

HA File # PA07.37

**2009-2010 Progress Report:  
Bog Turtle (*Glyptemys muhlenbergii*)  
Population Assessment Surveys, Radiotelemetry, and Nest Studies  
at ~~Middle Creek Wildlife Management Area~~  
Lancaster County, Pennsylvania**

**Notice:** Certain portions of this document have been redacted in order to protect, and not divulge the exact locations of critical Bog Turtle habitat.

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Special thanks goes to “Blondie” and “Creamsicle” for all their hard work.

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## INTRODUCTION

Herpetological Associates, Inc. (HA) conducted bog turtle (*Glyptemys muhlenbergii*) surveys at [REDACTED] Wildlife Management Area (MCWMA), Lancaster County, Pennsylvania (Figure 1) in 2009-2010, as an extension of surveys conducted in 2008, 2007, 2001, and 1993-1994. The primary goal of the investigation was to obtain a current assessment of bog turtle population size, examine nest hatching success, and monitor habitat changes. Radiotelemetry was initiated in 2009 and continued in 2010 to identify overwintering locations and to obtain movement data from this population. All field work was conducted as a volunteer effort and all equipment was donated by HA and the Pennsylvania Field Office of the U.S. Fish and Wildlife Service (USFWS).

This report presents the results of field work conducted by HA at [REDACTED] during 2009 and 2010. Our observations of the habitat management performed by others is also documented in this report. For the results of previous field investigations, refer to Torocco et al. (2009), Zappalorti et al. (2002), and Zappalorti et al. (1995).

## METHODS AND MATERIALS

### SURVEYORS

The primary surveyors were Michael Torocco and Tessa Bickhart, both of whom are recognized by the USFWS as Qualified Bog Turtle Biologists. William Callaghan and Quillyn Bickley participated in some of the field surveys.

### PERMITS

Scientific Collector Permits were obtained from the Pennsylvania Fish and Boat Commission (PFBC) to conduct all proposed research activities at [REDACTED] (Permit No. 88, Type 3; and Permit No. 158, Type 3).

### VISUAL SURVEY FOR BOG TURTLES

Searching for turtles was conducted by using standard visual survey techniques, as described by Torocco et al. (2009). Search parameters roughly followed the “Guidelines for Bog Turtle Surveys” issued by the U.S. Fish and Wildlife Service (2006), but the discretion of the surveyors was used regarding survey window, survey duration, and weather conditions.

### MARKING TURTLES

Upon initial capture, new (unmarked) turtles were assigned field numbers and marked by filing marginal scutes with a sequential notching code (Ernst et al. 1974; Zappalorti et al. 1995, 2002). In 2009 only, Passive Integrated Transponder (PIT) tags were implanted using the protocols accepted by USFWS (Herman et al., In Prep.). All of HA’s capture data will be shared, upon request, with



**Legend**

- Main or East Bog
- West Bog
- Breached Pond Bog

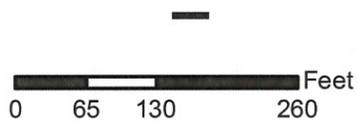


Figure 1. Bog turtle habitat delineations at [REDACTED]

Herpetological Associates, Inc.



Imagery: PAMAP Program Color Orthophotos of PA

the USFWS, PFBC, The Nature Conservancy (TNC), and other approved biologists to ensure positive turtle identification and congruency in marginal scute notching and PIT tagging.

### **DATA COLLECTED ON INDIVIDUAL BOG TURTLES**

In this study, as in previous HA studies, data collection on bog turtle and spotted turtle encounters included date, time, location, weather conditions, relative humidity and ambient temperature, as well as morphometric characters including sex, weight, reproductive status, length and width of carapace and plastron, shell height, number of annuli, abnormalities/injuries, and overall health. Each turtle was also photographed and notes were taken on turtle activity and the macro and microhabitat characteristics at each capture location.

### **NEST STUDY AND PREDATOR EXCLUDERS**

During the June nesting season, canopy-free sedge (primarily *Carex stricta*), *Sphagnum* sp., and other vegetated hummocks within the known nesting area, as well as other suitable locations throughout the wetland, were searched intensively for concealed eggs. While searching, great care was taken not to disturb individual hummocks or the surrounding vegetation. Data collection included nest location (via GPS), number and condition of eggs, hummock vegetation, and the distance from the top and base of the nest chamber to the substrate/water surface.

To ensure the protection of eggs from predators, "Predator Excluders" were installed over viable nests shortly after nests were located and nest data was collected. Predator Excluders were designed individually for each nest to completely encompass the hummock where eggs had been deposited (Torocco et al. 2009; Zappalorti et al. 1998). All Predator Excluders were carefully installed by a Qualified Bog Turtle Biologist. Excluders were buried by hand to a depth that was equal to the depth of the mucky substrate. Dry vegetation (e.g. cattail, grass) was used to further brace the interior and exterior of the Predator Excluder base, as well as plug mammal tunnels around the nest hummock. An area of water and substrate inside each Excluder was provided for hatchling refuge. The removable Excluder lids were secured with zip ties or wire ties, which were replaced whenever the nest was opened for inspection.

Nests were monitored periodically throughout the incubation period. When the projected date of hatching approached, nests were checked once per 1-3 days until all viable eggs had hatched. Predator Excluders were removed when all the hatchlings in the nest had absorbed their yoke sac and were active. Hatchlings were either released at the nest site location, or in an adjacent rivulet when drought conditions were persistent. Hatchlings were not notched in 2009 and 2010. Non-hatched eggs were inspected, but reasons for hatching failure eggs were difficult to determine.

## RADIOTELEMETRY

Six PD-2 (3.8g) Holohil transmitters were provided by the USFWS in 2010 and four RI-2B (6g) Holohil transmitters were provided by T. Bickhart in 2009 for this study. Transmitters were affixed to adult bog turtles with a minimum plastron length of 70mm and a minimum weight of 90g. The transmitters were attached to the rear of the carapace with a small amount of plumbing epoxy (PC Plumbing Putty Epoxy, Model 25598) and once dry, the transmitter, plumbing epoxy, and a small area of shell surrounding the transmitter were coated with Devcon 5 Minute Epoxy (Model S-208/20845; **Figure 2**). The weight of



**Figure 2.** PD-2 transmitter shortly after attachment (June 8, 2010).

the turtle was recorded before and after attachment, with the target weight of the transmitter plus the epoxy being less than or equal to 5% of turtle body mass.

Transmitters were placed on turtles during the active season and each turtle was tracked (relocated) approximately 1-3 times per week to determine activity range. An AVM LA-Q receiver and Yagi antenna was used to relocate turtles. When relocated, date, time, activity, and GPS locations were recorded for each turtle. Handling or disturbing relocated turtles was avoided to prevent influencing daily behavior.

