors observed by free roaming pine snakes within Stafford Forge WMA in 2012.

For the purpose of this investigation, habitat types selected and used by northern pine snakes in 2012 are defined as follows:

Open Field - little or no trees, sandy soil often dominated by various native grass species.

Artificial Hibernaculum - artificial snake shelter or den, designed and constructed by HA and located in the management fields.

Barren Ground/Disturbed - habitat with little to no vegetative cover or habitat that has been altered by human disturbance.

Ecotone Between Upland and Wetland - transitional edge between upland forest habitat and wetland habitat.

Forested Wetland - hardwood trees and/or cedar dominated wetland corridors.

Ecotone Between Forest and Barren Ground - transitional habitat between upland forest and disturbed or barren habitat (e.g., the management fields, and SPR property).

Pine/Oak Forest - pitch pine dominated forest, but containing an oak component.

Oak/Pine Forest - oak dominated forest, but containing a pitch pine component.

Pine Forest - pitch pine forest with no other overstory tree species present.

Selectively Thinned Forest - area of forest within Stafford Forge Wildlife Management Area that was selectively thinned by the New Jersey Division of Parks and Forestry.

Emergent Wetland - open canopy wetland habitat with herbaceous vegetation dominating the saturated substrate.

Note: The above listed forest types and descriptions were modified from McCormick (1970 and 1979) and Boyd (1991).

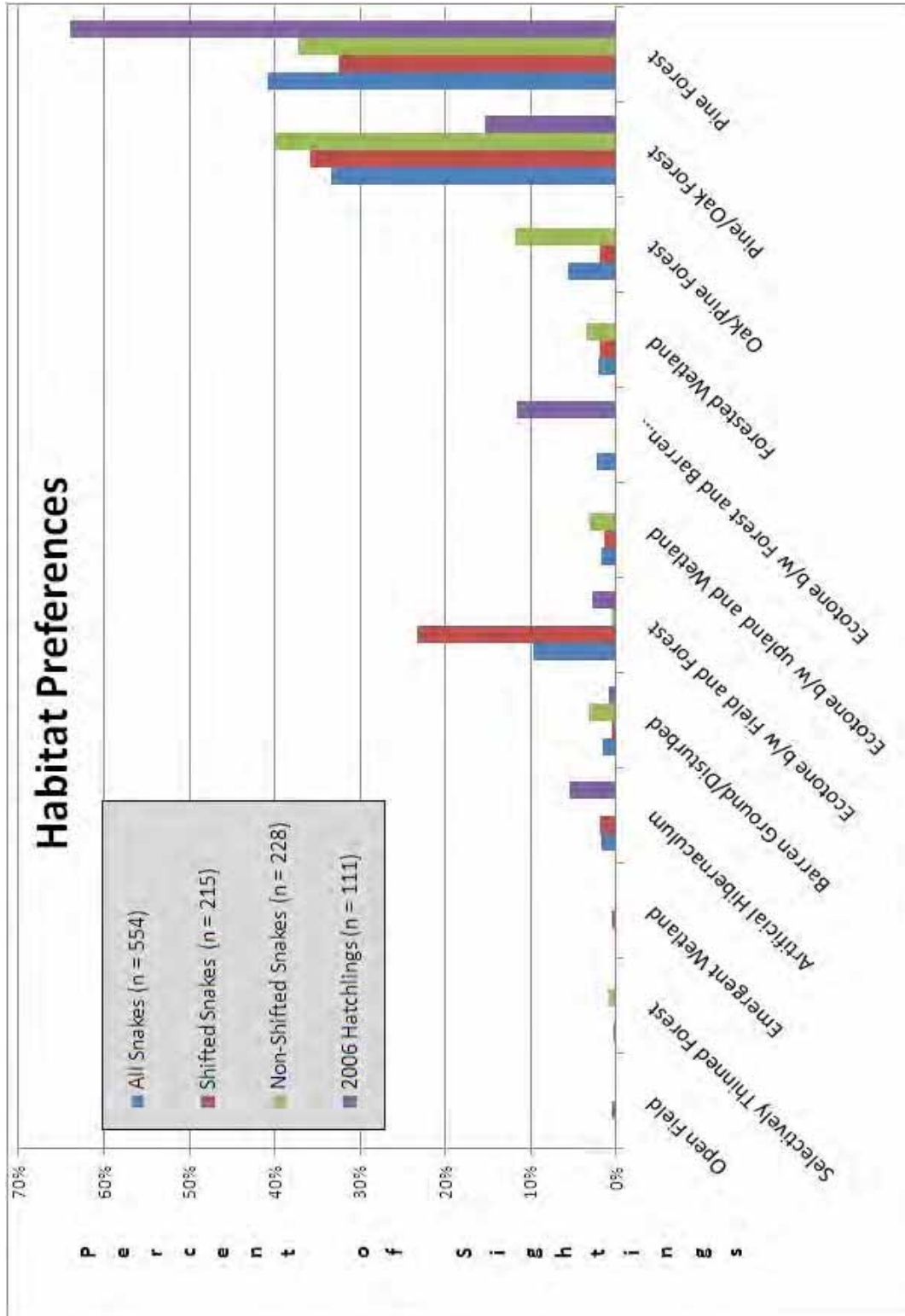


Figure 26.

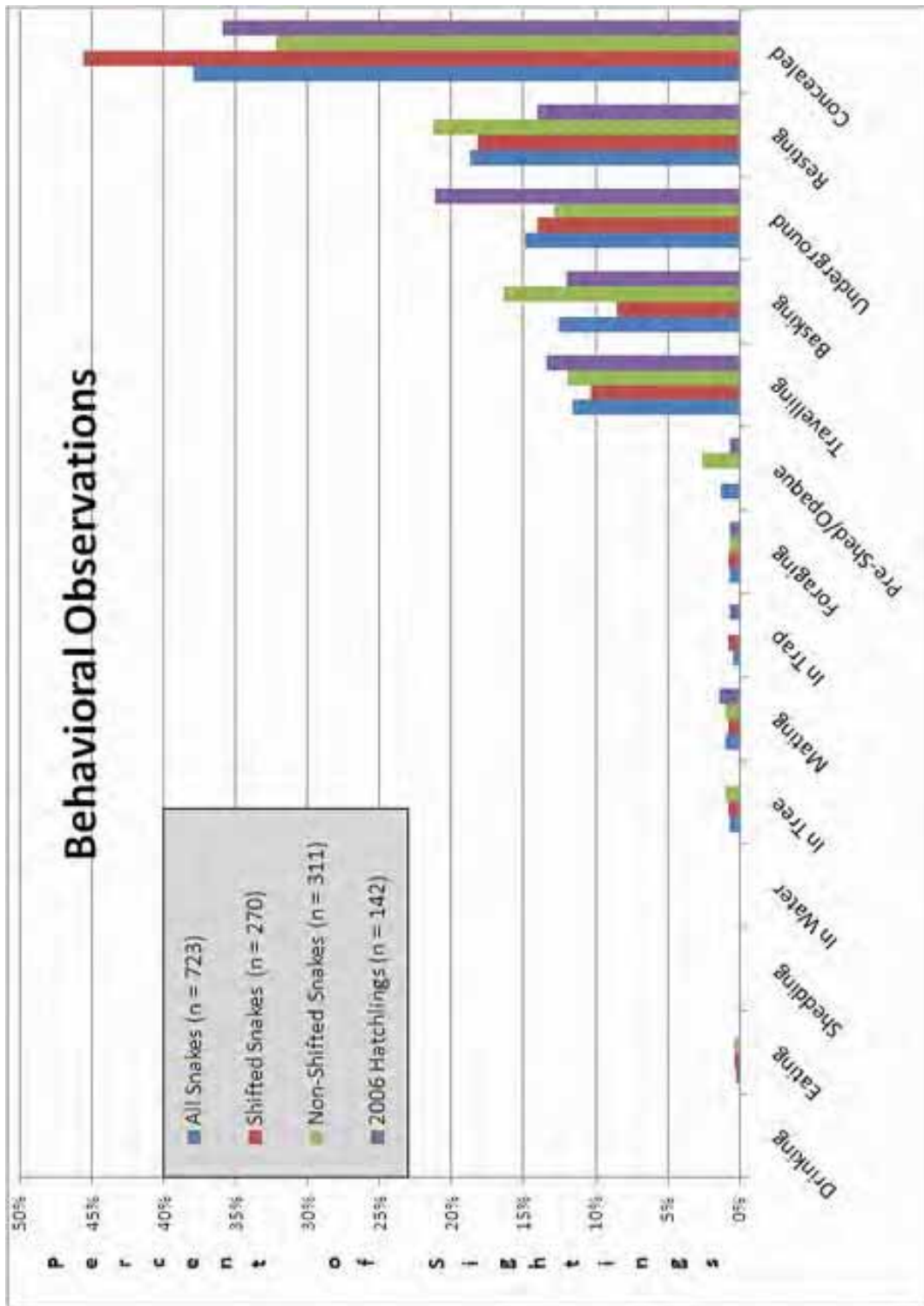


Figure 27.

Habitat Types	All Snakes (n = 554)		Shifted Snakes (n = 215)		Non-Shifted Snakes (n = 228)		2006 Hatchlings (n=111)	
	Number of Relocations	Percent of Total	Number of Relocations	Percent of Total	Number of Relocations	Percent of Total	Number of Relocations	Percent of Total
Open Field	1	0.18%	1	0.47%	0	0.00%	0	0.00%
Selectively Thinned Forest	2	0.36%	0	0.00%	2	0.88%	0	0.00%
Emergent Wetland	1	0.18%	1	0.47%	0	0.00%	0	0.00%
Artificial Hibernaculum	10	1.81%	4	1.86%	0	0.00%	6	5.41%
Barren Ground/Disturbed	9	1.62%	1	0.47%	7	3.07%	1	0.90%
Ecotone Between Field and Forest	54	9.75%	50	23.26%	1	0.44%	3	2.70%
Ecotone Between Upland and Wetland	10	1.81%	3	1.40%	7	3.07%	0	0.00%
Ecotone Between Forest and Barren Ground	13	2.35%	0	0.00%	0	0.00%	13	11.71%
Forested Wetland	12	2.17%	4	1.86%	8	3.51%	0	0.00%
Oak/Pine Forest	31	5.60%	4	1.86%	27	11.84%	0	0.00%
Pine/Oak Forest	185	33.39%	77	35.81%	91	39.91%	17	15.32%
Pine Forest	226	40.79%	70	32.56%	85	37.28%	71	63.96%
Total Relocations	554	---	215	---	228	---	111	---

THREE EXPERIMENTAL SNAKE TREATMENTS

By the end of the 2012 field season, only three original study snakes remained from the three treatment study groups (excluding 2006 hatchlings). Below are brief histories of the treatments and which snakes still remain alive from each study group.

Treatment A Snakes (One Winter, Excluding 2006 Hatchlings):

There were originally 12 snakes (not including hatchlings) in Treatment A, 9 of which were radio-tracked adults. The other three snakes were sub-adults and too small to surgically implant with transmitters. Instead, they were PIT tagged (Elbin and Burger 1994) and placed into the one winter treatments. At the beginning of the 2012 field season only one pine snake (study snake 2006.34) remained alive from this treatment.

Unfortunately, pine snake 2006.34 was found deceased on May 26th of this past year (refer to Snake Synopses and Home Range Maps). Therefore, none of the original 9 radio-tracked adult snakes remain from this treatment. However, in early 2010 a non-radio tracked male pine snake was found mating with a female study snake. This pine snake was 2006.108, one of the three “Treatment A” sub-adult snakes too small to implant in 2006. After this snake was done mating it was collected by HA staff for reprocessing. It was determined that it had grown to a sufficient body weight to be implanted with a transmitter. This snake currently remains alive and healthy and is overwintering in the same den as last winter.

Treatment B Snakes (Two Winters, Excluding 2006 Hatchlings):

There were originally 9 snakes (not including hatchlings) within “Treatment B”, 8 of which were radio-tracked adults. The other was a juvenile snake that could not be radio-tracked because it was too small at the time. All 8 of the original radio-tracked snakes from this treatment were found deceased prior to the 2012 field season (refer to **Appendix II** for the deceased snake synopsis). Therefore, no snakes from this treatment set were tracked in 2012.

Treatment C Snakes (One Winter in HA Lab):

There were originally 8 adult snakes in “Treatment C”. These snakes overwintered in HA’s laboratory during the 2006 - 2007 winter, due to various health reasons, and were released into AH 1, AH 4, and AH 6 (all two winter treatments) in the spring of 2007. At the beginning of the 2012 field season, only two snakes (2006.16 and 2006.19) from “Treatment C” remained. Unfortunately, as previously mentioned, pine snake 2006.19 died during transmitter re-implantation surgery (refer to transmitter surgeries in 2012 and/or snake synopsis and home range maps). However, pine snake 2006.16 remains alive and healthy and is currently overwintering in AF 1.

NON-SHIFTED PINE SNAKES

In order to provide a direct comparison with shifted snakes, a control group of non-shifted resident pine snakes have been fitted with radio-transmitters. The behavior and movement patterns of these non-shifted snakes are monitored and recorded simultaneously and via the same methodology as the shifted pine snakes. A total of 6 non-shifted snakes were radio-tracked in 2012, all of which were captured between 2007 and 2009. These snakes were captured using various survey techniques.

During the 2012 field season two of the “non-shifted” study snakes went missing when their transmitters suddenly failed. Another non-shifted snake (2007.09) was found dead outside of its den in February of this past year and thus was never radio-tracked during the 2012 field season (refer to snake synopsis and home range maps). The four remaining “non-shifted” pine snakes are currently overwintering in natural dens previously identified in the study. None of the “non-shifted” pine snakes have ever used the artificial dens.

History of Hatchling and Juvenile Pine Snakes (2006-2012)

2006 Hatchlings - In 2006, HA released 71 hatchling pine snakes, from clutches found on the landfill, into the artificial dens. Since then, HA staff has attempted to continue to account for these hatchlings by trapping the artificial dens during the spring egress and fall ingress, as well as, a select few of the natural dens that have been identified through radio-tracking efforts. Only one of the 2006 hatchling pine snakes was recaptured during the 2012 field season. This was pine snake 2006.46 (**Figure 28**) which was captured basking near the entrance to NH 2 on 03/19/2012. This snake was originally released into AH 3 as a hatchling in the fall of 2006. It had been recaptured on two occasions in the past, once in 2008 in a trap attached to AH 1 and again in 2009 in a trap attached to AH 3. On both occasions, the snake was considered too small to implant with a transmitter. However, when recaptured this year it was determined to have sufficient body weight to be implanted. This is the third 2006 hatchling that has been recaptured over the past six years to be implanted with a transmitter and introduced into the radio-tracking portion of the study.



