RECOVERY OF THE BLANDING'S TURTLE (*EMYDOIDEA BLANDINGII)* AT SPRING BLUFF NATURE PRESERVE, LAKE COUNTY FOREST PRESERVES

FINAL REPORT

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And
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Introduction

Urbanization in the Chicago Wilderness region has resulted in a substantial loss of natural wetland communities. Many land management and conservation agencies within the region have included wetland restoration, creation, and protection among their priorities. However, wetland species requiring large expanses of interspersed wetland and upland habitat, such as the Blanding's Turtle (*Emydoidea blandingii*), remain at risk of extirpation (Burke, et al. 1995). The Blanding's Turtle is experiencing range-wide declines and is protected in most states in which it occurs (Levell 1997), including Illinois (Redmer and Kruse 1998) and Wisconsin (Anonymous 1997). Within Illinois, the Blanding's turtle was historically common in the extensive marsh systems of the northern half of the state (Kennicott 1855), but because of severe habitat loss, they now occur in isolated remnant wetland patches (Smith 1961). Continued habitat degradation and fragmentation may be leading to increased isolation and possible extirpation of Blanding's turtle populations (Rubin, et al. 2001a). Recent studies indicate that Blanding's turtles are becoming uncommon in the Chicago region (Ludwig, et al. 1992; TAMS Consultants 1996; Redmer 1998; Zak 2003; Kuhns, et al. 2004; Rubin, et al. 2004). Because of their threatened status and rarity, recovery strategies must be initiated to halt further declines and stabilize local populations of Blanding's turtles. In 2004, we initiated a study to examine the spatial ecology and demography of Blanding's Turtles on Lake County Forest Preserve properties. The results of that study documented only one population of Blanding's Turtles on Lake County Forest Preserve lands, being at Spring Bluff Nature Preserve (SBNP) and adjacent Chiwaukee Prairie Nature Preserve(CPNP) (Kuhns et al 2005).

In 2007, we began a study to formulate a management plan for Blanding's Turtles in Illinois with the following objectives:

Job 1. Evaluate nest predation and efficacy of nest protection
- 1.1 Conduct predator abundance surveys
- 1.2 Determine nest predation rates using motion-triggered cameras
- 1.3 Monitor protected and un-protected nests (clutch frequency, hatch rate, predation rate) to determine efficacy of nest protection enclosures

Job 2. Population modeling
- 2.1 Continue data collection for population viability analysis
- 2.2 Model parameters such as nest protection, predation rates, augmentation rates, survival, maturity, etc. using the modeling programs Vortex, Stella, Madonna and MatLab.

Job 3. Population augmentation
- 3.1 Initiate contract with McHenry County Conservation District – Wildlife Resource Center (MCCD) to head-start turtles
- 3.2 Collect eggs and deliver to MCCD
- 3.3 Release and monitor released hatchlings

Job 4. SBNP Turtle Management Plan
- 4.1 Utilizing the conclusions drawn from the study, design a long term management plan to continue the effort to stabilize the population
- 4.2 Implement management plan by providing it to District staff and providing any training on specific techniques (trapping, monitoring, etc.)

Job 5. Prepare final report

5.1 Prepare final report per grant requirements

Job 1: Evaluate nest predation and efficacy of nest protection

1.1 Conduct predator abundance surveys.

Studies of Blanding's Turtles have documented that predation on the young stages of turtles (ie. predation of eggs and hatchlings) is very high and may limit population growth. Congdon et al (2000) found that predation rates on nests varied from 40% to 100% annually over a 23 year study of the species. In the aforementioned study, nearly ½ of all depredated nests were destroyed in the first 24 hours after deposition and 84% of nest predation occurred within five days of deposition. No nest predation was observed after 30 days. The primary source of nest predation of Blanding's Turtles is meso-predators such as raccoons, foxes, skunks, and opossum (Congdon et al. 1993, Ross and Anderson 1990, Temple 1987). The return of raccoons to a site where they had been trapped and removed resulted in a four-fold increase in nest predation rates for the yellow mud turtle, *Kinosternon flavescens* (Christiansen and Galloway 1984). Similarly, management of raccoon populations on a marine turtle nesting beach resulted in a decrease in nest predation rates from a high of 95% prior to removal down to 9.4% after four years of management (Engeman et al, 2005).

On 8 August 2007, we initiated a mesopredator presence survey at SBNP and adjacent CPNP. We monitored six scent stations baited with fatty acid tablets (USDA Pocatello Supply Depot) for a total of 85 station nights and 2035 station hours. Each station consisted of a ~1m ring of sand with a scent tablet placed in the center, and a motion sensing camera (Cuddeback, NoFlash and Excite Digital Scouting Cameras). Stations were operated for two to three nights weekly. At the conclusion of each sampling period, we identified visitors to the station by identifying tracks in the sand and images recorded on the digital memory cards.

Although stations were effective in recording the presence of wildlife (N = 72 visitors), few predators (N = 10) were documented. A total of five raccoons, one opossum, and four canids visited the stations which leads to a predator station visitation rate of 0.11 visits per station night. Potential egg predators not classified as meso-predators that visited the stations included four chipmunks, two squirrels, and one mouse and increases our visitation rate to 0.20 visits per station night. Non predator visitors include 33 birds, 15 rabbits, and seven deer.

In 2008, we had two random sampling points at which infrared digital remote camera stations (1 camera per point) were operated for four nights each (6-9 October 2008). Camera stations were baited with sardines. Cameras were checked daily and re-baited as needed. Cameras recorded 1 visitation by an opossum, three visitations by raccoons, and two by coyotes in eight station nights for a predator visitation rate of 0.625 visits per station night. Although not documented by our sampling in either year, muskrats and mink also occur at the site.

1.2 Determine nest predation rates using motion-triggered cameras.

The majority of gravid females in 2008 and 2009 were taken into captivity for egg deposition decreasing the number of nests available for predation studies. Therefore, near the end of the nesting season in 2008, we placed 40 pairs of artificial nests in Spring Bluff Nature Preserve.