## ACTIVITY RANGE ANALYSIS

Relocations for each radiotracked turtle were subjected to activity (home) range analysis. Activity range is defined as the area each turtle used for all life history activities over the course of a season. Two methods were used to arrive at the activity range for each turtle: Minimum Convex Polygon and Kernel Density Estimator. Analyses were performed in ArcMap 10.0 with Spatial Analyst 10.0 and GME 0.5.2 beta, and the subsequent shapefiles were exported to ArcMap 9.1 for mapping.

**Minimum Convex Polygon:** The Minimum Convex Polygon (MCP) method of activity range analysis has a historic prominence in the literature due to its relative ease of use. This method uses the smallest convex polygon produced by including 100% of the relocation points for each animal to calculate activity range. The outermost points are connected to form a polygon. The area of the polygon is then calculated to arrive at the MCP activity range. MCP analysis has limitations, especially regarding the inclusion of large areas that were never used by the animal, and it does not provide patterns of habitat section (core areas of use) within the activity range.

**Kernel Density Estimator:** Kernel Density Estimator (KDE) is generally considered to be one of the best methods for analyzing activity range data (Worton, 1989). KDE 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. It provides a utilization distribution, which shows the probability of each animal's use of an area for the period that it was monitored (Kernohan et al., 2001).

The advantage of this method is that it shows weighted habitat use, emphasizing areas that were used heavily by radiotracked animals. The main disadvantage is that the calculated home range size changes based on the smoothing factor (h) used. Various methods have been developed for calculating the most appropriate smoothing factor, with the most popular being the least squares cross validation method (LSCV; Silverman, 1986; Seaman and Powell, 1996). For our data sets, we opted to manually select the smoothing factor so that the 95% isopleth was equivalent in size to the 100% MCP area (Row and Bloudin-Demers, 2006). The bivariate normal density kernel was used as suggested by Worton (1989).

Two different measures of activity area were calculated: 95% and 50% isopleths. Each activity area was displayed on an aerial map of the study site, representing the probability (95% and 50%) of each study animal occurring in that area at any given time based on the existing radiotelemetry data. In essence, the 95% isopleth includes an activity range that should include 95% of a turtles movements, and excludes the outermost 5%, thereby producing a more realistic activity range. The 50% isopleth shows concentrated activity centers, where half of all locations are expected.

## **GPS/GIS**

Edges or transition zones of plant species or assemblages, main water channels, as well as nest locations and all telemetry relocations, were recorded using a Trimble GeoXT GPS unit. Data was post-processed using Trimble GPS Pathfinder Office ver. 4.1, differentially corrected using the "CORS, Schuylkill Haven (Pass), Pennsylvania" base provider, and exported to ArcMap ver. 9.1 for mapping.

## RESULTS

### BOG TURTLE VISUAL SURVEYS - 2009

Searches for bog turtles were conducted on 10 separate days from April 21 to July 4, 2009. Each search was conducted by 1-2 persons, for approximately 1-3 hours. Total search effort was 33 person-hours for the approximately 4.2 acre designated survey area, or 0.79 person-hours/acre/day.

Eighteen individual bog turtles were captured in 2009, plus an additional 8 recaptures of 6 turtles. In total, 26 bog turtle captures (initial capture plus recaptures) were made by HA in 2009 (**Table 1**). The majority of the captures (24 of 26 captures) were made during the primary visual survey period (April 21-July 4), although one new capture and one recapture were made after July 4. The two incidental encounters that were made during an additional 13 days spent in the wetland between July 4 and October 22 occurred while conducting other study activities (e.g. nest study and telemetry). The sex ratio of encountered turtles was 11 females: 7 males. Bog turtles found in 2009, categorized by *initial capture year*, included 5 from 1993; 2 from 1994; 5 from 2001; 1 from 2007, and 5 new turtles found in 2009. Representative photos are provided in **Appendix A**.

### BOG TURTLE VISUAL SURVEYS - 2010

Visual searches in 2010 were limited to 8 days between May 5 and July 13, although additional, limited searching was conducted after July 13 while conducting other study activities. Each search was conducted by 1-3 persons, for approximately 1-3 hours per visit. Search effort was 43 person-hours for the approximately 4.2 acre DSA, or 1.5 person-hours/acre/day. The primary goal of searches for bog turtles was to obtain animals for a radiotelemetry study.

Ten individual bog turtles were found during 2010, plus an additional 3 recaptures of those turtles, for a total of 13 captures (**Table 1**). Despite the slightly greater sampling effort expended in 2010, fewer bog turtles were caught. We attribute this to several factors, including fewer (but longer) sampling days, and survey days skewed later in the season (primarily June and July). Additionally, 6 bog turtles were removed from the mark-recapture study because they were being radiotracked.

### PIT TAGGING

Fifteen bog turtles were PIT tagged during 2009. Of those 15, 8 have been recaptured and 2 were included in the radiotelemetry study in 2009 and/or 2010. A full list of PIT tag identification numbers used at MCWMA is provided in **Table 1**. HA chose to PIT tag turtles for one season and then suspended PIT tagging until tagged turtles were recaptured and their health evaluated. Upon recapture, none of the PIT tagged turtles appeared to have been compromised by being tagged. However, one PIT tagged turtle was found dead on July 26, 2010; the cause of death is unknown. A second PIT tagged bog turtle was found dead at the known hibernaculum in the breached pond on March 2, 2011; cause of death unknown (see Documented Mortalities). HA does not suspect the PIT tags were the cause of death and maintains that PIT tagging is a valuable identification tool.



## DOCUMENTED MORTALITIES

Two bog turtle deaths were documented at ~~XXXXXX~~ by HA in 2010, and one death was noted in 2011. Two were found as empty shells and death was not determined, but one turtle carcass was sent to the National Wildlife Health Center (NWHC) for necropsy. The full necropsy report is provided in **Appendix B**. Details of the three dead bog turtles are provided below.

**Male 94.10 (L8-R8)** was initially captured on June 11, 1994 (shell worn smooth; approx. age 15+ years), and was recaptured for the sixth time on June 23, 2009 (approx. age 30+ years). On that date he was PIT tagged and affixed with a transmitter. He was tracked within a small area, south of the nesting area in the Main (or East) Bog, for three consecutive weeks. Over the course of approximately one week he was relocated three times at the same position. On July 26, 2009, concerned that he had not moved, his physical location was investigated and he was found dead. Only an empty shell remained, and there was no evidence of an attack by predator (tooth marks, punctures etc.), however cause of death was not determined.