Figure 28. Pine snake 2006.46. This is one of the hatchlings that was introduced into the artificial dens in the fall of 2006. Photo by David Burkett, HA staff.

2007 Hatchlings - In 2007, HA captured 10 hatchling pine snakes in AH 4 and AH 6. Of these 10, only one was recaptured in 2012. This was pine snake 2007.23, which was found traveling along the edge of MF 1 in late August. This snake was also recaptured by HA staff in 2011 in a trap attached to AH 2 during spring emergence. It appears that the management fields have become an important part of this snake's activity range, since it has been observed using them two years in a row.

2008 Hatchlings - In 2008, HA captured and PIT tagged 11 new hatchling and juvenile pine snakes. Nine of the snakes were from a nesting/denning location south of the SPR property in the area known as the "Stafford triangle" (See Appendix IV). No hatchling pine snakes with a 2008 field number were recaptured in 2012. However, HA staff also captured several young of the year pine snakes in traps attached to the artificial dens, as well as, NH 8 in the spring of 2009. Based on their size these snakes were definitely from 2008 cohorts, but were never captured by HA staff in 2008. This is why they were given 2009 field numbers. One of these (pine snake 2009.11) was observed twice during 2012. The first observation occurred on 05/31/2012, when it was found mating with radio-tracked study snake 2006.49. It was again caught in a trap attached to AF 1 during the fall ingress. This snake had originally been captured in a trap attached to AH 1 on 05/01/2009.

2009 Hatchlings - In 2009, HA staff captured and PIT tagged 40 new hatchling and juvenile pine snakes. Three of these new snakes were caught in the artificial den traps during spring emergence. HA also found a hatchling pine snake concealed under a cover board approximately 1 meter up a large earthen mound at the far north end of MF 3. Two radio-tracked females (field numbers 2006.29 and 2007.15), nested on the very top of this earth mound. It is therefore highly likely that this hatchling was from one of those nests. Also, a dead hatchling was found under a small log next to the entrance of one of the aforementioned nests. However, the vast majority of 2009 hatchling pine snakes came from four different clutches located in the "Stafford triangle". None of these PIT tagged 2009 hatchlings were recaptured in 2012.

2010 Hatchlings - In 2010, HA staff radio-tracked three female pine snakes that were gravid. Two of these females nested in the berm along the western edge of MF 1. The other female pine snake 2006.29, nested along the western edge of the SPR property, about 4 meters from the edge of the forest. In an attempt to capture some of the pine snake hatchlings in late summer, before the eggs began to hatch, HA placed cover boards around the known nest chambers in MF 1. However, no hatchlings were captured or observed under the cover boards or near the nest chamber in the fall of 2010. The nest on the SPR property was corralled by HA staff and Dr. Walt Bien's graduate students from Drexel University, to conduct an experimental study on scent trailing and directional orientation of hatchling pine snakes. Additionally, HA was curious to see how many eggs would hatch, considering it was thought to be a poor location for a nest. The nest produced 10 hatchlings in the fall. These snakes were processed by HA and Drexel students and then released outside the corral walls when the experiment was completed. None of these hatchlings were recaptured in 2012.

2011 Hatchlings - HA staff caught 30 hatchling pine snakes in 2011. Six of the hatchlings were found in the management fields and traps attached to the artificial dens in late summer and early fall. Another twenty four came from two nest sites in the “Stafford Triangle.” None of these 2011 hatchlings were recaptured in 2012. However, HA staff did capture two young of the year snakes during the 2012 spring egress. The size of these two snakes indicated that they had hatched in 2011. One of them was caught in an AH 1 trap and the other was captured at NH 42. Even though they are considered 2011 hatchlings, these two snakes have been given 2012 field numbers.

2012 Hatchlings - In 2012, HA captured 12 hatchlings (**Figure 29**) by random searching and den trapping. Ten of the hatchlings were caught attempting to enter one of the artificial den traps in the management fields during the fall ingress. Another hatchling was observed moving through the management fields during the early fall, and another individual was caught crossing Hay Road, also in the early fall. All of these hatchlings were processed, PIT tagged and released at their point of capture, except for one. One of the hatchlings in the traps had two severe lacerations to it’s body when captured. It was decided that the snake would need medical attention if it were to survive, so the snake was taken to the laboratory for treatment. HA staff immediately cleaned the wounds, which were thought to be made by a predator. The wounds were cleaned out and sutured. The snake is currently overwintering in HA’s laboratory, so it can heal properly. It will be released at its point of capture in the spring of 2013.



Figure 29. Hatchling pine snakes found in the artificial den traps in the fall of 2012. Photo by David Burkett, HA staff.

USE OF MANIPULATED AND ENHANCED HABITAT

With native grass seed provided by Walters, the Department's Division of Land Management planted the three management fields with warm-season grasses on June 1, 2008. The Division drill-seeded the grasses into the mineral soil with only minimal amounts of lime and fertilizer. Over the past four growing seasons these grasses are thriving, and now provide ground cover and shelter not only for pine snakes, but for other species of reptiles and amphibians including hognose snakes, northern black racers, eastern garter snakes and Fowler's toads (HA staff, personal observations). Additionally, the grasses and other vegetation growing in the management fields provides a rich seed stock for prey items such as small mammals and birds. The Department's Division of Land Management mowed the three management fields in March 2012, to keep the grasses and other vegetation in an early succession stage (McCormick 1970 and 1979, Boyd 1991).

In 2012, HA once again observed the study snakes using the management fields. Not only have the artificial winter dens been used by the snakes in every year of the study, but the earth berms that surround the management fields are also widely used throughout the field season for a variety of behaviors. In 2012, a total of 6 study snakes were observed using the berms for shedding and concealment. All 6 snakes have been relocated in the management fields in prior field seasons as well, indicating that the snakes have imprinted on the fields as suitable habitat for different biological needs.

In prior years (2007 - 2011), the management fields have been used by study snakes and non-study snakes for nesting purposes. In 2012, only one study snake may have possibly nested in the management fields. This is female snake 2006.46, which had been observed mating in the spring and is assumed to have become gravid. However, since it is a robust, healthy snake and its body is very thick, it was not determined if the snake was gravid. It should be noted that we don't ever handle the radio-tracked snakes once they are released, so we do not influence their natural behavior or disrupt their movements. Therefore, we could not palpate the snake for bulging eggs. This snake was never seen excavating a nesting burrow. However, the snake was located in the berms along the edge of the management fields during the nesting season. So, it is possible it deposited its eggs in one of the berms, since gravid radio-tracked snakes have nested in them in prior field seasons. No non-radiotracked snakes were observed in or near the fields during the 2012 nesting season. However, as previously mentioned, HA staff captured 11 hatchling pine snakes in the management fields in the early fall of 2012, so it is very likely at least one female pine snake nested somewhere within the vicinity of the fields. On the following page, there are brief descriptions of behavior exhibited by study snakes when located in the management fields and adjacent habitat in 2012.

Pine Snake 2006.16:

This snake has overwintered in AH 1 every year of the study. This snake often foraged in the oak/pine and pine/oak forest southwest of the management fields. However, it consistently returned to the berms along the west and southwest edges of MF 1 at various times throughout the field season. It has been recorded in one particular location in the southwest corner of MF 1 every field season. Whenever it returns to the berms it is not seen above ground for an extended period of time (often up to two weeks), then emerges freshly shed. It is highly probable that this snake is using the berms when it is going through a shed cycle.

Pine Snake 2006.19:

Each season this snake was relocated in and around the management fields. Like study snake 2006.16, it overwintered in an artificial den every year it was alive. It has been found using the fields for all behavioral purposes including foraging, nesting, and denning. This snake continued this trend again in 2012. However, for the second straight year this snake was never observed to be gravid and has never been seen nesting in the management fields. Unfortunately, as mentioned previously, this snake died of an enlarged heart during transmitter replacement surgery in August (refer to individual snake synopsis).

Pine Snake 2006.46:

This snake was originally released into AH 3 in the fall of 2006 as a hatchling. It has been recorded returning to the artificial dens in subsequent winters. It was caught in an AH 1 trap in 2008 and in an AH 3 trap in 2009. This past spring it was captured basking next to NH 2 and was considered large enough to be implanted with a radio-transmitter and introduced into the radio-tracking study. This snake spent a large portion of the 2012 field season in the berms or along the edges of the management fields.

Pine Snake 2006.49:

This snake was recorded overwintering in the artificial dens during the 2008/2009 and 2010/2011 winters. In 2012, it did not venture to the management fields until early October when it was caught in an AH 3 trap. It was released into the den and it was assumed it was going to overwinter there. However, after spending approximately two weeks in the den, it left and moved into NH 42 where it had denned last winter. That was the only period of time in 2012 that this snake was recorded using the management field habitat.

Pine Snake 2006.108:

In 2012, this snake was again found using the management field habitat. It made a brief foray into the management fields in early summer, and then returned in late summer and remained in or near

the berm along the western edge of MF 1 for an extended period of time.

Pine Snake 2009.13:

Every field season this snake has been relocated in the berms along the edge of MF 3 and this trend continued during the 2012 field season. Like previous years, it was often located in the western berm of MF 3. Often, after spending several days within the berm, it would appear to have recently shed when it was finally located outside the berm. Based on the observations from this year and prior years, it is highly likely this location serves as a shedding station for this snake.

ENVIRONMENTAL INSPECTIONS AND SITE MONITORING

Most of the habitat alteration, disturbance and licensed landfill construction on the SPR property was conducted between 2007 and 2010. However, in 2011 a small portion of forest was cleared along the southern edge of the SPR property in preparation for the development of the new Stafford Preserve Luxury Apartment Complex. HA staff was made aware of the clearing and was on site during the tree cutting and removal process. Construction continued on the Stafford Preserve Luxury Apartments in 2012, but there was no additional clearing that took place. Since the drift fence surrounding the property was removed in the Spring of 2011, there was no barrier hindering snakes or other small wildlife from entering the SPR property. As a result, HA staff conducted random sweeps of the construction areas and the new landfill on a regular basis to check for any pine snakes or other animals that may have accessed the property. During these sweeps, no snakes were observed on the landfill or SPR property. However, two pine snakes were observed on the SPR property in 2012 outside of the random sweeps. A new male pine snake was captured by Walters staff on the property of the new Stafford Park Luxury Apartments in late September. It was processed and released back into Stafford Forge WMA. Also, on 10/02/2012, radio tracked pine snake 2006.46 was located concealed among the grass along the western portion of the capped landfill at the end of a drainage culvert near the compost area.



Figure 30. Pine snake crawling along the edge on the management fields. Photo by R. T. Zappalorti.

Because of a prior nesting observation on the SPR property in 2010, HA staff once again conducted intensive surveys across the property during the known nesting season (mid June-mid July) of 2012. No pine snakes and/or their nests were observed during these surveys.

FORAGING AND FEEDING OBSERVATIONS

Over the past 6 years, HA has made several interesting feeding observations of the radio-tracked pine snakes (refer to our past year end reports). Given its vast size (approximately 7,564.8 acres), and habitat type diversity, Stafford Forge WMA is rich with birds and small mammal resources. These ideal conditions provide an ample food supply for northern pine snakes and other top predators that live in the forest (Reynolds and Scott 1982; Burt and Grossenheider 1980; Fitch 1982 and 1999; Arnold 1993; and Boyd 1991).

Due to their secretive nature, pine snakes are rarely observed feeding in the wild. However, as a result of radio-tracking efforts, HA has had the opportunity to observe several of the study snakes feeding on different species of small mammals and birds. Pine snake prey availability and feeding is an important part of population survivorship (Arnold 1993). In 2012, HA staff again witnessed pine snake feeding behavior. **Table 5** details the feeding observations made in 2012.

Table 5. Foraging and Feeding Observations of Pine Snakes in 2012*		
Snake ID	Date of Observation	Species Consumed
2007.10	04/20/12	Young Eastern Cottontail Rabbits (Figure 31).
2007.07	08/16/12	White-footed Mice.
2006.108	09/11/12	Raiding unknown nest inside the cavity of a standing dead pitch pine.

***Refer to the individual snake synopses section for more detailed descriptions of feeding observations.**



Figure 31. Study snake 2007.10 feeding on a young eastern cottontail rabbit. Photo by David Burkett, HA staff.



Figure 32. Adult female pine snake 2006.19 basking near the PVC entrance pipe at AH 1 in the management fields. Notice how well their dorsal pattern and cryptic coloration blends with their surroundings. Photo by Bob Zappalorti.

ARTIFICIAL DEN MONITORING AND SNAKE USE

Pine snakes often share their winter dens communally (Carpenter, 1953 and 1982; Burger et al., 1988). One of the 6 research questions in this study is whether or not pine snakes will continue to use the 6 artificial dens in the 3 management fields once they had a free choice. This information is easy to determine with the snakes that are being radio-tracked. However, we are also interested in determining if any non-radio-tracked pine snakes (or other snake species) are using the artificial dens. In order to determine how many snakes were overwintering in the artificial hibernacula (during the 2011/2012 winter), a trapping program was initiated in the early spring (March 2012). For comparison, we also trapped 3 of the natural dens. Even though we trapped the dens during the fall ingress in 2011, there was a possibility that snakes may have entered the dens before the traps were set, or after the traps were removed. That is why traps were installed at the dens again in the spring of 2012.

In 2010 and 2011, HA only encircled the dens with one meter silt fence, in order to catch any snakes that egressed from the dens through their own excavations, rather than from the 4 PVC pipe entrances with traps attached. However, it became apparent that adult pine snakes could climb and maneuver over the silt fence material without being caught in the traps. In 2012, in order to maximize our success with the trapping effort, we encircled the 6 dens with 4-foot high, 1/4-inch mesh hardware cloth.