Each nest pair consisted of two holes 3 meters apart. In one nest we placed ten quail eggs, the second paired nest was left empty. Both nests were then plugged with a wad of soil. Simulated nests were checked twice weekly for evidence of nest predation (Table 1.2.1). Twenty five percent of nests were depredated in the four weeks that they were monitored. Interestingly, there was no difference in predation rates between nests with and without eggs suggesting the scent of eggs was not the only cue that predators were using.

On 03 July 2009, we constructed 25 artificial nests at one of the main nesting locations for Blanding's Turtles at the site. Nests were constructed similarly to those described above although there were no negative controls (ie. eggs were placed in all holes). Nests were placed in five linear arrays of five nests each. Motion triggered cameras were placed at one end of each array in an attempt to document predation events. Nests were checked daily for predation events. All but three nests were depredated by 21 August 2009 (Table 1.2.2). Motion triggered cameras captured coyote and domestic dogs as potential nest predators (Plate 1.2.1).

1.3 Monitor protected and un-protected nests (clutch frequency, hatch rate, predation rate) to determine efficacy of nest protection enclosures.

During the nesting season, gravid females were tracked during the day and again around dusk to document nesting locations. Once gravid females were radio-located on land near potential nesting locations, we also tracked them by thread spooling. For this, we placed small thread bobbins inside a "fast-food" condiment packet, and duct taped the packet to the posterior of the carapace. One end of the thread was fed through a hole in the condiment packet and tied to nearby vegetation. By following the thread, we were able to re-trace female movements. Thread bobbins were replaced as needed.

Nests occurring within the preserve were protected as soon as they were observed, with a cage made of hardware cloth. Cages were cylindrical (~ 0.5 m diameter), open on the bottom, and capped with a square of hardware cloth wired to the top. Nest protection cages were centered over the nest chamber and the open end was buried ~10 cm into the soil and staked with small twigs. Cages were checked once or twice daily starting 15 August. Once emergence began, we waited until seven days had passed since we last saw a hatchling emerge and then excavated the nest to determine the number of infertile and un-hatched eggs.

Clutch size of these ten nests averaged 10.8 eggs and the hatching rate was 83% for nests laid and incubated *in situ*. Two nests (3 & 9 of Table 1.3.1) were not found until the morning after they were laid, at which time both had been partially depredated. It is unlikely that any hatchlings would have emerged from these two nests, had they not been caged on discovery. One nest (#1) was on private property and left unprotected until three days before hatchlings emerged. This is the only nest that we have observed that produced hatchlings without nest protection

If we consider that the two nests that were partially depredated prior to being caged would have failed, the result is that 5 of 6 (83%) unprotected nests were predated. This value coupled with the hatchling success rate for eggs that were not depredated results in an overall estimate of 14% (17% nest survival * 83% hatch rate) survival to hatching for the population of Blanding's Turtles inhabiting SBNP.

Table 1.2.1 Cumulative predations of 40 pairs of simulated turtle nests from 2008. Each pairing had one empty nest cavity (control) and one nest cavity with ten quail eggs. Paired nests were located 3 meters apart. Nests were checked twice weekly for predation.

Date	7/25	7/29	7/31	8/5	8/7	8/12	8/14	8/19	8/21
Control	1	2	3	3	3	5	7	10	11
Eggs	1	2	3	3	3	4	5	8	9

Table 1.2.2. Predation rates on 25 simulated turtle nests checked from 03 July through 21 August 2009. Each nest was seeded with ten quail eggs. Nests were laid out in five linear arrays of five nests per array with a motion-triggered camera including all five nests in its line of sight.

Nest #	Predation Date	# of days	Predation event
1	07/31/09	29	Full
2	08/16/09	45	Full
3	07/10/09	8	Partial (no re-check)
4	08/16/09	45	Full
5	07/10/09	8	Full
6	07/10/09	50	Survived
7	07/29/09	27	Full
8	07/29/09	27	Full
9	08/16/09	45	Full
10	07/10/09	8	Full
11	08/16/09	45	Full
12	08/16/09	45	Full
13	07/14/09	12	Partial*
14	07/29/09	27	Full
15	07/29/09	27	Full
16	08/16/09	45	Full
17	07/07/09	5	Full
18	08/21/09	50	Survived
19	08/21/09	50	Survived
20	07/31/09	29	Full
21	07/29/09	27	Full
22	07/29/09	27	Full
23	07/29/09	27	Partial**
24	07/29/09	27	Full
25	07/29/09	27	Partial**

* Fully depredated on 7/29/2009
** Fully depredated on 7/30/2009

Table 1.3.1. Clutch size, incubation duration, and hatchling success for Blanding's Turtles' nests monitored from 2006-2010 in Spring Bluff Nature Preserve & Chiwaukee Prairie Nature Preserve.

Nest	Deposition Date	Emergence Date	Nest Protected	Incubation Duration	Eggs Deposited	Hatchlings Emerged	% Emerged
1	6/12/2006	9/11/2006	No	91	19	15	79%
2	6/25/2006	9/05/2006	Yes	72	13	10	77%
3	7/01/2006	9/18/2006	Yes*	79	12	9	75%
4	7/11/2009	10/2/2006	Yes	83	8	9	89%
5	6/06/2007	8/20/2007	Yes	75	11	11	100%
6	6/09/2007	8/19/2007	Yes	71	14	10	71%
7	6/12/2007	8/31/2007	Yes	80	5	5	100%
8	6/13/2007	9/03/2007	Yes	82	9	9	100%
9	6/18/2007	9/07/2007	Yes*	81	10	5	50%
10	6/23/2007	9/04/2007	Yes	73	10	8	80%
11	6/26/2007	9/11/2007	Yes	77	12	12	100%
12	6/22/2008	NA	Yes**		8	0	0%
13	6/15/2008	9/05/2008	Yes	82	10	10	100%
14	6/07/2010	NA	No		NA	0	0%
15	6/10/2010	NA	No		NA	0	0%
16	6/11/2010	NA	No		NA	0	0%
17	6/17/2010	NA	No***		NA	NA	NA
Averages				77	10.8	8.7	83%

* Nests were partially depredated before being caged.
**Nest was destroyed by a farm implement. Excavated eggs indicated partial development of embryos.
***Nest was intact at last check 29 June 2010 but is not included in nest predation rate estimate

Plate 1.2.1. Potential nest predators documented from artificial turtle nests in 2009. The domestic dog is digging up one of the artificial nests. Coyote (arrowed) was not observed digging but was in the vicinity of a nesting array.