**Male 93.09 (L2-R1)** was initially captured on June 16, 1993 (8 annuli; approx. age 8 years), recaptured four times in 1994, and was not seen again until he was recaptured for the fifth time on September 9, 2009 (shell worn smooth, approx. age 24 years). Upon capture he appeared visibly lethargic and was covered in clay and silt (possibly run off from the access road removal). A transmitter was attached per USFWS protocols for "sick" turtles (USFWS, 2009). He was tracked twice to the same location and then found dead on September 17, 2009 on the third relocation. His carcass was collected, frozen and submitted to NWHC on September 22, 2009. The necropsy performed on September 23, 2009 indicated a puncture wound with chronic secondary infections and emaciation were the likely cause of death (**Appendix B**). No evidence of the disease suspected of impacting bog turtle populations in the Northeast was observed.

**Female 09.04 (L1,3-R2)** was initially captured on May 16, 2009 (12 annuli; approx. age 12 years) and was PIT tagged and notched as a new turtle at that time. She was recaptured two times, once on June 6, 2009 and once on June 21, 2010, and appeared in good health both times. Her empty shell was found on March 2, 2011 at the black willow hibernaculum, on the surface, in the breached pond (west of the access road). Again, no evidence of predator attack was observed and there was insufficient flesh remaining to conduct a necropsy. Death apparently occurred during hibernation, but no other information about her death is available.

## NEST SURVEY - 2009

Searches for nests were initiated on June 23, 2009. Two nests were discovered on the initial nest survey, one in the old, breached pond west of the access road (Nest #1), and the second in the main bog, on the south edge of the traditional nesting area (Nest #2). Nest #1 in the old, breached pond represents a new nesting area, which had not been documented prior to 2009. The nest contained two eggs and was located in a small hummock formed by *Carex lurida* and stilt grass. The egg chamber was less than three inches above ground water, and the soil surrounding the eggs was saturated. Given these conditions, we believed there was a high likelihood that the eggs would suffer from constant saturation and would likely fail to hatch. The second nest, Nest #2, contained only one egg and was located in a live tussock sedge within the known nesting area, east of the access road. The egg chamber was positioned 8 inches above surface water. Both nests were immediately fitted with Predator Excluders. Additional searches for nests were conducted on June 24 and July 4, but no new nests were found.

Monitoring of the nests revealed that, as predicted, both eggs in Nest #1 were decomposing. The Predator Excluder was removed from Nest #1 on July 18 due to mortality of both eggs. Periodic monitoring of Nest #2 continued through the incubation period, but after the expected date of hatching passed, the lone egg was carefully examined on October 3. A small hole was noted on the unexposed (bottom) side of the egg, all of the contents of the egg had been removed, and a small spider was inside the egg. It is unknown whether ants (or other insects) had predated the live embryo, or if the embryo died and then insects scavenged the remains. Hatching success was 0% for known nests in 2009.

## NEST SURVEY - 2010

Searches for nests were initiated on June 8, 2010. The warm spring temperatures and verification of nesting turtles at other sites prompted searches at this early date. No nests were detected during the initial survey, but searches continued on June 10 revealing three bog turtle nests (Nest #1-3) within the known nesting area, east of the access road. Additionally, Female 01.07 was observed attempting to nest near Nests #1 and #2, but she was disturbed by our activities while installing predator excluders and submerged beneath a hummock. However, on June 13 the hummock where Female 01.07 was attempting to nest was examined and Nest #4 containing three eggs was discovered (Figure 3). Female 01.07 was checked for eggs and was found to no longer



Figure 3. Nest #4 found on June 13, 2010 and presumed to have been laid by Female 01.07.

be gravid. It is presumed, but not proven, that Nest #4 was laid by Female 01.07. No other nests were found despite intensive searches through June 21.



**Figure 4.** Three hatchlings from Nest #4 ready for release on September 1, 2010.

Nest #1 and #2 were the first to show signs of hatching on August 10, 2010. By August 23, seven hatchlings from Nests #1-#3 were ready for release and the Predator Excluders were removed. Hatchling release and Excluder removal was delayed until all the hatchlings in a nest had absorbed their yoke sacs and appeared active (e.g. left nest chamber, exploring hummock). Nest #4 first showed signs of hatching on August 20

and on September 1 the last three hatchlings were released and the remaining Predator Excluder was removed (**Figure 4**). Hatchlings from Nest #2 were released at the nest site, but due to unsuitable, dry substrate the remaining hatchlings were released at hummocks adjacent to rivulets within 1-2m of their nests. Nests #1, #3 and #4 were all located on the southern fringe of the large cattail patch that now dominates the traditional nesting area. The expansion of cattail (causing shading) in the nesting area has likely forced turtles to find nest sites further away from the traditional nesting area and into areas with less suitable substrate and hydrology. However, hatching success in 2010 (83%; **Table 2**) was higher than the typical percentage (67%) of hatching success observed in previous years (unpublished data).

**Table 2. Hatching success for monitored nests in 2009 and 2010.**

Year	Nest Number	Total Number of Eggs	Number Hatched	% Hatching Success
2009	1	2	0	0%
	2	1	0	0%
	<b>Total</b>	<b>3</b>	<b>0</b>	<b>0%</b>
2010	1	3	3	100%
	2	4	3	75%
	3	2	1	50%
	4	3	3	100%
	<b>Total</b>	<b>12</b>	<b>10</b>	<b>83%</b>
<b>2009-2010 Combined Total</b>		<b>15</b>	<b>10</b>	<b>67%</b>

## RADIOTELEMETRY - 2009

In 2009, 3 bog turtles were radiotracked as part of a preliminary investigation into the movements of bog turtles and the identification of hibernaculum locations at ██████████. These turtles included a male and female (09.06 and 09.01, respectively) initially found in the breached pond and a male (94.10) initially found in the main bog (**Table 3**). A fourth turtle (93.09) was temporarily tracked per USFWS protocols for incidences of sick turtle encounters (see Documented Mortalities).

**Male 09.06** was found as a new turtle on June 23, 2009 by HA. He was processed, notched (L1,3-R8), PIT tagged, and fitted with a RI-2B transmitter. Aside from his movements into and across the reed canary grass dominated gas pipeline ROW which transects the site just north of the core habitat, he did not travel far from the breached pond. He was relocated to a black willow stand in the northern portion of the breached pond during fall, and it is presumed he hibernated at this location with Female 09.01. He was recaptured on April 16, 2010 without the transmitter walking in a rivulet near the black willow hibernaculum. It is presumed the transmitter detached during hibernation. He was recaptured again on July 11, 2010 and appeared in good health, but was not included in the 2010 radiotelemetry study since all transmitters were being used at the time.