In the spring, the traps were checked every day until their removal at the beginning of June (most snakes emerge from hibernation in mid-April or early May). Through radio-tracking efforts and trapping in the fall of 2011, HA identified 9 snakes that had entered the artificial dens prior to the 2011/2012 winter. No additional snakes were collected in the traps during the 2012 spring egress.

HA reversed the process during the fall of 2012 and placed traps on the inside of the hardware cloth to catch any snakes entering the artificial dens for the winter. The traps were attached and functional by September 15, and checked every day until the beginning of November.

A total of 11 pine snakes were captured in the traps, most of which were hatchlings. After being processed and PIT tagged, the snakes were released into the artificial dens they attempted to enter. This includes 1 radio-tracked snake, 8 new hatchlings, and 2 non-radio-tracked snakes that have both been recorded in the artificial dens in previous winters. The new hatchlings were measured, sexed, and permanently marked with PIT tags prior to being released back into the artificial dens. This is the sixth winter in a row (including this current winter), that HA has documented both adult and hatchling pine snakes selecting and overwintering in the artificial dens.

NATURAL DEN MONITORING AND SNAKE USE

HA staff also corralled a select few natural dens in Stafford Forge WMA. These natural dens were identified through HA's previous radio-tracking efforts. Only 3 of the 45 natural dens were corralled in the spring (NH 2, 8 and 42). A total of 12 pine snakes (including two radio-tracked snakes), were captured using these 3 natural dens. There were 4 pine snakes caught at NH 2, including the previously mentioned 2006 hatchling study snake 2006.46 (**Figure 38**, and refer to individual snake synopsis and home range maps). Also captured at NH 2, was former study snake 2007.03. In 2009, this snake had been due for a new transmitter. When it was pulled from the field it was noted that it had extremely low body mass its and health appeared to be on the decline. It was decided to keep the snake in the laboratory and help it back to normal body weight and overall health. Once the snake gained suitable weight, its transmitter was removed and the snake was liberated from the study. This snake had been recorded at NH 2 during the 2007-2008 and 2008-2009 winters when it was part of the radio-tracking study. When recaptured this spring, the snake appeared in very good health and even added body mass.



Figure 33. Adult female Pine Snake 2006.46 emerging from Natural Den 2, in April 2012. This is an abandoned burrow that the snakes use as a winter hibernaculum. Photo by Bob Zappalorti, HA.

Of the other two snakes captured at NH 2, one (2009.16) had been recorded at the den during the prior two winters (2009-2010 and 2010-2011). The other snake had never been identified before and was processed, PIT tagged, and released at the den.

Three snakes were documented using NH 8 during the 2011-2012 winter. One was radio-tracked pine snake 2007.11, which has overwintered at this natural den every year of the study (see Individual Snake Synopses and Home Range Maps). The two other snakes were non-radio-tracked snakes 2011.29 and 2009.06.

NH 42 is a new natural den that was discovered when radio-tracked pine snake 2006.49 was found there last winter. Since it was in close proximity to the management fields, HA corralled it, hoping that some of the unaccounted for 2006 hatchlings would be captured. HA did capture 4 additional pine snakes at this den during the spring egress, but none of them were 2006 hatchlings. In fact, all four were previously unidentified pine snakes never observed before.

PINE SNAKE FIDELITY TO WINTER DENS

Over the course of the past 6-years of radio-tracking pine snakes, HA has found and identified 45 different natural hibernacula in Stafford Forge WMA. This is a land-area of approximately 7,546.8 acres (or 3,054.2 hectares) in size which comprises at least 3 meta-populations. **Figure 34** below shows a breakdown of these various hibernacula types by category.

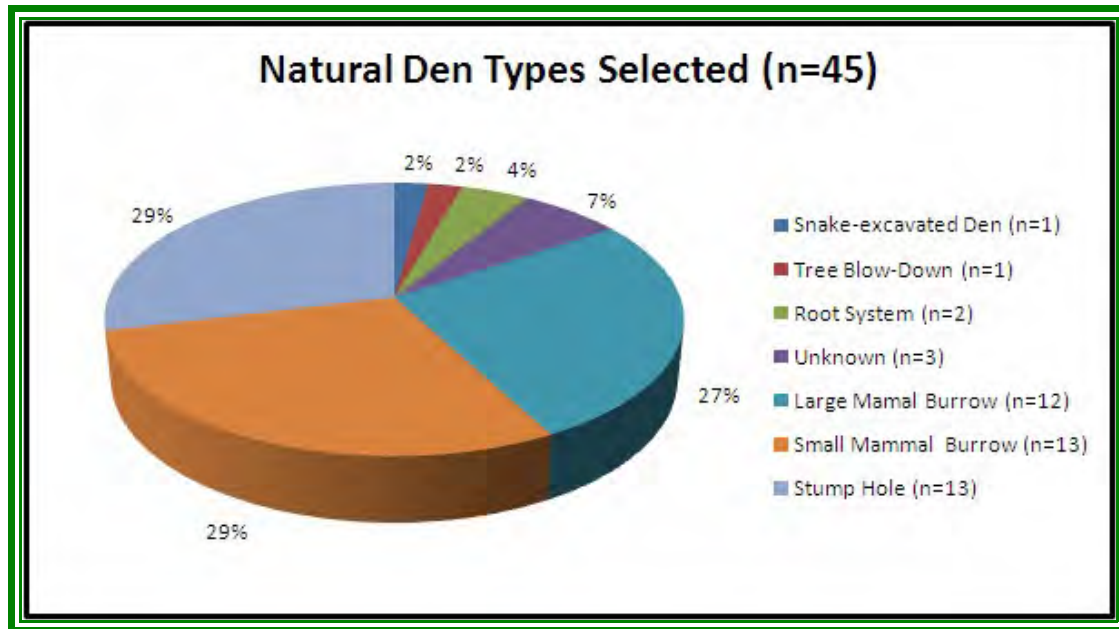


Figure 34. Percentage of natural den types chosen by the radio-tracked snakes during the past six winters.

As you can see from the graph, almost sixty percent of all natural den types located during the last six years of radio-tracking are mammal burrows. They are almost evenly split between large mammal burrows (i.e., fox, groundhog, etc.) and small mammal burrows (i.e., chipmunk). In addition to mammal burrows, HA staff also found that stump holes were a commonly selected refuge for overwintering snakes. Only one snake was recorded excavating its own den site during the study. The snake was found dead the following spring and it is possible the snake did not excavate far enough below ground to survive the cold temperatures of the winter. However, even though small mammal burrows were often chosen as overwintering locations, the snakes rarely returned to this den type. More often than not, these dens were only occupied one winter by a radio-tracked snake and were never found to have a radio-tracked snake overwintering in them again. **Figure 35** on the following page breaks down the den types used by a radio-tracked snake for only one winter during the entire study.

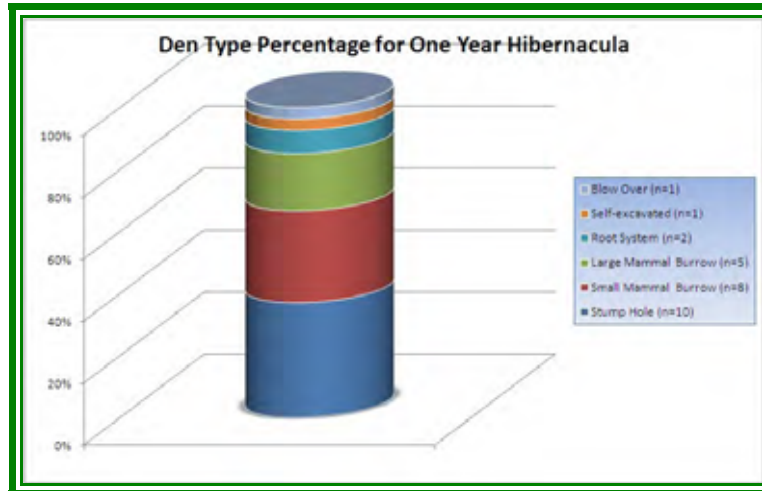


Figure 35. This graph breaks down den types where there was only one winter when a radio-tracked snake was found at that particular natural hibernaculum.

As in previous HA studies, some pine snakes have shown a fidelity to a particular winter den while others have shifted and used multiple dens in different winters (Burger et al, 1988; Burger and Zappalorti 2012). **Table 6**, on page 60, shows how some pine snakes switched from one natural den to another, while other pine snakes demonstrated a fidelity to particular den locations. For the purpose of this analysis, we describe den site fidelity as any free-roaming northern pine snake that returned to the same winter den location, two-years in a row.

Figure 36, on the next page illustrates the fidelity shown to a certain den type (*i.e.*, large mammal burrow, small mammal burrow or stump hole) by individual radio-tracked snakes from a two to six winter period. For example, by looking at the graph you will notice that only one individual radio-tracked snake returned to the same den six years in a row. This den type was a large mammal burrow. Therefore, the only den type that one individual pine snake showed fidelity to over a six year time period was a large mammal burrow. In comparison, two den types (large mammal burrow and artificial den) saw an individual snake (one snake for each den type) return to that den five out of the six winters.

In contrast to **Figure 36**, **Figure 37** (also on the following page) shows the overall fidelity to a natural den type (also from a two to six year period) by all the radio-tracked pine snakes monitored from the population, rather than individual snakes. For example, looking at the graph it shows that two dens had at least one pine snake (not necessarily the same snake) located at that den every winter for all six winters. Both of these dens were large mammal burrows. Therefore, the only den type that pine snakes were recorded in over a six year period is large mammal burrows. In contrast, you can see that seven different dens, representing three different den types (large mammal burrow, small mammal burrow and stump hole) had overwintering pine snakes in three out of the six years of the study.

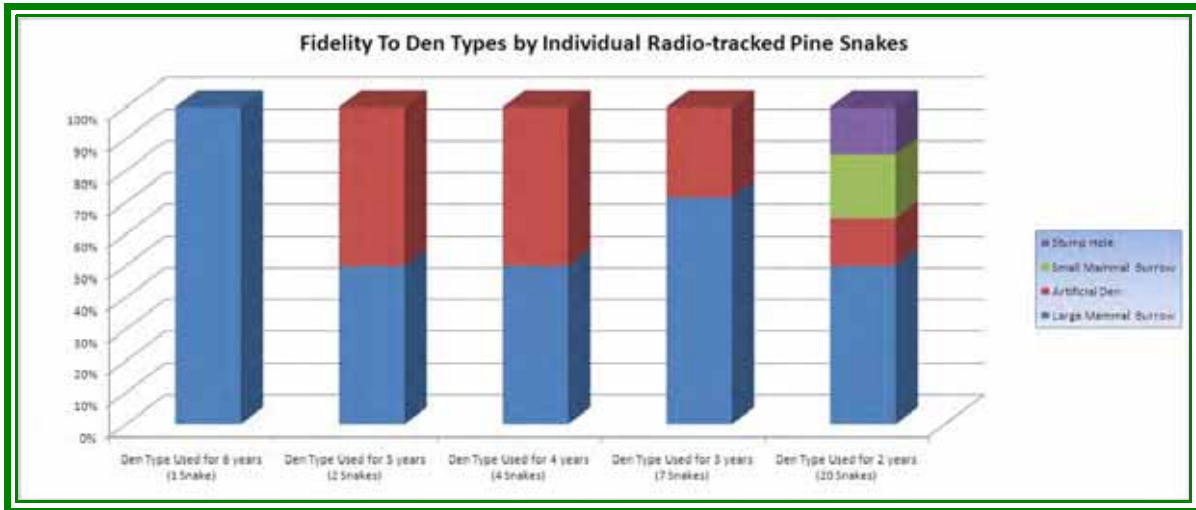


Figure 36. Graph showing fidelity to den type by individual pine snakes from a two to six year period.

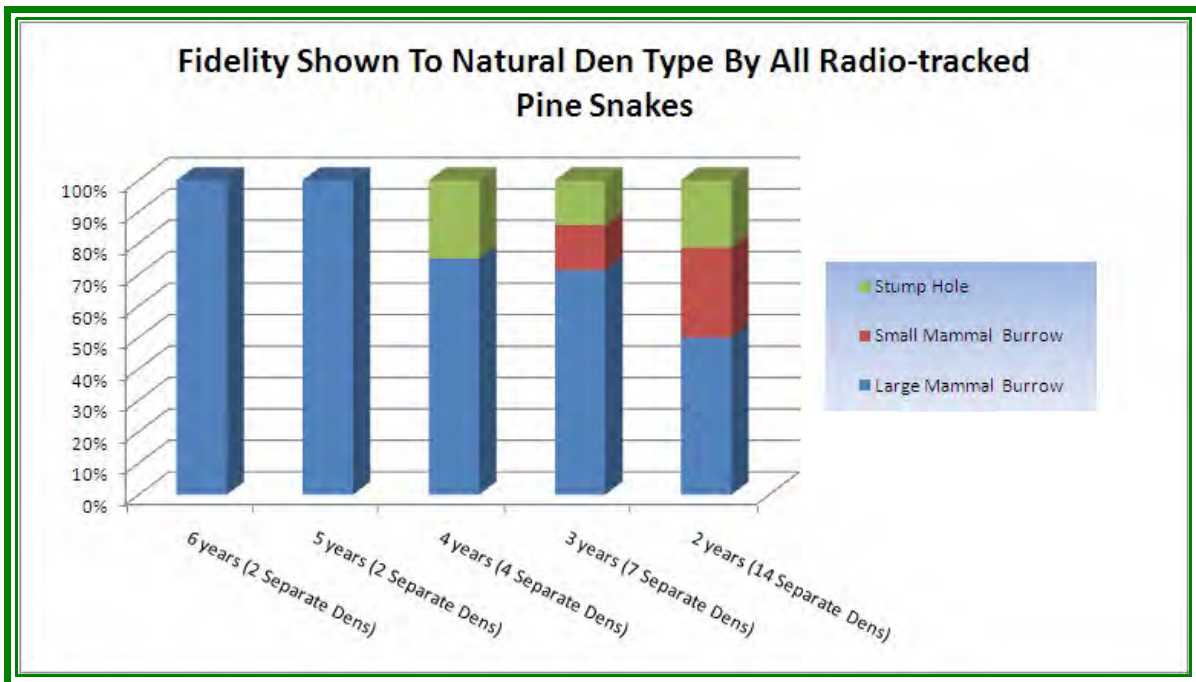


Figure 37. Graph showing natural den type occupation by all the radio-tracked pine snakes and not just by an individual snake.