Job 2. Population Modeling

2.1 Continue data collection for population viability analysis.

The predominant sampling method was baited hoop traps (Legler 1960) with double throats. We utilized three sizes of hoop traps (1m D x 1.5m L; 0.5m D x 1m L; and 0.3m D x 0.5m L). All hoop traps were placed such that at least 5cm of the trap was above the surface of the water to ensure turtles had access to air. Traps were placed parallel to the shoreline or other structures where possible, in an attempt to funnel turtles into the traps. We baited hoop traps with canned sardines. Traps also tended to self-bait with crayfish, and other aquatic invertebrates. Baits were changed every 2 – 4 days. We supplemented trapping with hand captures during routine trap checks, during radio-telemetry, and visual encounter surveys in the spring. Upon initial placement of traps, we recorded GPS coordinates (UTM; NAD83). Traps were moved to new locations when they had to be pulled for repair or when they yielded no captures after approximately one week of sampling. Each Blanding's Turtle was marked with a Passive Integrated Transponder (PIT tag; Biomark™).

We partitioned captured individuals of each species into four sex categories; male, female, juvenile and hatchling. Males were identified by having the combination of cloacal vent extension beyond the posterior carapace margin and a concave posterior plastral lobe. Females were identified by the presence of a cloacal vent that did not extend beyond the posterior carapace margin and no posterior plastral lobe concavity. Small and questionable individuals were classified as unknown. We palpated the inguinal pockets of all females to determine their reproductive condition. We took blood samples from the cervical sinus of captured turtles (Fisher 2003). We took no more than 0.1 cc per 100 grams of turtle mass (Moon and Hernandez-Divers 2001). Blood samples were stored in 100% EtOH at the Illinois Natural History Survey in a -80°C freezer. After workup, turtles were released at their capture location.

Turtles were tracked from approximately April through October, annually. At each location, we recorded GPS coordinates (UTM-NAD 83 CONUS) and a suite of habitat and environmental variables including: air temperature, soil/water temperature, relative humidity, water depth, ground and canopy cover, vegetation height, presence or absence of aquatic vegetation, and habitat type.

Once gravid females were observed on land, we augmented tracking with thread spools. For this, we placed small thread bobbins inside a "fast-food" condiment packet, and used duct tape to attach the packet to the posterior of the carapace. One end of the string was threaded through a hole in the packet and tied to nearby vegetation. The starting point was flagged. By following the string, we could then retrace the female's movements. Thread bobbins were replaced as needed until egg deposition.

Gravid females were tracked in the evening hours during the nesting season. If females were observed nesting, we noted the location with minimum disturbance and recorded environmental variables away from the nesting location. The following morning, we returned to the nest site and recorded habitat variables then located and palpated the female to verify if nesting was successful.

With the exception of 2010, all nests occurring within the preserves were protected from predation by a cylindrical hardware cloth cage (~ 0.5 m diameter), which was capped with additional hardware cloth. Cages were centered over the nest chamber and buried ~10 cm into the substrate. Cages were checked once or twice daily starting 15 September until no hatchlings had emerged from the nest for seven days. We then determined the presence of additional hatchlings, infertile, and un-hatched eggs (either by excavating the nest or feeling inside the nest chamber). A nest deposited on private property near SBNP was not protected but was caged during emergence to collect the hatchlings. Some nests were not discovered until the following morning at which time they had been partially depredated. In 2010, we did not protect any nests to determine predation rates.

We captured turtles 2352 times during the study, 783 of which were Blanding's Turtle captures (Table 2.1.1). Our overall capture rate for Blanding's Turtles was 0.049 turtles per trap night (Table 2.1.1). We calculated the adult sex ratio and juvenile-adult ratio based on individuals encountered through trapping and hand captures. We captured 45 female and 55 male adult Blanding's Turtles for a sex ratio of 0.81F:1M. In addition to the 100 adults, we captured 75 juveniles Blanding's Turtles from 2004 through 2010 which gives us an adult to juvenile sex ration of 0.75:1. I did not include captures of individuals that were released as part of the head-starting experiment (see below) in the calculations of sex or stage ratios.

To estimate population size we partitioned the data sets into monthly sampling intervals and utilized multiple mark/recapture period census estimates (Seber 1973). Closed models were used for population estimates. Data were partitioned into total captures (C_t), number of recaptures (R_t), number of new captures (U_t) and cumulative captures (M_t). In an attempt to help meet the assumptions of equal catchability and population closure we only used juvenile and adult turtles old enough to have been available for capture throughout the six years of the study. Therefore, if a four year old was captured in 2009, its capture history was not used for the estimate because it would not have been available for capture for all or most of 2005.

We calculated estimates for three closed population models, using Excel spreadsheets (Schnabel 1938; Schumacher and Eschmeyer 1943; Tanaka 1951). We tested the assumptions of equal catchability and population closure in tandem using linear regression of M_t and y_i = (Rt/Ct) the proportion of recaptures in the sample (Krebs 1989). If the y-intercept did not significantly differ from zero, we reran the regression fixing the y-intercept at zero. Population closure and equal catchability were met if the resulting scatterplot is linear. We did not meet the assumption of either equal catchability or population closure (Figure 2.1.1).

We calculated the percent relative precision of the closed population estimates (Greenwood 1996). The PRP was then used to rank the closed population models to determine which one gave the most precise estimate across years. The Tanaka model had the highest PRP with a population estimate of 162 (95% CI's 154 to176) individuals (Table 2.1.2). Despite not meeting the assumptions of population closure or equal catchability we believe that these results are representative of the population size at SBNP. A total of 175 Blanding's Turtles were captured in SBNP during the study and very few new adult individuals were captured after 2008. This would indicate that we have captured most of the individuals in the population. Further, our population estimates are very close to the actual numbers of turtles captured which further supports the validity of the estimates.