**Female 09.01** was trapped as a new turtle by Gian Rocco on April 21, 2009 and notched (L1,11-R1,11). She was recaptured by HA on May 16 and then again on August 3, when she was found while relocating Male 09.06. The two turtles were in contact together, submerged in mud within the breached pond wetland. She was PIT tagged, fitted with a RI-2B transmitter and tracked into hibernation. She remained in the breached pond throughout the season and hibernated at the black willow hibernaculum presumably with Male 09.06. She was recovered in the spring of 2010 and included in the 2010 tracking study (see Radiotelemetry - 2010).

**Male 94.10** was originally caught three times in 1994, then twice in 2001 and then again on June 23, 2009 when he was PIT tagged and fitted with a RI-2B transmitter. He was tracked for approximately one month and remained in the reed canary grass dominated area south of the known nesting area in the main bog (**Figure 5**). His location did not change during the week of July 20<sup>th</sup> and on July 26 a visual search for him revealed an empty shell. The transmitter was still attached and it was determined that he had died at the location where his shell was recovered. There was no evidence of a predator attack, but the cause of death was not determined (see Documented Mortality).



**Figure 5.** Male 94.10 on July 1, 2009.

## RADIOTELEMETRY - 2010

In 2010, the radiotelemetry study was expanded to include six bog turtles, who were all tracked into hibernation (**Table 3**). The 2010 study included five females and one male (94.12, 94.31, 01.02, 01.07, 09.01, and 10.01), with the general distribution including four bog turtles initially found in the Main (East) Bog and two to the west of the access road ([REDACTED]). PD-2 transmitters provided by USFWS were attached to turtles in May, June and July in the order of capture. Five of the six transmitters were removed on November 14, 2010 when turtles were presumed to have settled in their overwintering sites.

**Female 94.12** was initially captured on June 11, 1994 and recaptured for the first time on June 5, 2010 by HA. In 1994 her age was estimated at 16+ years, and in 2010, with a completely worn shell, her age is estimated at 32+ years. In 2010 she was located in the reed canary grass dominated area just south of the known nesting area (East Bog). She appeared in good health and was fitted with a PD-2 transmitter. She was not PIT tagged, even though she did not appear gravid; no females were tagged after May 31 (Herman et al., in prep.). She was tracked from June 5 to November 14 within 0.013 acre area just south of the known nesting area. Her movements ceased in October while she was in tunnels associated with a clump of common elder (*Sambucus nigra*) within the area she had been utilizing from the time she was initially tracked. Her transmitter was removed on November 14.

**Female 94.31** was initially captured on July 29, 1994 and was seen once in 1995 and again in 2001. She was recaptured for a third time on May 24, 2010 in the known nesting area within the main bog. Her approximate age in 1994 was 7 years, and now she has a partially worn shell and is estimated to be over 20 years old. In 2010 she appeared in good health and was gravid when initially captured. She was tracked from May 24 to November 14, where she was observed mostly in the northern fringes of the known nesting area. At the end of May and beginning of June she was relocated within the northern portion of the known nesting area. On June 8 she was physically checked for eggs and was no longer gravid. Although it was not determined where she nested, she was within the same area as Nest #2 during the nesting season. On July 28 she was relocated west of the road and was observed in a recent hoof print near a clump of black willow saplings near the access road. She crossed the road again and was back in the main bog by August 2 and remained in an area close to the road, north of the known nesting area. Her transmitter was removed on November 14.

**Female 01.02** was initially captured on May 24, 2001, seen once in 2009 and again on June 5, 2010. She had a partially worn shell and is estimated to be 20+ years old. She was in good health and gravid when she was recaptured in a small pool of water adjacent to the road (western edge of East Bog) on June 5. Her first relocation on June 8 was across the main bog to the east, along the shrub-lined upland edge where there is no surface muck or water, but rather a series of tunnels. She was no longer gravid, but it was not determined where she had nested. She remained in the tunnel area during the season, as well as hibernating in a tunnel at the base of swamp rose. Her transmitter was removed on November 14.

**Female 01.07** was captured twice in 2001 and then not seen again until June 8, 2010. She was found in the reed canary grass area south of the known nesting area and was gravid. On June 10 she was observed attempting to nest on the hummock where Nest #4 was found on June 13. It is assumed that she laid Nest #4 which produced three hatchlings from three eggs. Her movements include both sides of the road, and she was often found in close proximity to Male 10.01. In mid-October after spending much of the summer season west of the road she moved back into the main bog. Her last relocation on November 14 was in a tunnel adjacent to the main channel within the main bog in an area dominated by tussock sedge.

**Female 09.01** was the only turtle tracked in both 2009 and 2010. In 2010 she was first observed out of hibernation on March 19, 2010, basking at the base of a wool sedge approximately 3 m from where she hibernated. Her location was monitored during the fence installation at the end of March 2010 (see Habitat Management) and her RI-2B transmitter was removed on May 5. She was recaptured on July 11 when she was fitted with a PD-2 transmitter. She had very limited movements within breached pond and hibernated at the same location as she did the previous winter. Her transmitter was removed on November 14.

**Male 10.01** was the only new adult turtle found in 2010. He was initially found basking in the breached pond, was in good health and estimated to be 10+ years old. He spent much of the season moving back and forth from the Breached Pond Bog to the West Bog, west of the old access road. He was often relocated in close proximity to Females 01.07 and 09.01. On September 28 he was observed basking adjacent to a hoof print within 2m of the black willow hibernaculum in the breach pond (**Figure 6**). In October he moved back into the center bog and hibernated in a deep spring, at the



**Figure 6.** Male 10.01 basking on September 28, 2010 in the [REDACTED] near Female 09.01 and the black willow hibernaculum.

base of a multiflora rose on the south side of the center bog. His transmitter was not recovered on November 14. His location was checked on March 17, 2011 and assuming the transmitter is still attached, he had spent the winter at the base of the rose bush.

**ACTIVITY RANGE ANALYSIS 2009 - 2010**

Activity range size varied considerably between individuals, ranging between 0.016 acres (female 09.01) and approximately 1.5 acres (male 09.06; **Table 3**). Limitations of the data include relatively few relocations (range = 14-29), and monitoring for an incomplete field season (no tracking occurred during April and May for most turtles). Nevertheless, the results provide a glimpse at the normal movements of free-ranging bog turtles, show some interesting patterns of habitat selection, and identify six individual hibernacula at ~~Red Bank Creek Wildlife Management Area~~. An activity range map showing MCP's for all radiotracked turtles in 2009 and 2010 is provided in **Figure 7**. Activity range maps for individual radiotracked turtles are provided in **Appendix C**.