Table 6. Pine Snake Fidelity (= †) and Shifting (= →) to and from Winter Dens - 2007 to 2012.

Snake ID	2007-2008 Winter	2008-2009 Winter	2009-2010 Winter	2010-2011 Winter	2011-2012 Winter	2012-2013 Winter
2006.08	HA Lab	† NH 2	† NH 2	† NH 2	Missing	Missing
2006.09	NH 9	† NH 9	Dead	Dead	Dead	Dead
2006.11	NH 1	→ NH 17	Dead	Dead	Dead	Dead
2006.16	AH 1(Forced)	† AH 1	† AH 1	† AH 1	† AH 1	† AH 1
2006.17	AH 6 (Forced)	→ NH 2	Dead	Dead	Dead	Dead
2006.19	AH 1(Forced)	† AH 1	† AH 1	† AH 1	→ AH 2	Dead
2006.21	NH 11	→ NH 18	Dead	Dead	Dead	Dead
2006.26	NH 1	→ NH 14	† NH 14	Dead	Dead	Dead
2006.28	AH 1 (Forced)	→ NH 19	→ NH 30	Dead	Dead	Dead
2006.29	AH 6 (Forced)	→ NH 20	† NH 20	→ NH 36	Dead	Dead
2006.32	NH 4	→ NH 23	→ NH 32	Dead	Dead	Dead
2006.34	NH 15	→ NH 22	→ NH 34	→ NH 37	→ NH 41	Dead
2006.46	AH 3 forced (Hatchling) was not radio-tracked.	Not radio-tracked but caught in AH 5 trap.	Not radio-tracked.	Not radio-tracked.	Not radio-tracked but caught in NH 2 trap.	NH 45
2006.49	AH 1 forced (Hatchling) was not radio-tracked.	Not radio-tracked but caught in AH 1 trap.	Not radio-tracked.	Not radio-tracked but caught in AH 1 trap.	† NH 42	† NH 42
2006.108	AH 3 forced (juvenile) was not radio-tracked.	Not radio-tracked.	Not radio-tracked.	NH 5	† NH 27	† NH 27
2007.03	NH 2	† NH 2	Dead	Dead	Dead	Dead
2007.04	NH 12	→ NH 21	Dead	Dead	Dead	Dead
2007.05	NH 14	† NH 14	† NH 14	Dead	Dead	Dead
2007.07	NH 3	† NH 3	→ NH 33	→ NH 38	→ NH 33	→ NH 20
2007.09	NH 6	NH 25†	† NH 25	→ NH 39	† NH 39	Dead
2007.10	NH 10	→ NH 26	→ NH 35	→ NH 31	→ NH 43	Missing
2007.11	NH 8	† NH 8	† NH 8	† NH 8	† NH 8	† NH 8
2007.14	NH 7	→ NH 27	→ NH 29	→ NH 8	→ NH 44	→ NH 27
2007.15	NH 13	→ NH 24	Dead	Dead	Dead	Dead
2008.02	Not radio-tracked	NH 3	† NH 3	HA Lab	Dead	Dead
2008.03	Not radio-tracked.	NH 5	† NH 5	† NH 5	→ NH 45	Missing
2009.13	Not radio-tracked.	Not radio-tracked.	NH 31	→ NH 40	† NH 40	→ NH 2

BREEDING AND NESTING OBSERVATIONS

Female Breeding Observations

Once again HA observed courtship and mating behavior of individual pine snakes in 2012. Although this behavior is rarely witnessed in the wild, radio-tracking has made it possible to observe the mating habits of pine snakes (**Figure 38**). **Table 7** details every breeding observation witnessed by HA staff throughout the entire 6-year study, including 2012. It is interesting to note that some of the snake's mated with the same partners in multiple years of the study. It is likely that many of the snakes have learned where potential mates may be found within their established home ranges through olfactory scent trailing (Ford 1978 and 1986). Since, individual snake's home ranges do not often vary much from year to year, it is likely that many of the snake's encounter the same mate annually if they share similar overlapping home ranges (Zappalorti et al., 2007-2011).



Figure 38. Study snake 2006.34 mating with an unknown female.
Photo by David Burkett, HA staff.

Nesting Behavior

Only one of the radio-tracked female snakes was possibly gravid in 2012. This was female pine snake 2006.46, which was observed mating in May with an unknown male pine snake near the edge of MF 3. As previously mentioned, this snake had good body weight and was robust so it was difficult to determine if it became gravid. After the breeding observation, the snake remained in the vicinity of MF 3. It was not observed excavating a nest burrow, however it did move into the berm along the edge of MF 3 in early June. It is quite possible the snake nested within the confines of the sand and log berm (Burger and Zappalorti 1986, 1991, and 1992). This type of nesting behavior has been observed in the past with other radio-tracked snakes during this study (Zappalorti et al. 2007-2011). Although, we did not note any nests or gravid females (besides the potentially gravid 2006.46) in the management fields in 2012, we did find hatchlings in the fields in the early fall. The capture of these hatchlings is strong evidence suggesting that at least one female pine snake nested in the vicinity of the management fields. In addition, the fact that hatchlings were noted in all three management fields, suggests the possibility that multiple snakes may have nested in the three management fields. No other nesting behavior was observed anywhere else on the study site in 2012.

Table 7. Courtship and Breeding Observations of Radio-tracked Northern Pine Snake Interactions between 2007-2012.

Snake ID	2007	2008	2009	2010	2011	2012
2006.19 (Female)	None observed	None observed	None observed	Mated with Pine Snakes 2006.16, 2006.108, and unknown male.	None observed.	None observed.
2006.29 (Female)	None observed	None observed	Recorded breeding with Pine Snake 2007.10.	Recorded breeding with Pine Snake 2007.10.	N/A	N/A
2006.34 (Male)	Seen basking at a stump hole that Snake 2007.05 was concealed in.	In close proximity to 2007.05 during the breeding season.	Recorded breeding with Pine Snake 2007.05.	Mating with Pine Snake 2008.13 and an unknown female.	None observed.	Mating with an unknown female and coiled next to another unknown female.
2006.46 (Female)	N/A	N/A	N/A	N/A	N/A	Mating with an unknown male.
2006.49 (Male)	N/A	N/A	N/A	N/A	None observed.	Mating with pine snake 2009.11.
2006.108 (Male)	N/A	N/A	N/A	Mated with Pine Snake 2006.19.	None observed.	None observed.
2007.04 (Female)	N/A	None observed.	Scent trailed by a male. It was Gravid.	N/A	N/A	N/A
2007.05 (Female)	Found in stump hole with male Pine Snake 2006.34 during the breeding season.	Mated with Pine Snake 2008.12 and within 2 meters of Pine Snake 2006.34.	Mated with Pine Snake 2006.34 and observed Pine Snake 2008.12	None observed.	N/A	N/A

Table 7 continued. Courtship and Breeding Observations of Radio-tracked Northern Pine Snake Interactions between 2007-2012.						
Snake ID	2007	2008	2009	2010	2011	2012
2007.07 (Female)	N/A	None observed.	Not observed Mating, but gravid.	Mated with Pine Snake 2007.10.	None observed.	None observed.
2007.10 (Male)	N /A	None observed.	Mated with Pine Snake 2006.29.	Mated with Pine Snakes 2006.29 and 2007.07.	None observed.	None observed.
2007.11 (Male)	N/A	None observed.	None observed.	Observed in courtship behavior with Pine Snake 2007.07. No copulation observed.	None observed.	Observed mating with unknown female and was observed next to an unknown female on two other occasions.
2007.14 (Male)	N/A	None observed.	Recorded breeding with an unknown female.	None observed.	Observed breeding with an unknown female.	None observed.
2007.15 (Female)	N/A	None observed.	Seen near Pine Snake 2006.17 during the breeding season, but not gravid.	N/A	N/A	N/A
2008.03 (Female)	N/A	N/A	Seen with Snakes 2008.08 and 2009.15 twice. Mated with 2009.15.	Courted by males 2008.08 and 2009.15. But Snake was not gravid.	Observed mating with male 2009.13.	None observed.
2009.13 (Male)	N/A	N/A	None observed.	None observed.	Observed mating with female 2008.03.	None observed.

DISCUSSION AND PRELIMINARY CONCLUSIONS

PINE SNAKE MORTALITY

Since 2006, HA has documented a number of pine snake mortalities during the course of this investigation (refer to **Appendix II** for the Deceased Snake Synopses). Pine snakes in New Jersey have always had many natural predators, including birds of prey (raptors), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), red squirrel (*Tamiasciurus hudsonicus*), northern short-tailed shrew (*Blarina brevicauda*), and other small mammals. In addition to these historical predators, coyotes (*Canus latrins*) have now become well established in New Jersey and the population has risen over the past few decades (McBride 2006). Since, 2007, sightings of coyotes and evidence of their presence (tracks and scat) have continually risen (HA staff, personal observations). In fact, one HA staff member observed a coyote feeding on an adult pine snake alongside Hay Road in 2010. Also, HA staff has witnessed neonate pine snakes being eaten by Coyotes when they emerge from their nests (Zappalorti, personal observations). The presence of coyotes in and around the management fields continued in 2012. A coyote was observed by HA staff in late summer running from the landfill into the pine forest adjacent to the eastern edge of the management fields. HA staff also observed several coyote pups in SFWMA during the field season. In addition, numerous coyote tracks were observed in the management fields throughout the entire summer. Whether the increase in the coyote population is having, or will have, a significant negative impact on the pine snake populations in New Jersey is unknown, but it is obvious that coyotes are another predator that will feed on the snakes when the opportunity arises.

In 2012, three mortalities were observed among the radio-tracked snakes. As previously mentioned, snake 2006.19, died in the laboratory from enlarged heart complications. Two other radio-tracked pine snakes were found dead in the field. Unfortunately, the exact cause of death for either snake was not easy to determine. One snake (study snake 2007.09) was found dead outside of it's den in early March. It is quite possible that this snake emerged from it's den on a warm winter day to bask and was caught outside as the temperatures began to drop and froze to death. HA has witnessed this with snakes at other sites in the past (Zappalorti, personal observations). Study snake 2006.34 was found dead with a large gash along the bottom left side of it's body. When the snake was found insects had already began feeding in and around the wound, so it is impossible to know how big the wound opening was originally. It is possible that a small mammalian predator (such as a weasel) had attempted to predate on the snake and the snake was able to escape only to succumb to it's wound later.

Loss of Hatchling Pine Snakes - In addition to the mortalities suffered by the adult study snakes, HA has had little success recapturing hatchling pine snakes marked in prior years. HA released 71 hatchlings into the artificial dens in 2006. From 2007 to 2011, HA caught an additional 101 hatchling pine snakes (10 in 2007; 11 in 2008; 40 in 2009; 10 in 2010; and 30 in 2011), for a total of 172 hatchling pine snakes processed by HA staff between 2006 and 2011.

In prior years, very few of these marked hatchlings have been recaptured. This held true again in 2012, when only 3 of the 172 marked hatchling snakes were recaptured (one each from the 2006, 2007, and 2008 cohorts respectively). This was despite having trapped all 6 artificial dens and 3 natural dens. It is unknown why so few hatchlings have been accounted for after their initial processing. It is possible that the mortality rate among young snakes is extremely high. A herpetologist in Japan studied the survival rate of the Japanese rat snake (*Elaphe climacophora*), and found a 60% mortality rate during the first year of life (Fukada, 1978 and 1960). It is also possible that the majority of the marked hatchlings originally selected dens in the vicinity of where they hatched (*i.e.*, the management fields and NH 8), for their first winter. Since these were the dens that HA usually corrals, we may have only been able to account for them that first winter. Once they survived the first winter, the hatchlings established their base home ranges. The hatchlings quite possibly scent trailed adult pine snakes to other suitable natural dens within their respective home ranges. If these dens were not corralled by HA, then it would be very hard to recapture these snakes. Nevertheless, only recapturing 3 marked hatchlings from 172 is strong presumptive evidence that the mortality rate of hatchling pine snakes is relatively high (Fukada, 1978 and 1960).



Figure 39. Two neonate Northern Pine Snakes that were caught in traps while trying to enter artificial dens in the Management Fields in the fall of 2012. Photo by Dave Burkett, HA.

RESEARCH QUESTIONS AND FUTURE GOALS

As stated in the introduction section of this report, there are six research questions that the Department and HA are attempting to answer as part of this long-term study. After the sixth year, HA has been able to definitively answer most of these questions. Below are preliminary responses to the questions.

Question 1. Can adult and hatchling northern pine snakes establish themselves and overwinter successfully in constructed artificial hibernacula after being shifted to a different area within their known activity range?

Answer - Yes. Even though the shifted pine snakes were forced to spend one or two-winters in the artificial dens (following the approved management plan protocol), all of these snakes successfully hibernated in them. The corral walls were removed in the spring of 2008. From the winter of 2008/09 through the winter of 2011/12 HA documented a total of eighteen pine snakes of varying age classes (adults, juveniles and hatchlings) successfully overwintering in one, or more, of the six artificial hibernacula. In fact, shifted radio-tracked pine snake 2006.16 has hibernated in AH 1 every winter of the study. In addition to 2006.16, shifted radio-tracked pine snake 2006.19 overwintered in one of the artificial dens every winter it was alive (2008/09-2011/12). These snakes were free to select alternative denning locations each winter since the corral walls were removed, yet each returned to the artificial dens at the end of all their active field seasons. It is clear that each of these snakes recognized the artificial hibernacula as suitable overwintering sites. In addition to radio-tracked pine snake 2006.16 returning to AH 1 this winter (2012/13), two other pine snakes previously recorded overwintering in the artificial dens have also returned to them. Besides these returning snakes an additional eight newly identified snakes were captured in the artificial den traps during the fall ingress and are currently hibernating in the artificial dens.



Figure 40. Trap attached to the 4-foot high mesh hardware cloth surrounding AH 2 to capture snakes coming into the den in the fall.

HA has also captured a 2006 hatchling pine snake (2006.49) at AH 1 in multiple years, showing that it too has successfully imprinted on this man-made structure for its winter hibernaculum.