Because we trapped very early and very late in the sampling seasons, when few turtles were active, we did not expect to meet the assumptions of equal catchability. Therefore we attempted to use the Cormack-Jolly-Seber models provided in the program JOLLEY (Pollock et al 1990) to determine population size across years. Robust population estimates provide both within year population estimates when the populations are considered closed and an overall estimate of population size for the overall duration of the study where there is no assumption of population closure. For this analysis, I partitioned the within year data into two (pre and post nesting season) sampling periods. The model that best fit the data held survival rates constant across years with varying recapture probabilities. The population estimate varied from 87 individuals in 2005 to 134 individuals in 2010 with an average population estimate of 119 individuals (Table 2.1.3).

Survival estimates Survival estimates were calculated using program Mark. We estimated survival probabilities for four separate age/stage categories [hatchlings (0 to 1 YO), young juveniles (40 to 120mm CL), older juveniles (120-160mm CL), and adults (>160mm CL) utilizing different datasets collected during this study.

Hatchling survival was estimated using a telemetry dataset gathered by radio-locating hatchling turtles from nest emergence into early November 2008. Hatchlings came from both caged nests and individuals that had hatched out as part of the head-starting program. Hatchlings were released either from their nesting cage, or in the case of nests that were artificially incubated, from the location of their mother's nest the previous year. Hatchlings were tracked for approximately nine weeks before transmitters were removed. We then used the known fates method in program Mark to construct models to estimate survival over those nine weeks. This value was extrapolated over a 52-week period to estimate annual survival. Then, using the overall average clutch size (12), average nest predation rate (83%), average hatching rate of eggs in successful nests (83%), and the annual survival rate of hatchlings to estimate survival from age 0 to 1 results in a survival estimate of 0.07% from egg deposition through year one.

Young juvenile, older juvenile, and adult survival rates were calculated using the recoveries only procedure in program Mark and were based on annual recapture matrices of each of these age/stage classes with 0 representing not capturing the individual in that year and 1 indicating that the individual had been captured. These resulted in survival estimates of 0.67 for young juveniles, 0.86 for older juveniles, and 0.88 for adults. Using the program Datafit, we constructed a Von Bertlanaffy curve to estimate annual survival rates from age 0 through adulthood at age 14 (Table 2.1.4; Figure 2.1.2).

Table 2.1.1. Trapping results and catch per unit effort by year and species for turtles inhabiting Spring Bluff Nature Preserve and Chiwaukee Prairie Nature Preserve. CHPI= Painted Turtles, *Chrysemys picta*; CHSE = Snapping Turtle, *Chelydra serpentina*; EMBL = Blanding's Turtle, *Emydoidea blandingii*.

YEAR	2004	2005	2006	2007	2008	2009	2010	OVERALL
# Locations	22	129	162	78	59	105	100	655
Trap Days	472.99	2488.26	3438.07	2711.34	1637.59	3696.22	1635.62	16080.09
CHPI CAPS	17	474	232	106	80	113	8	1030
CHPI CPUE	0.036	0.190	0.067	0.039	0.049	0.031	0.005	0.064
CHSE CAPS	12	145	152	90	46	84	10	539
CHSE CPUE	0.025	0.058	0.044	0.033	0.028	0.023	0.006	0.034
EMBL CAPS	18	153	227	138	120	97	30	783
EMBL CPUE	0.038	0.061	0.066	0.051	0.073	0.026	0.018	0.049
Turtle CAPS	47	772	611	334	246	294	48	2352
Turtle CPUE	0.099	0.310	0.178	0.123	0.150	0.080	0.029	0.1463

Table 2.1.2. Closed population estimates for the population of Blanding's Turtles inhabiting Spring Bluff Nature Preserve and adjacent Chiwaukee Prairie Nature Preserve. Estimates come from turtles trapped from 2004 through 2009. N = Estimated Population Size flanked by the confidence intervals. PRP is the percent relative precision used to rank models.

Model	N	U 95% CI	L 95% CI	PRP
Tanaka	165	176	154	6.55
Schumacher-Eshmeyer	149	159	140	6.59
Schnabel	141	154	130	8.54

Table 2.1.3. CJS robust design population estimate for Blanding's Turtles inhabiting SBNP.

Year	N	Variance	error	95% C.I.'s	
2005	87.15	138.8810	11.78	64.05	110.24
2006	130.71	14.7732	3.84	123.18	138.25
2007	124.94	15.8076	3.98	117.15	132.73
2008	123.68	44.2195	6.65	110.64	136.71
2009	119.40	94.2277	9.71	100.37	138.42
2010	132.21	161.4336	12.71	107.30	157.11
MEAN	119.68	167.9741	12.96	94.28	145.08

Table 2.1.4. Mortality and survival rates for Blanding's Turtles from emergence to adulthood for the population at Spring Bluff Nature Preserve.

To Age	Survival Rate	Mortaity Rate
1	0.072	0.928
2	0.300	0.700
3	0.464	0.536
4	0.584	0.416
5	0.670	0.330
6	0.732	0.268
7	0.778	0.222
8	0.810	0.190
9	0.834	0.166
10	0.851	0.149
11	0.863	0.137
12	0.872	0.128
13	0.879	0.121
14	0.884	0.116

Figure 2.1.1. Test of equal catchability and population closure.