**Table 3. Activity ranges for radiotracked bog turtles in 2009 and 2010 at ~~Red Bank Creek Wildlife Management Area~~**

Field Number	Sex	Tracking Period	# of Locs	Activity Range					
				Min. Convex Polygon (100%)		95% Kernel		50% Kernel	
				Acres	Hectares	Acres	Hectares	Acres	Hectares
<b>2009</b>									
94.10	M	6/23/09-7/26/09	8	Not calculated - insufficient data					
09.01	F	8/3/09-9/29/09	14	0.016	0.007	0.016	0.007	0.003	0.001
09.06	M	6/23/09-9/29/09	25	1.579	0.639	1.495	0.604	0.184	0.074
<b>2010</b>									
09.01	F	7/11/10-9/23/10	18	0.032	0.013	0.028	0.011	0.006	0.002
94.12	F	6/5/10-9/23/10	26	0.131	0.053	0.136	0.055	0.029	0.012
94.31	F	5/24/10-9/23/10	29	0.481	0.195	0.495	0.200	0.083	0.034
01.02	F	6/5/10-9/23/10	27	0.098	0.040	0.097	0.040	0.026	0.010
01.07	F	6/8/10-9/23/10	25	0.923	0.373	1.090	0.443	0.275	0.112
10.01	M	6/5/10-9/23/10	27	0.485	0.196	0.514	0.208	0.097	0.039

**Notice:** Certain portions of this document have been redacted in order to protect, and not divulge the exact locations of critical Bog Turtle habitat.



**Legend**

- |  |  |
|--|--|
| Female 09.01 - Minimum Convex Polygon 2009 | Female 01.07 - Minimum Convex Polygon 2010 |
| Male 09.06 - Minimum Convex Polygon 2009   | Female 09.01 - Minimum Convex Polygon 2010 |
| Female 94.12 - Minimum Convex Polygon 2010 | Male 10.01 - Minimum Convex Polygon 2010   |
| Female 94.31 - Minimum Convex Polygon 2010 | Primary Habitat                            |
| Female 01.02 - Minimum Convex Polygon 2010 | Known Hibernaculum                         |

Figure 7. Minimum Convex Polygon Activity Range Map and Hibernaculum Locations for All Bog Turtles in 2009 and 2010

Imagery: PAMAP Program 2005 Color

Created: 3/21/11

Herpetological Associates, Inc.



## HABITAT MANAGEMENT

Although HA has not conducted habitat management at ██████████, management has been undertaken by others while the 2009 and 2010 surveys were in progress. The most notable management has been the removal of the paved access road in 2009 and grazing in the western portion of the wetland by two Scottish Highland steers in 2010.

In August 2009 the road that once bisected the wetland from north to south was removed (**Figure 8**). Since then, contiguous habitat exists where there was once fragmented wetland, and several branching rivulets, instead of one culvert, move water from the west side to the east side of the wetland. New, flooded areas have been created by the changing water flow where turtle activity has already been observed (e.g. tracks, visual encounters). Although the substrate remains gravelly and firm in the path of the removed road, the shallow rivulets that have formed and the maturing vegetation are creating usable habitat where an impermeable surface once existed (**Figure 9**). Movement across the removed road by females 94.31 and 01.07 was documented.



**Figure 8.** Southerly view of the road shortly after it was removed (August 21, 2009).



**Figure 9.** Southerly view of the removed road on September 18, 2010.

During the last week of March 2010 high tensile electric fencing was erected surrounding 11.5 acres which is divided into two sections, a 4.0 ac western section and a 7.5 ac eastern section. The fence encompasses core habitat as well as surrounding wetland and upland. By the end of May 2010 two Scottish Highland steers were browsing in the western section. After only a few months the density of cattail, sensitive fern, and reed canary grass was dramatically reduced. Purple loosestrife growth was also stunted and no flowering occurred on browsed plants, however the density of loosestrife seedlings has increased. Additional photo-documentation of the before and after management in 2009 and 2010 are provided.

## REPTILES AND AMPHIBIANS OBSERVED

Reptile and amphibian diversity does not appear to be high at the [REDACTED] bog. A list of species observed during 2009-2010 is presented in Table 4.

**Table 4. List of Reptiles and Amphibians Observed at [REDACTED]**

Common Name	Scientific Name
<b>Reptiles</b>	
Bog Turtle	<i>Glyptemys muhlenbergii</i>
Spotted Turtle	<i>Clemmys guttata</i>
Eastern Painted Turtle	<i>Chrysemys picta</i>
Common Snapping Turtle	<i>Chelydra serpentina</i>
Eastern Box Turtle	<i>Terrapene c. carolina</i>
<b>Amphibians</b>	
Spring Peeper	<i>Pseudacris crucifer</i>
N. Gray Treefrog	<i>Hyla versicolor</i>
American Toad	<i>Anaxyrus (Bufo) americanus</i>
Green Frog	<i>Lithobates (Rana) clamitans</i>
Pickerel Frog	<i>Lithobates (Rana) palustris</i>



**Figure 10.** Male box turtle found in the pipeline ROW north of the main bog (September 29, 2009). Box turtles are infrequently observed in the vicinity of the bog.

## DISCUSSION AND SUMMARY

Herpetological Associates, Inc. (HA) conducted on-going bog turtle (*Glyptemys muhlenbergii*) surveys at [REDACTED] (the [REDACTED] Wildlife Management Area), Lancaster County, Pennsylvania in 2009-2010, as an extension of surveys conducted in 2008, 2007, 2001, and 1993-1994. The primary goal of the investigation was to obtain a current assessment of bog turtle population size, examine nest hatching success, and monitor habitat changes. Radiotelemetry was initiated in 2009 to identify overwintering locations and to obtain movement data from this population. All field work was conducted as a volunteer effort and all equipment was donated by HA and the PA Field Office of the U.S. Fish and Wildlife Service (USFWS).

The 2009-2010 Mark-recapture study resulted in the capture of 23 individual adult bog turtles with 15 recaptures. Five new, unmarked adult turtles were found in 2009 and one new, unmarked adult turtle was found in 2010. The remaining 17 turtles were originally marked in 1993, 1994, 2001, and 2007. Overall, fewer bog turtles have been observed in recent years, and the lack of captures in younger age classes may indicate a gap in recruitment. It is also possible that this population is included in a metapopulation with movement between [REDACTED] and other unknown sites. This speculation possibly accounts for turtles eluding recaptures during previous year's searches.