Figure 41. Eastern Hognose Snakes have been seen around the artificial dens on a few occasions. Photo by R.T. Zappalorti, HA.

Question 2. Do non-shifted northern pine snakes (or other snake species) from the existing Stafford Forge Wildlife Management Area population begin to use the artificial hibernacula constructed at the three management fields on their own?

Answer - Yes. Since the corral walls were removed in February of 2008, HA staff has captured 13 non-shifted pine snakes in the artificial dens. Almost all of these have been juvenile or hatchling pine snakes. More important, 4 of these non-shifted pine snakes have been recorded using the dens in multiple years of the study. Additionally, as previously mentioned, 8 newly identified non-shifted pine snakes (all hatchlings), were captured in the artificial den trap in the fall of 2012, and are currently overwintering in the artificial dens. Besides pine snakes, HA has seen two other species of snakes, eastern hognose (*Heterodon platyrhinos*) (**Figure 41**) and eastern

garter snake (*Thamnophis s. sirtalis*) (**Figure 42**) use the artificial dens. HA captured a young hognose snake in an artificial den trap in the fall of 2011 and a young hognose was found beneath a cover board near AH 1 in the fall of 2010. This past fall (2012), HA caught two hatchling garter snakes in the den traps. They are currently overwintering in the artificial dens this winter. We also found two adult garter snakes under shelter boards near the dens in fields one and two in the fall of 2012. HA will continue to trap the artificial dens during the spring egress in 2013, in case any snakes moved into the dens prior to or after the traps were attached.



Figure 42. An Eastern Garter Snake that was found under a shelter board near AH 1. Photo by R.T. Zappalorti.

Question 3. How do the spatial movements and other behaviors (*e.g.*, habitat use, foraging, mating, nesting, and denning) of the shifted pine snakes differ from the non-shifted pine snakes?

Answer - Inconclusive. Preliminarily, it appears that during each activity season the non-shifted pine snakes have consistently had larger home ranges than the shifted snakes. A more in depth analysis will be conducted using all of the radiotelemetry data in the 2013 final project report.

Overall, the radio-tracked snakes (both shifted and non-shifted) were most often recorded in the pine forest and pine/oak forest habitat types in 2012. This is similar to previous seasons. However, an interesting observation regarding habitat use between the two study groups has been noted in the habitat categories of “ecotone between forest and field” and “ecotone between forest and barren ground”. In the past three field seasons, HA has seen a disparity in the number of times the non-shifted study snakes have been found in these habitat types (less often) as compared to the shifted snakes. These two habitat types are most often found around the management fields on the SPR study site. Without a doubt, the shifted snakes have used the management fields far more regularly than the non-shifted snakes during the study. No significant behavioral differences were observed between the two study groups in 2012. Significant conclusions (if any), regarding differences in home range sizes, behavioral observations, and habitat preferences between non-shifted and shifted snakes cannot be made until all six years of data are analyzed together.



Figure 43. Study snake 2007.11 in shed. Phot by David Burkett, HA staff.

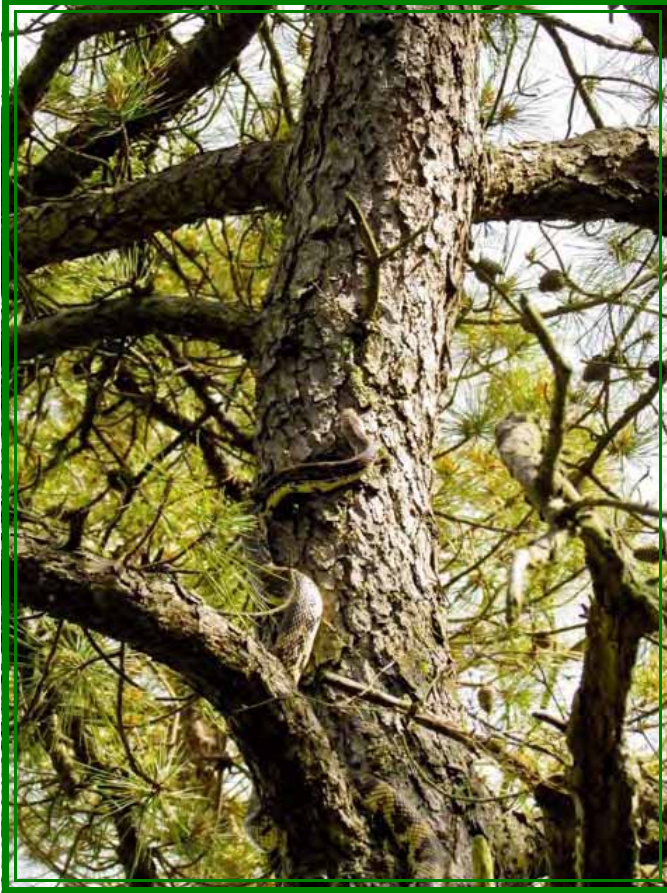


Figure 44. Radio-tracked Pine Snake 2006.16, climbing a large pitch pine tree. Photo by Dave Burkett, HA Staff.

Question 4. Do pine snakes from this population (both shifted and non-shifted snakes) attempt to move back onto the redevelopment area of Stafford Township Business Park during the construction period, and if so, does this tendency diminish over time?

Answer - Yes. In every year of the study (except for 2011), a radio-tracked pine snake has been documented breaching the perimeter drift fence and entering the SPR property. Most of these snakes have been gravid females, presumably trying to return to their traditional nesting habitat. The perimeter drift fence was removed in the fall of 2010, so from then on snakes have had unrestricted access to the SPR property.

In 2012, two pine snakes were observed on the SPR property (one radio-tracked and one non-radio-tracked snake). As previously mentioned, radio-tracked study snake 2006.46 was located on the western portion of the capped landfill, on 10/02/2012, in the vicinity of the compost area. A non-radio-tracked pine snake was found by William

Kunze, a member of the Walters group, on 09/25/2012 by the clubhouse of the new Stafford Park Preserve Apartments.

Once the radio-tracking study ends in late 2013, without additional monitoring, it will not be possible to know whether the pine snakes return to the developed portion of the property, or if this behavior will diminish overtime. While there have been several observations of pine snakes caught in the perimeter drift fence traps, or radio-tracked along the edge of the SPR property, only a few have been observed on the actual property itself.

Question 5. Do a higher percentage of northern pine snakes (adult and juvenile) return to and overwinter in the artificial hibernacula when they are kept in an enclosed area around the hibernacula and fed for two winters versus only a single winter?

Answer - Inconclusive. Since the 2008-2009 winter (when all corral walls were removed from the artificial dens) five of the “Treatment Snakes” have been documented overwintering in the artificial dens. Of the five snakes, two are adults from the “Treatment C” (Lab Treatment) and three are 2006 hatchlings. The two adults (pine snakes 2006.16 and 2006.19) spent the first winter (2006-2007) in HA’s lab and were introduced into AH 1 in 2007. Although AH 1 was one of the two winter treatment dens, these two snakes were only forced to overwinter in it for one year. As previously mentioned, study snake 2006.16 has returned to the artificial dens every winter and 2006.19 returned to the dens every winter it was alive.

Two of the hatchlings (pine snakes 2006.41 and 2006.49) were introduced into AH 1 (a two winter treatment den) in the fall of 2006, and have returned to this den to overwinter in subsequent years. The other 2006 hatchling (2006.46) was released into AH 3 (a one winter treatment den) in 2006, and was relocated in a trap affixed to AH 5 during the 2009 emergence. The data strongly suggests that it did not matter how many winters the snakes were forced to overwinter in the artificial dens. Once released, the majority of the snakes moved back into natural dens in the surrounding forest.

Question 6. Will shifted and non-shifted gravid female northern pine snakes from this population begin using the three management fields as nesting habitat in future years?

Answer - Yes. In 2008, 2009 and 2010, HA staff observed both shifted and non-shifted gravid female pine snakes using the management fields as nesting habitat (Zappalorti et al., 2008; Zappalorti et al., 2009; Zappalorti et al., 2010). In 2012, as previously mentioned, no radio-tracked pine snakes were confirmed to have nested in the management fields. Likewise, no non-radio-tracked pine snakes were observed using the fields during the nesting season. However, the capture of neonate pine snakes during the late summer months suggests that at least one pine snake nested somewhere in, or in the vicinity of, one of the management fields. It is very possible that these neonates were from radio-tracked female 2006.46 which may have been gravid and was observed in the berm along MF 3 during the nesting season. Or they could have come from a clutch laid by an undetected non-radio-tracked gravid female snake.

SUMMARY

In 2012, HA completed its 6th year of pine snake radio-tracking at the SPR property and the surrounding Stafford Forge WMA. HA has continued to document the secretive behavior of pine snakes in the wild, which otherwise could not be observed. These observations included courtship and mating (breeding), foraging for mammal and avian prey, evidence of nesting and egg laying (capturing hatchlings), winter den selection, and demonstration of den fidelity (overwintering behavior). The continued use of the management fields and artificial dens by both shifted and non-shifted snakes suggests that some free roaming snakes have learned to recognize the fields as suitable nesting, foraging, and hibernating habitat. This behavior is likely to continue, based upon similar pine snake and corn snake management and conservation studies HA has conducted at the Audubon Sanctuary and at the Crossley Sanctuary in western Berkeley Township, Ocean County, New Jersey (Frier and Zappalorti, 1983; Zappalorti and Reinert, 1994; Zappalorti and Golden, 2006; and Robert Zappalorti, personal observations).

While there are other pine snake studies published in literature such as Kauffeld (1957); Zappalorti et al. (1985); Burger and Zappalorti (1986, 1987, 1988, 1989, 1991, and 1992); Burger et al. (2000); Burger et al. (2007); Himes et al. (2006); Gerald, Bailey, and Holmes (2006a and 2006b); Golden et al. (2009); and Burger and Zappalorti (2011), none of these studies compare to this current investigation. The level of effort, the amount of resources and funding that is being provided by Walters, Inc., HA and the NJDEP's Division of Fish and Wildlife is unprecedented. The results of 2007, 2008, 2009, 2010, and 2011 have already been submitted, while the 2012 results are contained in this document and submitted herewith. There is much more to be learned over the remainder of the study and HA looks forward to continuing this important research and investigation on the secret life history of the northern pine snake.

Respectfully submitted,

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APPENDICES

APPENDIX I

Appendix I							
Hibernaculum	Field No. of snakes that denned in Hibernaculum (2007-08)	Field No. of snakes that denned in Hibernaculum (2008-09)	Field No. of snakes that denned in Hibernaculum (2009-10)	Field No. of snakes that denned in Hibernaculum (2010-11)	Field No. of snakes that denned in Hibernaculum (2011-12)	Field No. of snakes that denned in Hibernaculum (2012-13)	Description of Hibernaculum
AH 1	2006.16, 2006.19, 2006.22, 2006.08	2006.16, 2006.19, 2006.41**, 2006.49**, 2009.12**	2006.16, 2006.19, 2009.12 ****	2006.16, 2006.19, 2006.49****, 2010.04****, 2011.18****	2006.16, 2011.25****, 2011.29****	2006.16, 2009.11, 2010.04, 2012.06, 2012.09, 2012.11, 2012.12, 2012.14	Artificial hibernaculum created by Walters using HA's design. Located on south side of MF 1.
AH 2	None Known	2009.09	None Known	None Known	2006.19	None Known	Artificial hibernaculum created by Walters using HA's design. Located on north side of MF 1.
AH 3	None Known	2009.11**	None Known	None Known	None Known	2012.15, 2012.16, 2012.18	Artificial hibernaculum created by Walters using HA's design. Located on south side of MF 2.
AH 4	2006.15, 2006.30	None Known	None Known	None Known	2011.25****, 2011.28****	None Known	Artificial hibernaculum created by Walters using HA's design. Located on north side of MF 2.
AH 5	None Known	2006.46**	None Known	2009.12	2009.12	None Known	Artificial hibernaculum created by Walters using HA's design. Located on south side of MF 3.
AH 6	2006.17, 2006.29	None Known	2010.01****	None Known	2011.23****, 2011.24****, 2011.27****	None Known	Artificial hibernaculum created by Walters using HA's design. Located on north side of MF 3.
NH 1	2006.26, 2006.11	None Known	None Known	None Known	None Known	None Known	Small mammal burrow in pine forest approximately 90 meters west of MF 3.
NH 2	2007.03	2007.03, 2006.08, 2006.17	2006.08, 2009.16***	2006.08, 2007.23, 2008.09, 2009.16, 2011.01	2006.46, 2007.03, 2009.16, 2011.20	2009.13	Large mammal burrow in pine forest approximately 70 meters NW of AH 6.

Appendix I (continued)							
Hibernaculum	Field No. of snakes that denned in Hibernaculum (2007-08)	Field No. of snakes that denned in Hibernaculum (2008-09)	Field No. of snakes that denned in Hibernaculum (2009-10)	Field No. of snakes that denned in Hibernaculum (2010-11)	Field No. of snakes that denned in Hibernaculum (2011-12)	Field No. of snakes that denned in Hibernaculum (2012-13)	Description of Hibernaculum
NH 3	2007.07, 2008.02*	2007.07, 2008.02	2008.02	None Known	None Known	None Known	Large mammal burrow in upland pine forest in SFWMA west of management fields.
NH 4	2006.32	None Known	None Known	None Known	None Known	None Known	Stump hole in lowland oak/pine forest approximately 27 meters SW of Hay Road in SFWMA.
NH 5	2006.33, 2008.03*	2008.03	2008.03	2006.108 2008.03	None Known	None Known	Large mammal burrow in upland pine forest in the interior of SFWMA.
NH 6	2007.09	None Known	None Known	None Known	None Known	None Known	Small mammal burrow with stump hole complex present in upland pine forest in interior of SFWMA.
NH 7	2007.14, 2008.04*	None Known	None Known	None Known	None Known	None Known	Small mammal burrow leading into earth berm in disturbed pine forest habitat approximately 3.0 km S/SW of the SPR site.
NH 8	2007.11	2007.11, 2008.18**, 2008.21**, 2008.25**, 2009.02**, 2009.04**, 2009.05**, 2009.06**, 2009.07**, 2009.08**, two (2) sub-adult northern black racers	2007.11	2007.11, 2007.14, 2009.07****, 2011.02****, 2011.03****, 2011.04****, 2011.08****, 2011.09****, 2011.10****, 2011.11****, 2011.13****, 2011.14****, 2011.15****, 2011.16****, 2011.17****	2007.11, 2011.29****, 2009.06	2007.11	Large mammal burrow in disturbed pine forest approximately 100 meters from NH G.
NH 9	2006.09	2006.09	None Known	None Known	None Known	None Known	Stump hole (complex) in upland oak/pine forest approximately 1.1 kilometers N/NW of management fields.