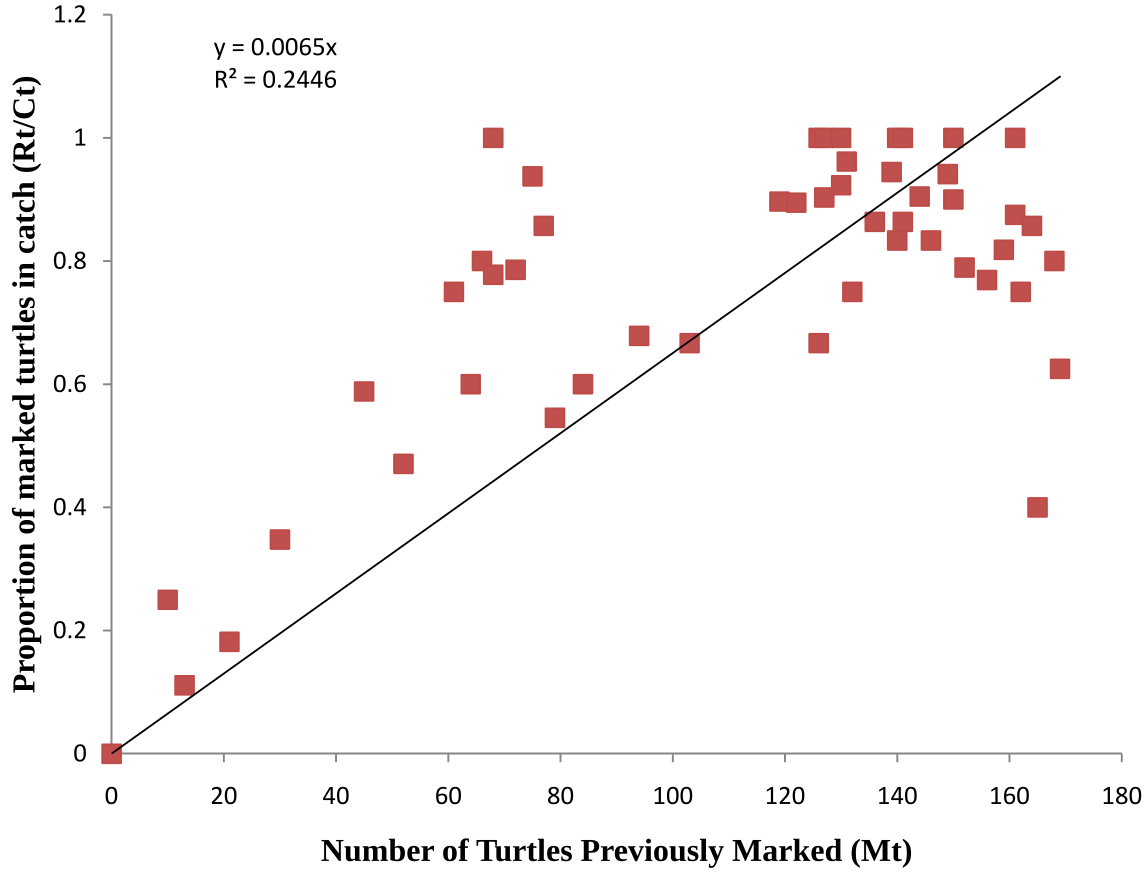
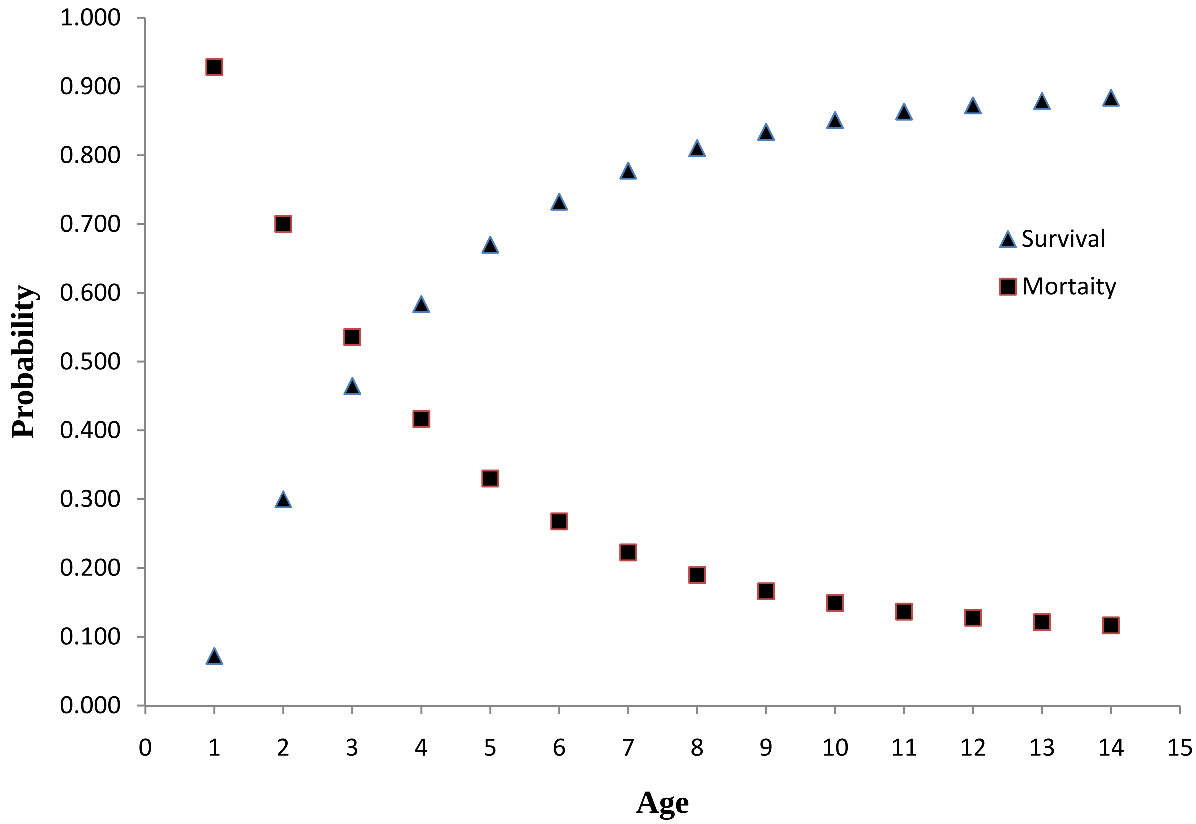


Figure 2.1.2 von Bertlanaffy curve of survival rates to adulthood for Blanding's Turtles from Spring Bluff Nature Preserve. $S= 0.8959322*(1-1.27087e^{-0.32338*Age})$. Mortality rates for the Vortex model were estimated as 1- S.



2.2 Model parameters such as nest protection, predation rates, augmentation rates, survival, maturity, etc. using the modeling programs Vortex, Stella, Madonna and MatLab.