The 2009-2010 Nest Study documented six bog turtle nests with a total of 15 eggs, all of which were protected with predator excluders. Hatching success during the 2009-2010 period was 67% (10 of 15 eggs hatched) with 0% hatching success in 2009 and 83% hatching success in 2010. Also, the identification of a new nesting area was documented in 2009. In 2010 nesting was documented earlier than in the previous year's studies, with nesting being first observed on June 11. Warmer spring temperatures in 2010 were likely the cause of the earlier egg laying, however, it is unknown whether mating occurred earlier or if egg development was shorter as a result of the warmer temperatures. The greater hatching success in 2010 is attributed to a drier period during egg incubation. Also, nests in 2010 were likely detected by HA within days of being laid and subsequently protected from predation. The predation of eggs by mammalian predators remains a significant problem for this population and should be investigated further to determine the appropriate management needed.

The 2009-2010 Radiotelemetry Study included 8 bog turtles with 3 tracked in 2009 and 6 tracked in 2010, one of which was tracked during both years. Turtles were not tracked for their entire active period due to funding restraints, but movements into overwintering sites was documented in both years. In 2009, one previously unknown hibernaculum was identified in the Breached Pond Bog of the site. In 2010, five other areas not previously assumed to be suitable for hibernating were documented through the use of telemetry. The one turtle tracked during both years hibernated at the same location during both winters and two other turtles have been documented at this location indicating a communal hibernacula. The selection of overwintering sites appears random within the wetland without knowledge of the subsurface characteristics. Each hibernaculum was observed to contain subsurface tunnels with ground water flow, but were dissimilar in amount and depth. These observations conclude that a wider range of suitable hibernacula are present at [REDACTED]. Despite

the limited number of relocations and abbreviated tracking period, HA formulated home range size for each turtle tracked and found home range sizes between 0.016 acres and approximately 1.5 acres.

HA's continuing studies at ~~MCWMA~~ have provided a greater understanding of habitat use and movements by the resident bog turtle population. Despite the documented death of three turtles, the population appears stable with the observation of new, unmarked turtles as well as recaptured turtles that have not been seen since 1993-94. With habitat management underway and HA's continued commitment to the survival of hatchlings, it is anticipated that this population will thrive and remain viable. Additional studies of habitat use and movements would be advantageous for this population and possibly expand the area we currently acknowledge as their habitat. HA also suggests mammalian trapping studies to better quantify the pressure on the population from predation. Protection of nests from predators remains a priority at this site for HA. Likewise the improvement of the available nesting habitat through grazing management will inevitably help recruitment and the survival of this population.

**Notice:** Certain portions of this document have been redacted in order to protect, and not divulge the exact locations of critical Bog Turtle habitat.



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**Appendix A:  
Bog Turtle Photographs**



**Appendix A-1.** Male 94.10 on June 23, 2009. He was found dead three weeks later.



**Appendix A-2.** Male 09.06 when found as a new, unmarked turtle on June 23, 2009.



**Appendix A-3.** Male 07.01 as found basking partially submerged in muck on May 23, 2009.



**Appendix A-4.** Female 09.04 initially found basking on vegetation on June 6, 2009.



**Appendix A-5.** Males 94.10 and 09.06 shortly after transmitter attachment on June 23, 2009.



**Appendix A-6.** Female 93.11 on her only capture in 2009 (May 9, 2009).



**Appendix A-7.** Female 09.01 basking on March 19, 2010.



**Appendix A-8.** Female 01.07 on June 8, 2010.



**Appendix A-9.** Female 94.31 submerged in muck on July 27, 2010.



**Appendix A-10.** Female 01.02 in a tunnel on September 13, 2010.



**Appendix A-11.** Hatching in Nest#2 on August 10, 2010.



**Appendix A-12.** Hatchling from Nest #3 ready for release on August 23, 2010.

**Appendix B:  
Necropsy Report for Bog Turtle 93.09**



# NATIONAL WILDLIFE HEALTH CENTER

6006 Schroeder Road  
Madison, Wisconsin 53711-6223  
608-270-2400 (FAX 608-270-2415)

## DIAGNOSTIC SERVICES CASE REPORT

### Final Report

9/29/2010

CASE: 22775

EPIZOO:

Legal  INV#:

Declassified

Submitter:

Tessa Bickhart  
Herpetological Associates, Inc.  
581 Airport Road  
Bethel, PA 19507

Date Submitted: 9/22/2009

Specimen description/identification/Location:

ACC	SPECIES	SPECIMEN TYPE	BAND NUMBER	SUBMITTER'S ID	COUNTY	STATE
001	Turtle, Bog	CARCASS	L2R1	93.09	Lancaster	PA

DIAGNOSIS

1. Suspect puncture wound with chronic secondary infections
2. Emaciation secondary to puncture wound and secondary infections

Comment:

Thank you for submitting this exceptionally interesting and challenging diagnostic case. While some cultures are still in progress, the principle abnormalities in this emaciated adult male Bog Turtle were a chain of granulomas ("abscesses") that appeared to arise in the skin of the right inguinal area and extended into the body cavity to the liver. These granulomas contained fragments of plant material, rare fungal hyphae and variable numbers of Gram-positive streptococci. The fungus and streptococci were not isolated in cultures, so their precise identity remains unknown. It is suspected that this chain of granulomas arose as a puncture wound in the right inguinal skin; the puncture probably perforated muscles and the body cavity. The presence of plant material in the centers of several granulomas suggests this turtle may have been stabbed accidentally by a stem of grass or the wound may have begun as a simple wound caused by a grass awn that continued to migrate into the body. The few fungi and bacteria within the granulomas probably were simple environmental organisms associated with the plant material.

Two other infectious diseases may have been present in this Bog Turtle. First, *Salmonella* sp. was isolated from the colon, but not from any of the granulomas or other visceral organs. The sero-type of the *Salmonella* has not yet been determined. However, all *Salmonella* spp. should be considered zoonotic organisms capable of infecting other wildlife, domestic animals and humans. Hence, all biologists that handle these Bog Turtles or their excrements are urged to practice excellent personal hygiene by thoroughly washing their hands after handling each turtle. Second, this turtle had numerous minute pustules in its skin; these pustules contained Gram-positive streptococci and rarely other Gram-negative bacilli. Again, the precise identity of the streptococci was not determined. No fungi were observed in the skin and claws of this turtle in histological examinations, but a watermold organism was isolated from the skin. Watermolds (eg, *Saprolegnia* spp.) are ubiquitous in wetlands, and this mold probably invaded the skin after the death of the turtle or may have simply been present on the surface of the skin. Finally, a few decomposed nematode worms were found in the small intestine of this turtle but they were too decomposed to be identified. It is suspected they were innocuous pinworms.

Virus cultures for ranaviruses and West Nile virus on the esophagus, liver, spleen and kidney were negative. Numerous genera of bacteria were isolated from the skin, nasal cavity, lung, liver and granulomas, but most were considered post-mortem invaders (putrefying organisms) from the environment and intestinal tract. Bacteria included *Klebsiella* spp., *Aeromonas* sp., *Enterobacter* spp., *Serratia* sp., *Citrobacter* sp., *Vagococcus* sp. and *Escherichia coli*. Again, none of these bacteria were considered pathogens in this turtle, and most are ubiquitous in marshy environments and the intestinal tracts of animals. Special cultures of the nasal cavity and conjunctiva were negative for *Mycoplasma* spp.