Appendix I (continued)							
Hibernaculum	Field No. of snakes that denned in Hibernaculum (2007-08)	Field No. of snakes that denned in Hibernaculum (2008-09)	Field No. of snakes that denned in Hibernaculum (2009-10)	Field No. of snakes that denned in Hibernaculum (2010-11)	Field No. of snakes that denned in Hibernaculum (2011-12)	Field No. of snakes that denned in Hibernaculum (2012-13)	Description of Hibernaculum
NH 10	2007.10	None Known	None Known	None Known	None Known	None Known	Small mammal burrow in upland oak/pine forest approximately 1.7 km north of management fields within SFWMA.
NH 11	2006.21	None Known	None Known	None Known	None Known	None Known	Small mammal burrow in upland oak/pine forest on privately owned land approximately 2.4 kilometers north of the management fields.
NH 12	2007.04	None Known	None Known	None Known	None Known	None Known	Small mammal burrow at base of a mountain laurel in upland oak/pine forest on privately owned land approximately 15 meters in on west side of route 72.
NH 13	2007.15	None Known	None Known	None Known	None Known	None Known	Stump hole in privately owned upland oak/pine forest south of the SPR site.
NH 14	2007.05	2007.05, 2006.26	2006.26	None Known	None Known	None Known	Small mammal burrow in upland oak/pine forest south of the SPR site. Not far from NH M.
NH 15	2006..34	None Known	None Known	None Known	None Known	None Known	Stump hole in upland oak/pine forest approximately 1.3 km S/SW of the SPR site.
NH 16	2007.06	Not Known	Not Known	Not Known	Not Known	Not Known	This was an unsuccessful attempt by the snake to excavate its own overwintering spot. Snake's carcass was found only a few inches under the surface in the spring of 2008.

Appendix I (continued)							
Hibernaculum	Field No. of snakes that denned in Hibernaculum (2007-08)	Field No. of snakes that denned in Hibernaculum (2008-09)	Field No. of snakes that denned in Hibernaculum (2009-10)	Field No. of snakes that denned in Hibernaculum (2010-11)	Field No. of snakes that denned in Hibernaculum (2011-12)	Field No. of snakes that denned in Hibernaculum (2012-13)	Description of Hibernaculum
NH 17	None Known	2006.11	None Known	None Known	None Known	None Known	Stump hole in a section of pine/oak forest near the Garden State Parkway south of the SPR site.
NH 18	None Known	2006.21	None Known	None Known	None Known	None Known	Stump hole in pine/oak forest only a few meters in on west side of Route 72. Location is approximately 3.1 km north of MF 3.
NH 19	None Known	2006.28	None Known	None Known	None Known	None Known	Small mammal burrow in pine/oak forest a considerable distance SW of the SPR site.
NH 20	None Known	2006.29	2006.29, 2009.51****	None Known	2008.03	2007.07	Stump hole in upland pine forest west of the management fields.
NH 21	None Known	2007.04	None Known	None Known	None Known	None Known	Stump hole on slight upland rise in pine/oak forest approximately 2.25 kilometers north of the management fields and 0.4 kilometers west of Route 72.
NH 22	None Known	2006.34	None Known	None Known	None Known	None Known	Small mammal burrow in oak/pine forest south of the SPR site. Multiple stump holes as well as NH 15 nearby – part of complex of refugia.

Appendix I (continued)							
Hibernaculum	Field No. of snakes that denned in Hibernaculum (2007-08)	Field No. of snakes that denned in Hibernaculum (2008-09)	Field No. of snakes that denned in Hibernaculum (2009-10)	Field No. of snakes that denned in Hibernaculum (2010-11)	Field No. of snakes that denned in Hibernaculum (2011-12)	Field No. of snakes that denned in Hibernaculum (2012-13)	Description of Hibernaculum
NH 23	None Known	2006.32	None Known	None Known	None Known	None Known	Den is located in unburned upland oak/pine forest approximately six meters in on north side of Hay Road. There was no noticeable entrance hole to den location due to large amount of leaf litter on the forest floor.
NH 24	None Known	2007.15	None Known	None Known	None Known	None Known	Mammal burrow approx. 160 meters south of the drift fence along the southern portion of the SBR site near the Costco building.
NH 25	None Known	2007.09	None Known	None Known	None Known	None Known	Stump hole located on private property near the Brighton Road Development Property on west side of Route 72. Location is approximately 4.4 km NW of the management fields.
NH 26	None Known	2007.10	None Known	None Known	None Known	None Known	Q. alba root system in same tract of upland oak/pine forest that the snake hibernated in last year.
NH 27	None Known	2007.14	None Known	None Known	2006.108	2006.108, 2007.14	Large hunter's pit/mammal burrow in upland pine forest approximately 1.6 km SW of MF 1.
NH 28	None Known	NoneKnown	2007.14	None Known	None Known	NoneKnown	Large mammal burrow.
NH 29	None Known	None Known	2007.07	None Known	2007.07	None Known	Stump hole in pine/oak forest south of the SPR site near the Garden State Parkway.

Appendix I (continued)							
Hibernaculum	Field No. of snakes that denned in Hibernaculum (2007-08)	Field No. of snakes that denned in Hibernaculum (2008-09)	Field No. of snakes that denned in Hibernaculum (2009-10)	Field No. of snakes that denned in Hibernaculum (2010-11)	Field No. of snakes that denned in Hibernaculum (2011-12)	Field No. of snakes that denned in Hibernaculum (2012-13)	Description of Hibernaculum
NH 30	None Known	None Known	2006.28	None Known	None Known	None Known	Root system of old white oak in oak/pine forest south of the SPR site.
NH 31	None Known	None Known	2009.13	2007.10	None Known	None Known	Small mammal burrow in oak/pine forest approx. 1.3 km NW of the management fields.
NH 32	None Known	None Known	2006.32	None Known	None Known	None Known	Stump hole in upland pine forest west of Hay Road.
NH 33	None Known	None Known	2007.07	None Known	2007.07	None Known	Cluster of small mammal burrows leading underground in oak/pine forest approx. 1.65 kilometers north of the management fields.
NH 34	None Known	None Known	2006.34	None Known	None Known	None Known	A nondescript mammal burrow in a pine/oak forest south of the SPR site.
NH 35	None Known	None Known	2007.10	None Known	None Known	None Known	Small stump hole in a pine/oak forest south of the SPR site.
NH 36	None Known	None Known	None Known	2006.29	None Known	None Known	Large mammal burrow.
NH 37	None Known	None Known	None Known	2006.34	None Known	None Known	Stump hole in upland oak/pine forest south/southeast of the management fields.
NH 38	None Known	None Known	None Known	2007.07	None Known	None Known	Base of a half-fallen pitch pine.
NH 39	None Known	None Known	None Known	2007.09, 2010.06****, 2011.05*****, 2011.06*****, 2011.07*****, 2011.09*****, 2011.12*****, 2011.19*****	2007.09	None Known	Large mammal burrow.

Appendix I (continued)							
Hibernaculum	Field No. of snakes that denned in Hibernaculum (2007-08)	Field No. of snakes that denned in Hibernaculum (2008-09)	Field No. of snakes that denned in Hibernaculum (2009-10)	Field No. of snakes that denned in Hibernaculum (2010-11)	Field No. of snakes that denned in Hibernaculum (2011-12)	Field No. of snakes that denned in Hibernaculum (2012-13)	Description of Hibernaculum
NH 40	None Known	None Known	None Known	2009.13	2009.13	None Known	Small mammal burrow.
NH 41	None Known	None Known	None Known	None Known	2006.34	None Known	Small mammal burrow.
NH 42	None Known	None Known	None Known	None Known	2006.49, 2012.01, 2012.02, 2012.03, 2012.04	2006.49	Medium sized mammal burrow.
NH 43	None Known	None Known	None Known	None Known	2007.10	None Known	Non-descript hole.
NH 44	None Known	None Known	None Known	None Known	2007.14	None Known	Medium size mammal burrow.
NH 45	None Known	None Known	None Known	None Known	None Known	2006.46	Large mammal burrow west of management field three.
* Denotes a non-radiotracked snake that was captured in a trap attached to a corralled den in the spring of 2008.							
** Denotes a non-radiotracked snake that was captured in a trap attached to a corralled den in the spring of 2009.							
*** Denotes a non-radiotracked snake that was found basking at a known natural den entrance in the fall of 2009.							
****Denotes a non-radiotracked snake found trapped or basking at a known den in the spring or fall of 2010.							
*****Denotes a s non-radiotracked snake found trapped or basking at a known den in the spring or fall of 2011.							

APPENDIX II

Appendix II. Deceased Study Snake Synopses:

Shifted Snakes

1) *N. Pine Snake No. 2006.06* (♂). (Treatment B/2 winter) Deceased in 2007.

This snake was originally captured by Ecolsciences, Inc. in 2004. It was recaptured by EcolSciences, Inc. on 04/19/06 in their eastern den trap array. It was implanted with a transmitter and released into AH 6, which was a two winter treatment, on 09/22/06. This snake was killed and partially eaten by a red-tailed hawk on 03/14/07.

2) *N. Pine Snake No.2006.07* (♂). (Died before treatment assignment) Deceased in 2006.

This snake was captured in the eastern den trap array by EcolSciences, Inc. on 04/19/06. This snake died in HA's lab on 09/21/06. HA performed a necropsy and removed the transmitter. The transmitter was located inside the small intestine of the snake and this was determined to be the cause of death.

3) *N. Pine Snake No. 2006.08* (♀). (Shifted Snake, Treatment C/Lab) Current status = Undetermined. This specimen was initially captured near the landfill by EcolSciences, Inc. on 05/05/06.

Following a relocation on 10/28/2011, HA staff was unable to pick up this snake's transmitter signal. It is possible that the snake was predated on, or possibly, the transmitter failed for some reason.

4) *N. Pine Snake No. 2006.09* (♀). (Shifted Snake, Treatment A/1 winter) Deceased in 2009.

This snake was originally captured during a presence/absence survey conducted by EcolSciences, Inc. in 2004. On 11/04/09, this snake was observed basking near a stump hole approximately 20 meters north of NH I. The snake was observed to be alert and was actively tongue flicking despite the cool ambient temperature (13.6 degrees C). It was assumed that it would once again overwinter within NH I. When HA staff later attempted to confirm that the snake was actually within NH I, no signal could be detected in the immediate vicinity. A concerted effort was made to locate the snake from several points within its known home range, and despite the use of three receiver boxes, no signal was received and the snake was not found. It is thought that the snake was carried off by a hawk or mammal predator since no transmitter signal was ever again detected, and no carcass was found

5) *N. Pine Snake No. 2006.10* (♂). (Treatment B/2 winter) Deceased in 2006.

This specimen was originally captured by EcolSciences, Inc. on 05/09/06 near the landfill. This snake was released into Den 6, a two winter treatment, on 09/22/06. On 10/30/06, HA staff observed two red-tailed hawks flush from the pine/oak island inside the corral. Upon entering the den corral, the snake's carcass was found partially consumed. It is HA's belief that these two hawks were feeding on the pine snake. Upon perching in nearby trees, the hawks began cleaning their beaks on tree branches (a hygienic behavior used by all bird species immediately after eating). HA also observed these animals to have bulging crops by use of binoculars.

6) *N. Pine Snake No. 2006.11* (♂). (Shifted Snake, Treatment A/1 winter) Deceased in 2009.

This snake was originally caught by EcolSciences, Inc. on the landfill access road on 05/17/06. On 05/20/09, this snake was found killed by an unknown predator along the edge of a wetland corridor west of its previous relocation. The snake had been decapitated and a portion of the upper body was missing. Based on the condition of the carcass (i.e., the cleanly severed backbone and tissue at the wound, rather than stripping of the flesh), HA suggests mammalian predation. It appeared to have been a recent mortality, since there was no odor emanating from the carcass and rigor mortis had not set in yet. It is possible that the predator that was responsible was scared off by the approach of HA staff before it could finish eating the snake. Because there were just 15 relocations for this snake in 2009, a home range map was not shown.

7) *N. Pine Snake No. 2006.12* (♂). (Treatment A/1 winter) Deceased in 2006.

This specimen was originally captured by EcolSciences, Inc. on 05/17/06 along the landfill access road. This snake was released into Den 5, a one winter treatment, on 09/22/06. On 10/13/06, this snake was found partially consumed between the hibernaculum and the pine/oak island inside the den. Upon approach, two red-tailed hawks flushed from the AH den area.

8) *N. Pine Snake No. 2006.13* (♂). (Treatment B/2 winter) Deceased in 2006.

This snake was originally captured by EcolSciences, Inc. on 05/17/06 in trap 106 along the perimeter drift fence. This snake was released into Den 4, a two winter treatment, on 09/22/06. On 10/31/06, HA staff flushed a red tailed hawk from the area of Den 4. Upon examination of the den, this snake was found partially consumed on top of the hibernaculum.

9) *N. Pine Snake No. 2006.15* (♂). (Shifted Snake, Treatment C/Lab) Current status = Undetermined.

This snake was captured in trap 24 along the perimeter drift fence by EcolSciences, Inc. on 05/17/06. According to the transmitter signal, pine snake 2006.15 never egressed from the large earthen mound in MF 2 where it hibernated during the 2008 - 2009 winter. Whether this snake failed to successfully overwinter, or the radio-transmitter fell off is not known. This snake was fitted with an external transmitter towards the end of the 2008 field season and it is possible that the radio-transmitter may have slipped-off during the winter or during spring egress. Attempts by HA staff to dig-up and unearth this transmitter were unsuccessful.

10) *N. Pine Snake No. 2006.17* (♂). (Treatment C/Lab) Deceased in 2009.