The trajectory of the Spring Bluff population of Blanding's Turtles was modeled using Vortex 9.72. Input parameters for Vortex models are available in Appendix I. All values used in the model came from data collected from the study site with the exception of maximum age of reproduction which is unknown in our population, but estimated based on reports from the literature. Models were constructed to run 1000 iterations and model the population trajectory over a 50 year time period.

It is important to note that a model is only as good as the validity of the values entered into the program. There is an inherent difficulty in predicting the trajectory of a population while monitoring it for the equivalent of < ½ of its generation time. It has been suggested that population trajectory models and extinction probabilities are only valid out to the equivalent of 10 to 20% of the time that the population was monitored (Fieberg and Ellner 2000). For these models we used values estimated from data at our study site. In some instances (eg. nest predation rates) these values are based on small sample sizes. I chose to use the closed population estimates for modeling trajectories even though the data indicate that the population is not in fact closed. Therefore, models based on our best estimate can only be considered our "best guess" of what this population is experiencing and used to suggest general trends in the population.

I chose to use the closed population estimate because I find it unlikely that 32% (175 captures, pop estimate of 119) of the turtles captured during the course of this study have died or left the population and that the closed estimate of 165 individuals is likely closer to the true population size.

The initial model of current conditions (Table 2.2.1-No Management) indicated that the stochastic growth rate of the population is currently -0.091, indicating that the population size is decreasing. This model predicts that within the next 50 years there is a 95% probability that the population will go extinct. Further, the average population size of the modeled populations that remain is only three individuals.

I then modeled population trajectories under different management plans including head-starting and releasing 50 and 100 turtles annually. I did not exceed the 100 hatchling turtle mark as it would likely be unfeasible to collect more than ten gravid females annually. To incorporate head-starting into the models, I harvested one year old individuals from the population and the following year they were returned to the population as four year old individuals (ie had a survival rate equal to that of a four year old). I modeled the population trajectories under different numbers of hatchlings released and for different durations ranging from 50 individuals for ten years to 100 individuals for 30 years. While head-starting did significantly reduce the probability of extinction by 2060, the stochastic growth rate remained negative indicating that the population size continued to decrease.

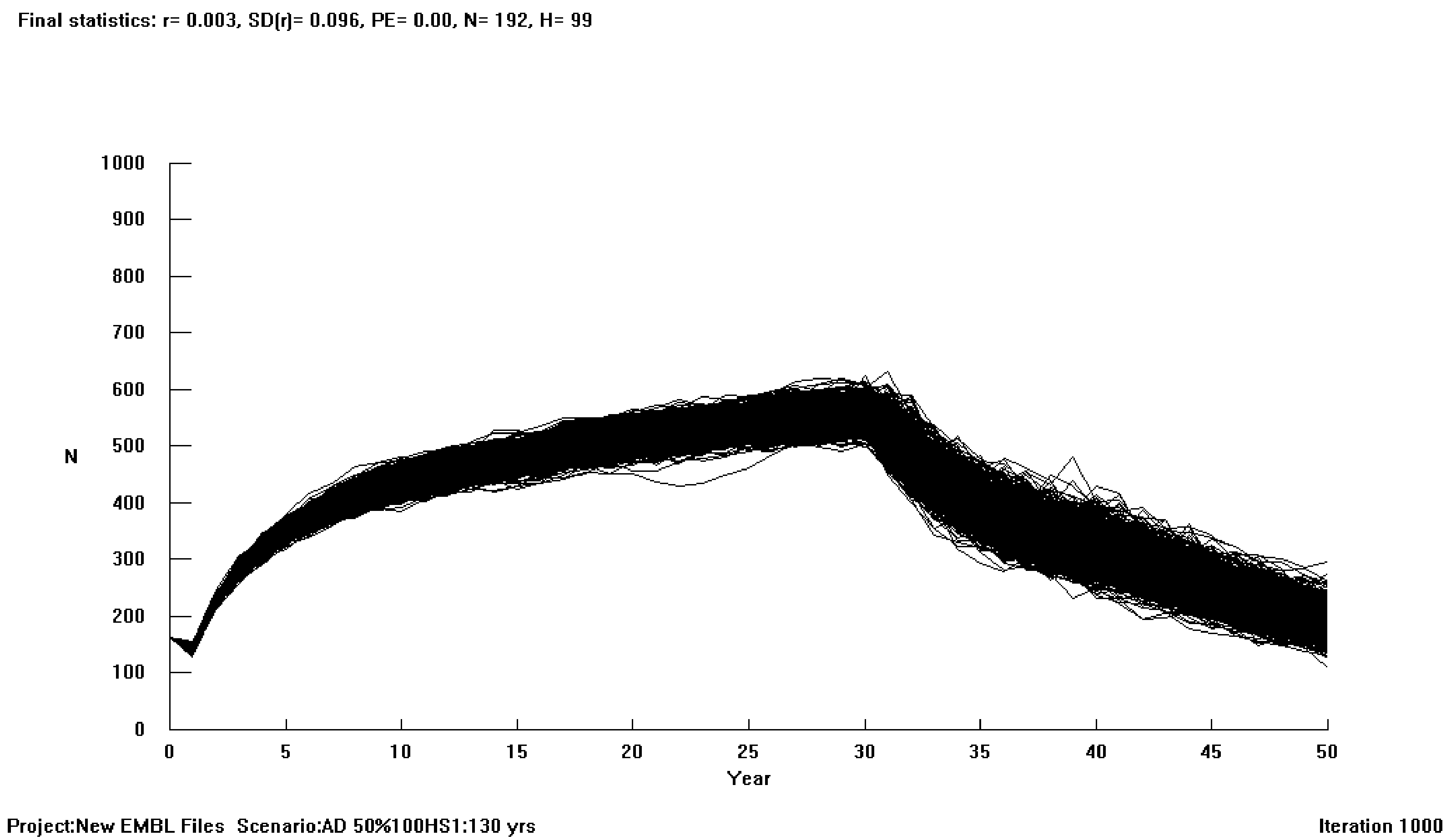
I then modeled the effect a reduction in the adult mortality rates would have on the population. I modeled reductions of 50% and 70%. This is equivalent to a 1.16% reduction in overall mortality rates per 10% reduction (ie. a 50% reduction of the 11.6% mortality rate results in a mortality rate of 5.8% and a 70% reduction equates to a mortality rate of 3.5%). Reducing adult mortality by 50% still resulted in a negative population growth rate, although the probability of extinction dropped to 14% and average population size in 50 years was only nine individuals.