In summary, the cause of death in this Bog Turtle is attributed to severe weight loss (emaciation) secondary to a puncture wound with secondary bacterial wound infections in the skin, body cavity and liver.

CASE: 22775

## Final Report

9/29/2010

EPIZOO:

Legal  INV#:

Declassified



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David Earl Green DVM, DACVP  
Staff Diagnostic Pathologist

If you have questions regarding this case, contact:



---

Anne E. Ballmann DVM, Ph.D.  
Wildlife Disease Specialist

Phone: 608-270-2445 E-Mail: [aballmann@usgs.gov](mailto:aballmann@usgs.gov)

Diagnostic findings may not be used for publication without the pathologist's knowledge and consent.

Copies To:

ALISON WHITLOCK

USFWS Northeast Regional Office/Hadley MA, Division of Wildlife and Sport Fish Restoration, 300 Westgate Center Drive, Hadley, MA 01035

CAROLE COPEYON

USFWS Endangered Species/State College PA, 315 South Allen Street, Suite 322, State College, PA 16801



# NATIONAL WILDLIFE HEALTH CENTER

6006 Schroeder Road  
Madison, Wisconsin 53711-6223  
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## DIAGNOSTIC SERVICES CASE UPDATE

**CASE:** 22775

**FINDINGS TO DATE**

10/9/2009

**EPIZOO:**

Legal  **INV#:**

Declassified

**Submitter:**

Tessa Bickhart  
Herpetological Associates, Inc.  
581 Airport Road  
Bethel, PA 19507

**Date Submitted:** 9/22/2009

**Specimen description/identification/Location:**

ACC	SPECIES	SPECIMEN TYPE	BAND NUMBER	SUBMITTER'S ID	COUNTY	STATE
001	Turtle, Bog	CARCASS	L2R1	93.09	LANCASTER	PA

**Comment:**

10/9/09 This 18-20 year-old male Bog Turtle was necropsied on 9/23/09. It was emaciated (109.6 g, carapace length 86 mm, width 65 mm) with essentially no subcutaneous or intramuscular fat reserves. The radio transmitter was removed using a scalpel blade and 100% alcohol. There appeared to be a minimal to mild mucoid, slightly cloudy ocular discharge from the right eye. Ear membranes were normal as was the skin of the head and neck. The right forelimb had all normal appearing 5 digits & claws. The skin of the left and right forelimbs was normal. The left front limb had 5 digits, although Digit IV had a short, slightly deformed claw. The hind limbs and all 4 clawed digits on each foot were normal and symmetrical. In the skin of the left inguinal area, just anterior to the left hind limb, there was a single, raised, 6 x 5-mm pale, nodule that projects through the muscles, into the body cavity and was adherent to the left lobe of the liver. An additional 6-7 nodules, the largest being 7 mm diameter, were present in the liver.

The probable cause of death in this adult male turtle was chronic abscesses & granulomas present in liver, left hind limb & skin of inguinal area of the left hind limb. This may represent a puncture wound that potentially became secondarily infected by fungus, mycobacteria, or other bacteria. Numerous bacterial, viral, mycoplasma cultures have been requested in addition to parasitology. No viruses, including West Nile virus, were isolated. Histology is pending. AEB

If you have questions regarding this case, contact:

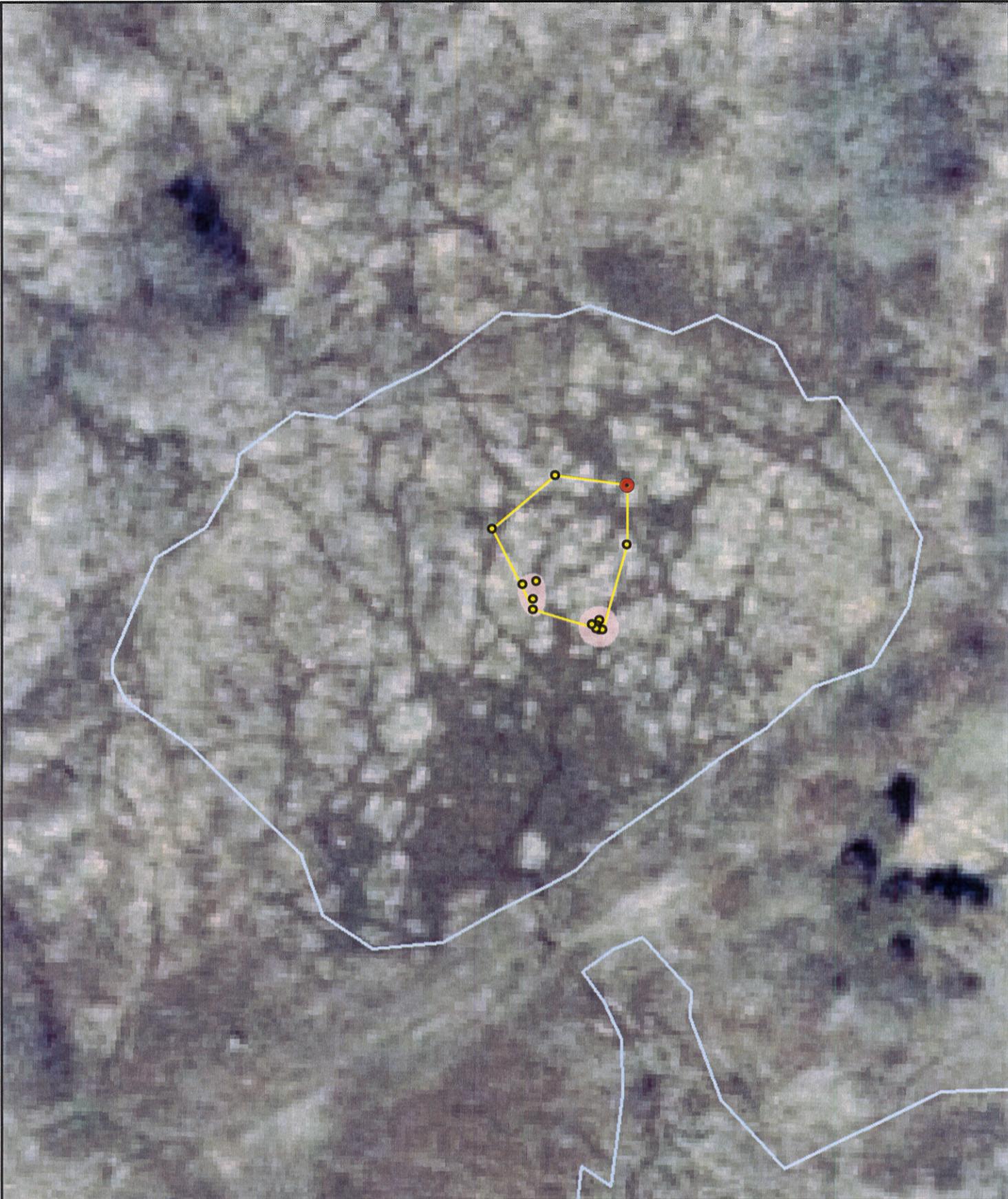
*Signature on File*

ANNE BALLMANN, DVM, Ph.D.  
Wildlife Disease Specialist

Phone: 608-270-2445 E-Mail: aballmann@usgs.gov

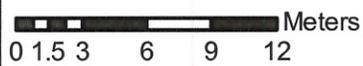
**Diagnostic findings may not be used for publication without the pathologist's knowledge and consent.**

**Appendix C:  
Activity Range Maps for Individual Bog Turtles**



**Legend**

- Female 09.01 - Locations 2009
- Female 09.01 - Minimum Convex Polygon 2009
- Female 09.01 - Kernel 50% Isopleth 2009
- Hibernaculum
- Primary Habitat



Appendix C-1. Activity range map for female bog turtle #09.01 in 2009. Activity ranges are displayed by the MCP and Kernel (50% isopleth = core habitat) methods.

Imagery: PAMAP Program 2005 Color

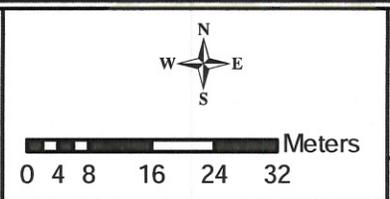
Created: 3/21/11

Herpetological Associates, Inc.





Legend	
	Male 09.06 - Locations 2009
	Male 09.06 - Minimum Convex Polygon 2009
	Male 09.06 - Kernel 50% Isopleth 2009
	Hibernaculum
	Primary Habitat



Appendix C-2. Activity range map for male bog turtle #09.06 in 2009. Activity ranges are displayed by the MCP and Kernel (50% isopleth = core habitat) methods.

Imagery: PAMAP Program 2005 Color

Created: 3/21/11

Herpetological Associates, Inc.



**Legend**

- Female 09.01 - Locations 2010
- Female 09.01 - Minimum Convex Polygon 2010
- Female 09.01 - Kernel 50% Isopleth 2010
- Primary Habitat
- Hibernaculum



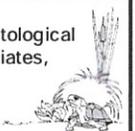
0 1.5 3 6 9 12 Meters

Appendix C-3. Activity range map for female bog turtle #09.01 in 2010. Activity ranges are displayed by the MCP and Kernel (50% isopleth = core habitat) methods.

Imagery: PAMAP Program 2005 Color

Created: 3/21/11

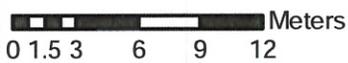
Herpetological Associates, Inc.





**Legend**

- Female 94.12 - Locations 2010
- Female 94.12 - Minimum Convex Polygon 2010
- Female 94.12 - Kernel 50% Isopleth 2010
- Hibernaculum
- Primary Habitat



Appendix C-4. Activity range map for female bog turtle #94.12 in 2010. Activity ranges are displayed by the MCP and Kernel (50% isopleth = core habitat) methods.

Imagery: PAMAP Program 2005 Color

Created: 3/21/11

Herpetological Associates, Inc.





**Legend**

- Female 94.31 - Locations 2010
- Female 94.31 - Minimum Convex Polygon 2010
- Female 94.31 - Kernel 50% Isopleth 2010
- Hibernaculum
- Primary Habitat

N  
W —+— E  
S

0 3 6 12 18 24 Meters

Appendix C-5. Activity range map for female bog turtle #94.31 in 2010. Activity ranges are displayed by the MCP and Kernel (50% isopleth = core habitat) methods.

Imagery: PAMAP Program 2005 Color

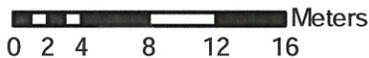
Created: 3/21/11

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**Legend**

- Female 01.02 - Locations 2010
- ▭ Female 01.02 - Minimum Convex Polygon 2010
- ▭ Female 01.02 - Kernel 50% Isopleth 2010
- Hibernaculum
- ▭ Primary Habitat

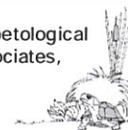


Appendix C-6. Activity range map for female bog turtle #01.02 in 2010. Activity ranges are displayed by the MCP and Kernel (50% isopleth = core habitat) methods.

Imagery: PAMAP Program 2005 Color

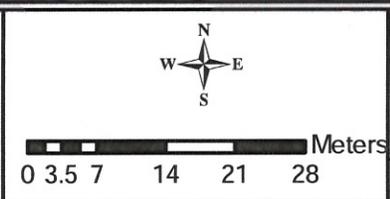
Created: 3/21/11

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Legend	
●	Female 01.07 - Locations 2010
□	Female 01.07 - Minimum Convex Polygon 2010
■	Female 01.07 - Kernel 50% Isopleth 2010
●	Hibernaculum
□	Primary Habitat



Appendix C-7. Activity range map for female bog turtle #01.07 in 2010. Activity ranges are displayed by the MCP and Kernel (50% isopleth = core habitat) methods.

Imagery: PAMAP Program 2005 Color

Created: 3/21/11

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<p><b>Legend</b></p> <ul style="list-style-type: none"> <li>● Male 10.01 - Locations 2010</li> <li>▭ Male 10.01 - Minimum Convex Polygon 2010</li> <li>▭ Male 10.01 - Kernel 50% Isopleth 2010</li> <li>● Hibernaculum</li> <li>▭ Primary Habitat</li> </ul>		<p>Appendix C-8. Activity range map for male bog turtle #10.01 in 2010. Activity ranges are displayed by the MCP and Kernel (50% isopleth = core habitat) methods.</p> <p>Imagery: PAMAP Program 2005 Color</p>	<p>Created: 3/21/11</p> <p>Herpetological Associates, Inc.</p>
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HA File No.PA2007.37

**Bog Turtle Surveys and a Radio-telemetry Study  
at a Wetland Complex in Lancaster County,  
Pennsylvania 2009-2010**



*A juvenile Bog Turtle*

Submitted January 17, 2012

to

***The Nature Conservancy***

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Gilbertsville, Pennsylvania 19525

by

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