This snake was captured by EcolSciences, Inc. on 05/21/06 in trap eighteen (18) along the perimeter drift fence. On 05/20/09, this snake was found dead on the road (DOR), on the edge of the Garden State Parkway's southbound lane. The dead pine snake was seen by an HA staff member in a passing vehicle. He went back to inspect the snake and found its non-functional transmitter popped-out of the body, thus confirming its identity.

11) N. Pine Snake No. 2006.18 (♂). (Treatment A/1 winter) Deceased in 2007.

This male snake was captured on the landfill slope by EcolSciences, Inc. on 05/22/06. This snake was released into AH 3, a one winter treatment, on 09/22/06 and hibernated there for the 2006-07 winter. This snake was caught in a corral trap egressing from the den on 05/01/07 and released into the adjacent forest. The snake's first relocation was approximately 0.40 kilometers S/SW of the management fields. All of the following relocations occurred within a few meters of its first relocation. The snake was found dead following the forest fire on 5/16/07.

12) N. Pine Snake No. 2006.20 (♂). (Treatment B/2 winter) Deceased in 2008.

This snake was originally captured by EcolSciences, Inc. in trap 3 along the perimeter drift fence on 05/27/06. It was implanted with a transmitter and released into AH 4 on 09/22/06. This snake was caught in the south trap attempting to egress from the den on 05/12/07. It was released into the three-acre corral. After the fire, the snake was found concealed inside a man made earthen mound on the NW side of AH 4 and had suffered burn trauma to its head and neck. On 05/20/07 this snake was recaptured and released back into the one-acre AH 4 enclosure. In the winter of 2007-08 this snake hibernated in AH 4. This animal never egressed from AH 4. It died during hibernation possibly from burn injuries sustained from the May 2007 forest fire.

13) N. Pine Snake No. 2006.21 (♀). (Treatment A/1 winter) Deceased in 2009.

This snake was originally captured in trap 95 along the perimeter drift fence by EcolSciences, Inc. on 05/27/06. On 04/23/09, this snake was discovered in an active defensive posture (coiled in a striking position and hissing) and bleeding profusely from its eye and snout. An active red squirrel (*Tamiasciurus hudsonicus*) feeding station and burrow was noted within 1 meter of the snake. It is likely that the snake was attempting to shelter in the burrow, as the ambient temperature was 14.5 degrees C. It is probable that the snake was too cool to feed or defend itself adequately and received a serious bite from the red squirrel. Though outwardly healthy and in good body weight upon egress from hibernation, the snake went into a slow decline after suffering this serious facial injury. Pine snake 2006.21 moved a few hundred meters southeast from its location on 4/23/09 into upland oak/pine forest approximately 180 meters SW of Route 72, and remained in this general area throughout the season. This snake eventually became blind in its right eye, developed a mouth infection, and continued to lose weight as the season progressed. On 10/21/09, the snake was found killed by an unknown small predator, possibly a fox or raccoon. The snake's head and neck were missing, and the posterior third of the body was eviscerated with the transmitter exposed. The carcass was collected and frozen by HA staff.

14) N. Pine Snake No. 2006.22 (♂). (Treatment B/2 winter) Deceased in 2008.

This snake was originally captured by EcolSciences, Inc. in trap 95 along the perimeter drift fence on 05/27/06. This snake was released into AH 1, a two winter treatment, on 09/22/06 where it spent the 2006-07 winter. In April 2008, this snake was observed to be breathing irregularly. The animal was taken to a veterinarian where it died. The exact cause of death is unknown, but the necropsy revealed a white chalky substance surrounding the heart, possibly indicative of gout.

15) N. Pine Snake No. 2006.23 (♀). (Treatment B/2 winter) Deceased in 2006.

This female snake was originally captured by EcolSciences, Inc. on 5/30/06 in trap 74 along the perimeter drift fence. The snake was released into AH 4 on 09/22/06. On 10/09/06, this snake was radio-tracked outside of the corral fence. The snake's partially consumed carcass was found in a pine tree at breast height. While collecting the carcass, a red-tailed hawk began to scream toward the direction of the collectors from a treetop 5 meters away.

16) N. Pine Snake No. 2006.26 (♂). (Shifted Snake, Treatment A/1 Winter) Current status = Undetermined/Lost.

This snake was originally captured by EcolSciences, Inc. during the summer of 2006. Beginning in the middle of May 2010 HA staff were unable to pick up the signal from this snake's transmitter despite repeated efforts throughout the remainder of the field season. HA had a similar problem with pine snake 2006.28 (see synopsis for 2006.28 for further details regarding that snake's current status) which was using the same area of forest during the same time period.

17) N. Pine Snake No. 2006.27 (♀). (Treatment B/2 winter) Deceased in 2006.

This female snake was originally captured by EcolSciences, Inc. near the landfill on 06/22/06. This snake was gravid and laid 11 eggs in HA's lab. It was released into AH 1, a two winter treatment, on 09/22/06. On 11/17/06, HA staff observed a red-tailed hawk trapped between the ground and the netting surrounding AH 1. Once the hawk was removed from the den enclosure, HA staff discovered the partially consumed carcass of this snake on the SE side of the hibernaculum.

17) N. Pine Snake No. 2006.28 (♀). (Shifted Snake, Treatment C/Lab) Current status = Deceased.

This snake was initially captured by HA on the landfill on 06/23/06. On 05/22/10, this snake made a large northward move towards the edge of the old landfill parcel. As mentioned in the synopsis for pine snake 2006.26, this snake's transmitter signal was subsequently lost. It was not until 07/13/10 that HA staff relocated pine snake number 2006.28's radio-transmitter. It was found on a vegetated island in the middle of a wetland corridor. The antenna wire on the radio-transmitter was chewed or snapped off. There were no scales, bones, or remnants of the snake's carcass which was probably eaten.

18) N. Pine Snake No. 2006.29 (♀). (Shifted Snake, Treatment B/2 winters) Current status = Deceased. This snake was captured on 06/26/06 in trap 97 of the perimeter drift fence by EcolSciences.

This adult female pine snake failed to emerge from its winter hibernation site in the spring of 2011. HA continually checked on the snake's transmitter signal throughout the spring and summer months, and the radio signal always indicated that the snake was still in the den. Normally, HA staff will attempt to dig up a snake when the transmitter indicates it has not egressed from a den location. However, the location along with the den size and structure (large mammal burrow with thick vegetation surrounding it) made it impossible to excavate the den in this case. Because this pine snake never came to the surface over the entire summer season, the snake was presumed dead.

19) N. Pine Snake No. 2006.30 (♀). (*Lab Treatment*) *Current status = unknown.*

This snake was captured by HA staff on 06/28/06. The snake was gravid and laid 9 eggs in HA's lab on 07/07/06. It overwintered in the HA lab for the 2006-2007 winter and was released into Den 4, a two winter treatment, on 04/03/07. HA staff experienced problems with this snake's transmitter up until 06/01/07 when the transmitter failed completely. The animal was confined within the AH 4 enclosure for the 2007-08 winter.

20) N. Pine Snake No. 2006.31 (♀). (*Treatment C/Lab*) *Current status = Deceased in 2007.*

This female snake was originally captured on 07/01/06 in trap 113 along the perimeter drift fence by EcolSciences, Inc. The snake was gravid and laid a clutch of 10 eggs in the HA lab where it also overwintered in 2006-2007. It was released into AH 4, a two winter treatment, on 04/03/07. On 05/01/07, this snake was found in the east corral trap of AH 4 and released into the three-acre outer corral. For approximately one month after the forest fire on 05/16/07, this snake was consistently relocated within an earthen berm immediately southwest of AH 4. The decision was made to dig up the snake to determine whether or not it was deceased. On 06/14/07, the charred remains of this animal and the transmitter were dug out of the berm. The forest fire was determined to be the cause of its death.

21) N. Pine Snake No. 2006.32 (♀). (*Shifted Snake, Treatment A/1 winter*) *Current status = Deceased.*

This snake was originally captured in trap 61 along the perimeter drift fence on 07/08/06. It is not certain when this snake egressed from NH 32, where it overwintered because most of the study snakes came out of hibernation earlier than normal due to an unusually warm Spring. When the snake was checked on 04/15/10, HA only found the radio-transmitter on the ground surface within a couple of meters from the den. Because of the physical evidence found at the scene, HA is confident that a raptor had killed the snake. It is likely that when it emerged from its den to bask during a warm spell, a raptor, such as a red-tailed hawk attacked, killed, and ate the snake.

22) N. Pine Snake No. 2006.33 (♀). (*Treatment A/1 winter*) *Deceased in 2008.*

This snake was originally captured in trap 5 along the perimeter drift fence by EcolSciences, Inc. on 08/11/06. This animal was implanted with a transmitter and released into AH 5, a one winter treatment, on 09/22/06, where it hibernated in the 2006-07 winter. In March 2008, this snake was observed on the surface near the entrance hole of NH 5, when HA staff were preparing to corral the denning site. The ambient air temperature was at or near 0 degrees Celsius at the time. HA decided that this animal was behaving in a manner that would result in its death, so it was collected to be observed by a veterinarian. The animal died in the HA field trailer on 03/24/08. The carcass has been frozen and retained for further analysis.

23) *N. Pine Snake No. 2006.41* (♂) (A Laboratory Hatched Snake, Released into Treatment A/1 Winter) Current status = Deceased.

This snake was from a 2006 clutch laid by Pine snake 2006.09 in HA's laboratory. It was hatched out and released into AH 1 in the fall of 2006. On 08/14/10, this snake was found deceased hanging from a tree branch approximately fifteen feet up in a pitch pine tree. HA staff was able to retrieve part of the snake's carcass, in which the anterior one third of the snake was missing. Based on the amount of whitewash that was present at the base of the pine tree, it is highly suspected that raptor predation was the cause of its death.

Non-Shifted Snakes

1) *N. Pine Snake No. 2007.02* (♂). Deceased in 2007.

This male snake was originally captured by HA staff on 05/02/07. The snake was caught at the base of a stump pile in MF 2. It was implanted with a transmitter and released on 05/04/07. After its release this snake spent the first two relocations in the upland pine forest west of the management fields and then moved north towards Hay Road. This snake was killed in the forest fire on 5/16/07. The thoroughly burned remains of this snake were found under a burnt pitch pine log on the forest floor.

2) *N. Pine Snake No. 2007.04* (♀). Deceased in 2009.

This snake was originally captured by HA staff on 05/25/07, in an isolated section of disturbed pine/oak forest on the east side of the Stafford Park construction site. On 08/14/09, HA staff discovered the partially eaten body of the snake. It was a few meters into the forest, and was apparently killed by an unknown predator. Upon recovery of the transmitter, HA staff observed that the antenna wire was ripped from the transmitter casing and was twisted and damaged. Based upon past observations HA suspects a red-tailed hawk was the predator.

3) *N Pine Snake 2007.05* (♀). Current status = Undetermined.

This snake was originally captured by HA staff on 05/28/07, emerging from a stump hole next to pine snake 2006.34, during a radio-tracking relocation south of the construction site. On 06/19/10, HA staff was unable to pick up a signal from the snake's transmitter. Despite repeated efforts throughout the remainder of the field season HA staff was not able to relocate this snake. It is unknown what happened to cause the transmitter signal to be lost. It is interesting to note that the snake was lost in the same tract of forest where a researcher had the encounter with a coyote when radio-tracking this snake earlier in the season. At the beginning of the field season one study snake was found predated upon and another went missing in the same section of forest this snake disappeared in. It's possible that coyote or red fox are preying upon HA's study snakes in this area of the forest.

4) N. Pine Snake No. 2007.06 (♀). Deceased in 2008.

This snake was originally captured by HA staff while radio-tracking. This snake was found traveling in burned upland pine forest 15 meters from the location of Pine Snake 2006.21 on 06/03/07.

In 2008, this snake had not emerged from its overwintering location by mid-May. On 05/21/08, HA staff observed a portion of the snake's carcass on the forest floor above its overwintering location. Evidence of digging by an unidentified mammal was noted at the site. HA staff proceeded to excavate the area around the exposed remains. The remainder of the snake was found in an advanced stage of decomposition, with the bulk of the carcass and the still active transmitter found only four inches below the surface (just under the top soil layer). No holes were found providing this animal deeper access underground. It is believed that this animal failed to select (or create) a suitably deep hibernaculum, and subsequently froze to death.

5) N. Pine Snake No. 2007.08 (♂). Deceased in 2007.

This large male snake was originally captured by HA staff in a heavily burnt pine forest on 6/04/07 during a random search effort. It was implanted with a transmitter on 07/19/07 and released the following day. On 08/01/07, this snake was relocated within 15 meters of a residential property in the village of Warren Grove, Ocean County, New Jersey. From 08/03/07 until 09/04/07, this snake was consistently relocated in either open field or disturbed habitat, including the front lawn of a private residence. All of the property was situated along the east side of Route 539 in the village of Warren Grove. On 09/04/07, this snake was found dead on Route 539 in Warren Grove by an HA staff member.

6) N. Pine Snake No. 2007.12 (♀). Deceased in 2007.

This female snake was relocated 9 times during the 2007 field season. It was originally found concealed inside an abandoned motorcycle gas tank on 06/20/07 by HA staff during random search efforts. The capture location was in transitional habitat of oak/pine forest to hardwood swamp approximately 90 meters from the HA/Walters Homes trailer complex on Stafford Blvd. (previously Recovery Road).

The snake was implanted with a transmitter on 07/25/07. From 07/30/07 to 08/11/07, this snake was relocated beneath a concrete slab in a disturbed open field directly behind the trailer complex. On 08/13/07, the snake was relocated in a metal pipe running under ground in the pine/oak forest behind the trailers. On 08/15/07, this snake was found dead in an open field behind the trailer complex. The cause of death appeared to be human-induced blunt force trauma to the head and neck region of the snake.

7) N. Pine Snake 2007.13 (♀). Deceased in 2007.

This female snake was relocated 39 times during the 2007 field season. It was captured on 07/13/07 crossing a dirt trail south of the construction site. It was implanted with a transmitter on 07/25/07 and released. Throughout the season this snake never traveled far from its original capture location (please refer to the *Home Range Analysis* for more details). It was often relocated in an upland pine and pine/oak forest near the large wetland corridor that runs through the wildlife management area S/SW of the site. Several relocations occurred along the edges of the wetland corridor. This snake was found dead on 10/16/07, approximately 400 meters SE of its previous relocation. Two pieces of vertebrae as well as the transmitter were recovered. The cause of death is unknown, but predation is suspected.