I then modeled the effect of reducing adult mortality combined with population augmentation by head-starting (Table 2.2.1). To meet the conditions of a stable or increasing population growth rate, adult mortality would need to be reduced 50% while head-starting 100 individuals annually for 30 years. It is, however, important to note that as soon as the head-starting stops, the population size begins to decline (Figure 2.2.1). Interestingly, decreasing adult mortality 70% would cut the duration of head-starting nearly in half although the population growth rate remained slightly negative at -0.002.

Table 2.2.1. Results of Vortex models examining population trajectories under different management strategies. #HS indicates the number of head-started individuals released annually, HS sex ratio is the sex ratio (F:M) of head-started turtles, SGR is the average Stochastic Growth Rate of the population *sd* (SGR) is the standard deviation of SGR, Extinction Probability is the likelihood that the population at SBNP will go extinct in the next 50 years under the scenario, N extant is the average population size of extant populations at the end of 50 years, *sd* (N-ext) is the standard deviation on N extant. For parameter estimates used in these models see Appendix I.

Scenario	Reduce Adult Mort	# HS	HS sex ratio	Duration (yrs)	SGR	*sd* (SGR)	Extinction Probability	N extant	*sd* (N-ext)
No Management	0	0	---	---	-0.109	0.202	0.949	3	1.4
50HS 1:1 10yrs	0	50	1:1	10	-0.078	0.176	0.547	5	2.7
50HS 1:1 30yrs	0	50	1:1	30	-0.032	0.095	0.000	34	8.5
100HS 1:1 10yrs	0	100	1:1	10	-0.068	0.175	0.241	7	3.6
100HS 1:1 30yrs	0	100	1:1	30	-0.032	0.095	0.000	70	12.8
Adult mortality reduced 50%	50%	0	---	---	-0.063	0.151	0.137	9	4.1
Adult mortality reduced 70%	70%	0	---	---	-0.041	0.107	0.000	23	6.9
Adult mort reduced 50% HS 50 1:1 10yrs	50%	50	1:1	10	-0.038	0.110	0.000	26	7.6
Adult mort reduced 50% HS 100 1:1 10yrs	50%	100	1:1	10	-0.026	0.122	0.000	45	10.8
Adult mort reduced 50% HS 100 1:1 20yrs	50%	100	1:1	20	-0.009	0.108	0.000	106	16.9
Adult mort reduced 50% HS 100 1:1 30yrs	50%	100	1:1	30	0.003	0.096	0.000	191	23.0
Adult mort reduced 50% HS 100 2:1 20yrs	50%	100	2:1	20	-0.006	0.108	0.000	122	18.1
Adult mort reduced 70% HS 100 1:1 15 yrs	70%	100	1:1	15	-0.002	0.104	0.000	149	20.5

Figure 2.2.1 Population trajectory for Vortex model assuming a 50% reduction in adult mortality, and releasing 100 head-started hatchling turtles at a 1:1 sex ratio for 30 years. Note that the population is in decline despite the fact that the overall stochastic growth rate is positive and the average population size at 50 years is 192 individuals.



Job 3. Population Augmentation

3.1 Initiate contract with McHenry County Conservation District – Wildlife Resource Center (MCCD) to head-start turtles. Completed.

3.2 Collect eggs and deliver to MCCD In 2008, 20 adult females were monitored by radio-telemetry. Seventeen of the 20 became gravid and ten of those were taken to McHenry County Conservation District Wildlife Resources Clinic to deposit their eggs in captivity. The ten clutches deposited in captivity resulted in 123 eggs, 67 of which hatched (54%). In 2009 five gravid females were taken to MCCD and four clutches totaling 53 eggs. At the time of this report 12 hatchlings have been released and 21 remain in captivity to increase their sizes before release in 2011. Eleven clutches totaling 136 eggs were deposited in captivity in 2010. These eggs are being incubated at MCCD and then will be transferred to LCFPD for rearing and head-starting. These individuals will be released in 2011. Information on the on the fates of all artificially incubated eggs over the 2008 winter is available in Table 3.2.1. Overall 312 eggs were deposited in captivity over the three years of this project and to date 69 hatchlings have been released, 21 remain in captivity from the 2009 cohort, and 122 hatchlings from 136 eggs incubated in 2010 are being head-started (Table 3.2.2).

3.3 Release and monitor released hatchlings.

We undertook two separate studies to examine this portion of the project. In 2007, we released and monitored turtles from the 2006 cohort that had been raised in captivity overwinter. In 2008, we tracked hatchling turtles from emergence to the selection of overwintering sites. Hatchlings came from both caged nests and eggs that had been incubated in captivity.

Head-started turtle monitoring-

In 2006, fourty-two hatchlings were collected from four nests (mean = 10.5, range 8-14)caged with wire mesh to deter predators and detain hatchlings. Hatchlings were removed from the cages after emergence in the fall and overwintered in the lab. In captivity, hatchlings were weighed and measured bi-weekly. At emergence, hatchlings averaged 8.0 g, with an average carapace length of 33.3 mm. Growth was fairly negligible until mid-December when it increased greatly until time of release (Figure 3.3.1). Thirty-nine hatchlings were released back into SBNP/CPNP on 7/17/2007. Transmitters were initially attached to ten head-started turtles and eight wild caught juveniles captured at the study site. If transmitters fell off, they were re-attached to the same or other head-started turtles as they were recaptured. A total of 15 head-started (HS) and 9 wild caught (WC) turtles were tracked between 7/17/2007 and 10/30/2008. All hatchlings were released in water nearest their original nest location on 7/17/2007. We attempted to track all turtles daily during the active season of 2007-2008. We recorded coordinates with Garmin GPS 12. Double throated collapsible hoop traps (Legler, 1960), were deployed in areas where turtles were released.