8) N. Pine Snake 2007.15 (♀). Deceased in 2009.

This snake was originally captured in trap 8 on 08/17/07 along the perimeter drift fence on the south side of the SPR property.

On 10/21/09, this snake's transmitter was found on the forest floor approximately 260 meters northwest of its 2008 overwintering location. The markings on the transmitter wire suggested that the snake was likely killed by a raptor because the wire had tear marks in it. Additional evidence that a hawk killed the snake was observed in the form of a quantity of "whitewash" (white uric acid from a raptor) on the trunk of a pine tree and shrubs. No additional remains of this snake were recovered by HA staff, with the exception of the abovementioned transmitter.

9) N. Pine Snake No. 2008.02 (♂). Current status = Deceased. This snake was originally captured by HA staff while emerging from NH 3 on 04/16/08.

In the late fall of 2011, this snake was relocated at NH 25, a den previously used by pine snake number 2007.09. Over the following few relocations, this snake was continuously found basking even though the air temperature was cool (~16.5 degrees C). This is not warm enough to be suitable basking conditions unless a snake is in poor health. Also, during this period the snake's overall appearance continued to deteriorate (loss of weight was conspicuous). On 10/20/10, the snake was captured and evaluated. It had lost most of its body fat and was very thin. Obviously, it had trouble finding prey and had not eaten much in 2010. It also appeared to have a respiratory problem.

Therefore, it was decided that the snake was not healthy enough to enter hibernation and survive the entire winter. HA staff tried to rehabilitate this snake in the laboratory during the 2010/11 winter. The snake occasionally fed, however it's health continued to decline and it died in the laboratory during the winter. A necropsy was performed, and it was noted that the snake's lungs were filled with mucous caused by a respiratory infection.

APPENDIX III

Appendix III Hatchling Snakes Recaptured Since Initial Release Into Artificial Hibernacula in September 2006.						
HA Field Number	Recaptured in 2007	Recaptured in 2008	Recaptured in 2009	Recaptured in 2010	Recaptured in 2011	Recaptured in 2012
2006.36	Yes (In AH 6 trap during spring egress)	No	No	No	No	No
2006.37	No	No	No	No	No	No
2006.38	No	No	No	No	No	No
2006.39	No	No	No	No	No	No
2006.40	Yes (In AH 1 trap during spring egress)	No	No	No	No	No
2006.41	Yes (In AH 1 trap during spring egress)	No	Yes (In AH 1 trap during spring egress)	Yes (Found crossing Slocum Road approximately 800 meters southwest of the management fields. It was implanted with a one year transmitter. Killed by a raptor in 2010.)	Died in 2010	Died in 2010
2006.42	Yes (In AH 5 trap during spring egress)	No	No	No	No	No
2006.43	No	No	No	No	No	No
2006.44	Yes (In AH 5 trap during spring egress)	No	No	No	No	No

Appendix III (Continued)						
HA Field Number	Recaptured in 2007	Recaptured in 2008	Recaptured in 2009	Recaptured in 2010	Recaptured in 2011	Recaptured in 2012
2006.45	No	No	No	No	No	No
2006.46	No	Yes	Yes (In AH 3 trap during spring egress)	No	No	Yes (At NH 2 and is now part of the radio-tracking study)
2006.47	Yes (In AH 1 trap during spring egress)	No	No	No	No	No
2006.48	Yes (Under cover board near AH 2)	No	No	No	No	No
2006.49	No	Yes (Crawling along perimeter drift fence near trap 55)	Yes (On top of AH 1 on 04/25/09)	No	Yes. (Snake was found in a trap attached to an artificial den 1 trap. Has been added to the radio-tracking study)	Still part of the radio-tracking study.
2006.50	No	No	No	No	No	No
2006.51	No	No	No	No	No	No
2006.52	Yes (In AH 2 trap during spring egress)	No	No	No	No	No
2006.53	Yes (In AH 3 trap during spring egress)	No	No	No	No	No
2006.54	No	No	No	No	No	No

Appendix III (Continued)						
HA Field Number	Recaptured in 2007	Recaptured in 2008	Recaptured in 2009	Recaptured in 2010	Recaptured in 2011	Recaptured in 2012
2006.55	No	No	No	No	No	No
2006.56	No	No	No	No	No	No
2006.57	No	No	No	No	No	No
2006.58	Yes (Found dead in the AH 1 outer corral after the May 2007 forest fire)	N/A	N/A	N/A	N/A	N/A
2006.59	No	No	No	No	No	No
2006.60	No	No	No	No	No	No
2006.61	No	No	No	No	No	No
2006.62	No	No	No	No	No	No
2006.63	Yes (In AH 2 trap during spring egress)	No	No	No	No	No
2006.64	Yes (In AH 3 trap during spring egress)	No	No	No	No	No
2006.65	Yes (Found dead near AH 3. Cause unknown.)	N/A	N/A	N/A	N/A	N/A
2006.66	No	No	No	No	No	No
2006.67	No	No	No	No	No	No

Appendix III (Continued)						
HA Field Number	Recaptured in 2007	Recaptured in 2008	Recaptured in 2009	Recaptured in 2010	Recaptured in 2011	Recaptured in 2012
2006.68	No	No	No	No	No	No
2006.69	No	No	No	No	No	No
2006.70	Yes (In the inner corral of AH 6)	No	No	No	No	No
2006.71	No	No	No	No	No	No
2006.72	Yes (In AH 1 trap during spring egress)	No	No	No	No	No
2006.73	Yes (In AH 2 trap during spring egress)	No	No	No	No	No
2006.74	Yes (In AH 2 trap during spring egress)	No	No	No	No	No
2006.75	No	No	No	No	No	No
2006.76	No	No	No	No	No	No
2006.77	Yes (In AH 2 trap during spring egress)	No	No	No	No	No
2006.78	Yes (In AH 1 trap during spring egress)	No	No	No	No	No

Appendix III (Continued)						
HA Field Number	Recaptured in 2007	Recaptured in 2008	Recaptured in 2009	Recaptured in 2010	Recaptured in 2011	Recaptured in 2012
2006.79	Yes (In AH 5 trap during spring egress)	No	No	No	No	No
2006.80	No	No	No	No	No	No
2006.81	No	No	No	No	No	No
2006.82	Yes (In AH 2 inner corral)	No	No	No	No	No
2006.83	Yes (In AH 5 trap during spring egress)	No	No	No	No	No
2006.84	No	No	No	No	No	No
2006.85	No	No	No	No	No	No
2006.86	Yes (In AH 5 trap during spring egress)	No	No	No	No	No
2006.87	Yes (In AH 2 trap during spring egress)	No	No	No	No	No
2006.88	No	No	No	No	No	No
2006.89	Yes (In AH 5 trap during spring egress)	No	No	No	No	No
2006.90	No	No	No	No	No	No

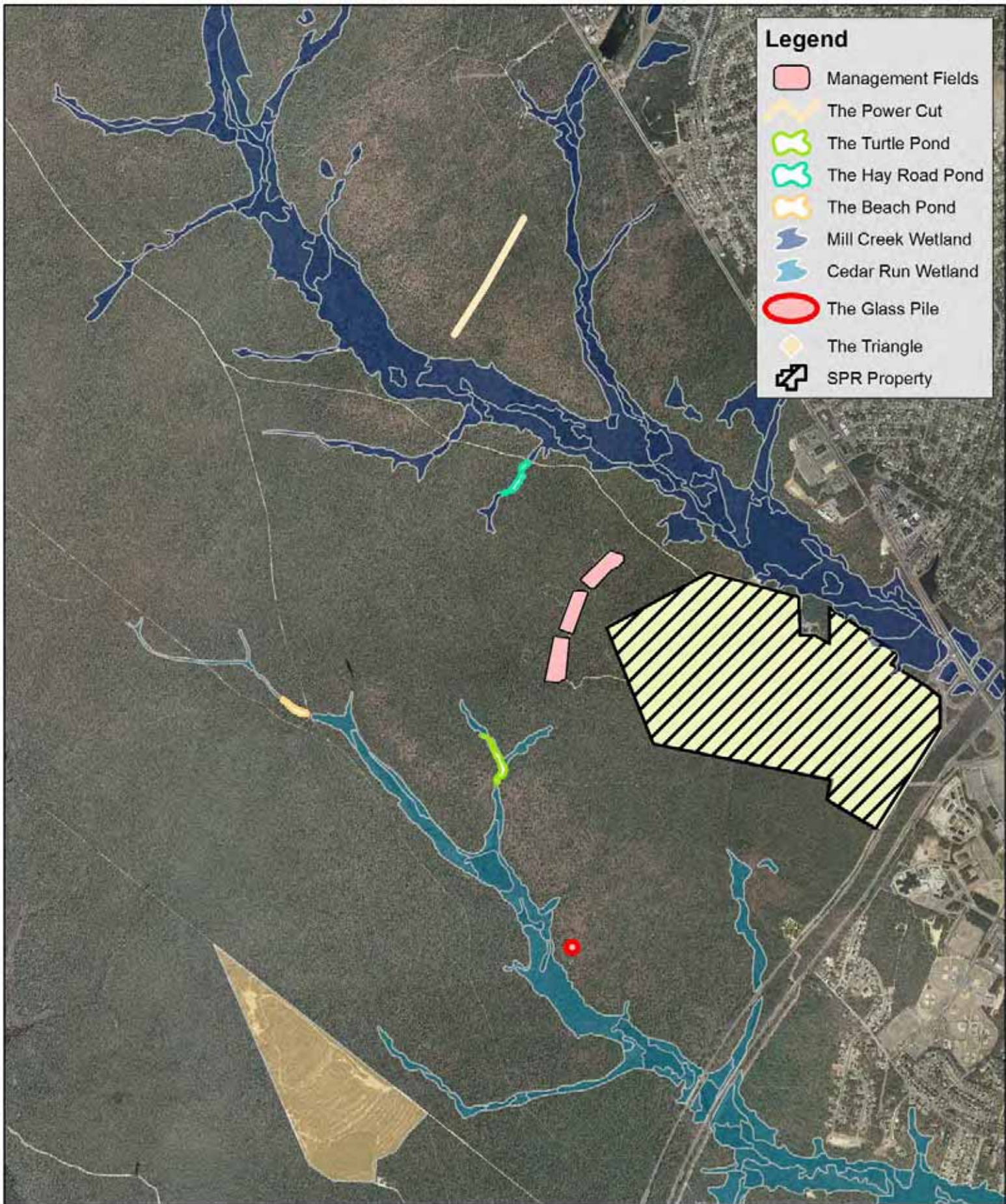
Appendix III (Continued)						
HA Field Number	Recaptured in 2007	Recaptured in 2008	Recaptured in 2009	Recaptured in 2010	Recaptured in 2011	Recaptured in 2012
2006.91	Yes (In AH 5 trap during spring egress)	No	No	No	No	No
2006.92	No	No	No	No	No	No
2006.93	No	No	No	No	No	No
2006.94	No	No	No	No	No	No
2006.95	Yes AH 3 trap in spring	No	No	No	No	No
2006.96	Yes (AH 4 inner corral)	No	No	No	No	No
2006.97	No	No	No	No	No	No
2006.98	Yes (AH 6 trap in spring)	No	No	No	No	No
2006.99	No	No	No	No	No	No
2006.100	No	No	No	No	No	No
2006.101	No	No	No	No	No	No
2006.102	No	No	No	No	No	No
2006.103	No	No	No	No	No	No
2006.104	Yes (Near AH 3)	No	No	No	No	No

Appendix III (Continued)						
HA Field Number	Recaptured in 2007	Recaptured in 2008	Recaptured in 2009	Recaptured in 2010	Recaptured in 2011	Recaptured in 2012
2006.105	Yes (Near AH 5)	No	No	No	No	No
2006.106	Yes (Near AH 1)	No	No	No	No	No

APPENDIX IV

APPENDIX IV: LANDMARK DESCRIPTIONS FOR MAP LEGEND

- 1. The Management Fields:** Three (3) consecutive, partially cleared sections of forest located within the SF WMA. These areas, comprising three (3) acres each, have been enhanced by the creation of artificial hibernacula and the planting of warm-season grasses, in addition to other methods of encouraging utilization by pine snakes and other species.
- 2. SPR Property:** Location of Stafford Park Redevelopment site.
- 3. The Triangle:** A large (approximately 127 acre) section of old disturbed forest located in the southern portion of SF WMA. This area is characterized by its distinctive triangular shape when viewed from the air, and by a series of low, man-made transverse ridges created years ago for reasons undetermined. This open canopied, sandy area has become an important denning and nesting site for northern pine snakes.
- 4. Hay Road Pond:** A small body of water less than two (2) acres in size, located approximately one (1) kilometer NW of the SPR property, and immediately SW of Hay Road.
- 5. Turtle Pond:** A small body of water approximately one (1) kilometer east of the Beach Pond, referenced by the frequent observation of aquatic turtles within its environs.
- 6. Beach Pond:** A small body of water located west of the SPR site, referenced by the open sandy shore along its eastern edge.
- 7. Mill Creek Wetland Corridor:** An extensive wetland corridor lying largely to the NW of the SPR property. The environs of this wetland and the varied habitats within the associated Mill Creek system are extensively utilized by area pine snakes and other herpetofauna.
- 8. Cedar Run Wetland Corridor:** A relatively small (in comparison to the Mill Creek wetland), narrow wetland corridor extending SE of the Beach Pond. This particular wetland is often utilized by study snakes frequenting the southern portion of SF WMA.
- 9. The “Power Cut”:** A series of overgrown roads and narrow clearings, accessed from Route 72 and extending to the immediate east of the Mill Creek wetland corridor. The purpose behind the original construction of these narrow roads/trails is unknown, but they traverse and provide access to habitat important to several study animals.
- 10. The Glass Pile:** An old disturbed, open canopied site characterized by non-native vegetation and a series of large grass-covered mounds of earth, old bottles, and other debris.



Appendix IV. Frequently referenced landmarks in Stafford Forge WMA

Source Image: 2007 NJGIN Orthophotography

Herpetological Associates, Inc. 2010