Only turtles with greater than 60 locations (9 HS, 6 WC) were used for analysis of movements and activity areas (Table 3.3.3). Tracked head-started turtles were significantly smaller ($p>0.001$) and lighter ($p>0.001$) than wild caught juveniles (Table 3.3.1). There was no significant difference in Mean Daily Distance (*p*=0.196), Mean Distance per Move (*p*=0.194), or Maximum Distance (24 hrs) (*p*=0.934) travelled although values were smaller for head-started turtles (Table 3.3.1). Similarly, although the mean activity area size of head-started turtles was less than half of that of wild caught juveniles, there result was not significantly different (*p* = 0.189) because of the large discrepancies in activity area sizes between individuals within each category (Table 3.3.2, Figure 3.3.2). In 2007, trapping resulted in 26 captures of 15 head-started turtles. In 2008, we recorded 28 captures of 15 head started turtles, 6 of which had not been recaptured in 2007.

We re-captured 21 of the 39 head-started turtles since release and have recorded two mortalities. Survival estimates were generated for these individuals in two ways using program MARK. Based on radio-telemetry data we used the known fates program to estimate annual survival for the individuals that were radio-located. This generated an annual survival estimate of 0.66. Additionally, we estimated survival rates for the entire cohort of 41 individuals using a closed population estimate. This also resulted in a survival rate of 66%. These survival estimates were very similar to the estimates for wild captured juveniles presented in the modeling section of this report.

While movements and activity area sizes are smaller for head-started turtles than wild caught juveniles, they appear to be using similar habitats and recapture rates appear high. However, the full efficacy of this experiment will not truly be known until we can determine if any of these individuals reach reproductive age (13-18 years) and successfully reproduce.

Hatchling turtle monitoring-

The majority of the 2008 cohort was raised over winter to be released in late spring 2009. However, we released two hatchlings (1F:1M) from each of seven clutches after they were equipped with 0.5g radio transmitters (Advanced Telemetry Systems model R1625, average battery life of 21 days). In addition to these 14 individuals, we also equipped three hatchlings from a caged nest and one hatchling that we incidentally encountered. Two hatchlings died within the first week of release. One never made it to water (although it was less than 10 meters from the release site) and the second drowned when a precipitation event lead to an increased water depth at its location. These hatchlings were tracked for an average of 51 days from 9/06/2008 through 11/07/2008 (Table 3.3). We tracked hatchlings 543 times and documented 216 novel locations. At each location we recorded GPS coordinates or distance and direction from last location, and recorded a suite of habitat and environmental variables. We released the remainder of the head-started turtles on 17 June 2009 and tracked them in the same manner we did for their cohorts the previous fall. Survival estimates for these individuals was estimated to be 57% annually as presented in the modeling section of this study.

Table 3.2.1. Number and fates of Blanding's Turtle eggs deposited at McHenry County Conservation District Wildlife Resource Center for clutches laid in 2008.

Parameter	Value
Total clutches to MCCD	10
Total eggs	123
Total eggs hatched in MCCD	68
Hatch success	55%
Number of hatchlings head-started*	54
Mortalities of head-started hatchlings	11
Overwinter survival in lab	80%
Hatchlings released in 2009	43
Percent of eggs that survived to be released in 2009**	39%
Total hatchlings released 2008-2009	57
Percent of eggs that survived to release	46%

* 14 hatchlings were released in 2008. So this number is figured as 68-14.

** Excluding 14 eggs/hatchlings released in 2008 (ie. 43 hatchlings from 109 egg)

Table 3.2.2. Clutch size, hatchling success, overwinter mortalities, and number of hatchling Blanding's Turtles released for eggs deposited at the McHenry County Conservation District Wildlife Resource Center in Blanding's turtles from 2008-2010. Clutches from 2010 have not hatched as of the filing date of this report.

Year	Mother	Clutch Size	# Hatched	% Hatched	Total Released
2008	Beullah	11	10	91%	10
2008	Delia	16	12	75%	8
2008	Viola	19	0	0%	0
2008	Abigail	10	3	30%	3
2008	Gillian	13	11	85%	10
2008	Lyda Jane	14	5	36%	5
2008	Elle Mae	14	11	79%	11
2008	Esther	10	9	90%	8
2008	Shirley	8	3	38%	1
2008	Nancy	8	4	50%	1
2009	Beullah	10	7	70%	3*
2009	Gillian	18	17	94%	6*
2009	Esther	8	0	0%	0
2009	Zelda	17	14	82%	3*
2010	Mabel	10	N/A	N/A	N/A
2010	Doreen	12	N/A	N/A	N/A
2010	Gillian	13	N/A	N/A	N/A
2010	Lyda Jane	13	N/A	N/A	N/A
2010	Esther	13	N/A	N/A	N/A
2010	Elle Mae	16	N/A	N/A	N/A
2010	Zelda	13	N/A	N/A	N/A
2010	Sara	16	N/A	N/A	N/A
2010	Nancy	10	N/A	N/A	N/A
2010	Betsy	9	N/A	N/A	N/A
2010	Mary	11	N/A	N/A	N/A
Totals		312	106	59%	69

***** Other hatchlings from the 2009 clutches remain in captivity and will be released in 2011. Clutches from 2010 are currently incubating at MCCD.

Table 3.3.1. Turtle size, number of locations, movement statistics, and activity area sizes of head-started vs. wild caught Blanding's Turtles.

ID	CL	Mass	# Loc	MDD	MDPM	Max	AA (m2)
HS1	74	74	75	1.6	3.3	6	19
HS2	77	74	118	2.9	3.5	85	7628
HS3	77	74	184	12.0	15.5	192	170879
HS4	76	71	194	8.2	11.1	217	90918
HS5	87	111	164	7.2	12.7	143	32923
HS6	81	86	119	6.2	9.7	52	9118
HS7	97	131	171	11.1	15.1	126	54159
HS8	86	86	115	7.2	9.4	138	9360
HS9	89	113	189	8.8	10.8	159	11816
Average	**83**	**91**	**148**	**7.3**	**10.1**	**124**	**42980**
WC1	95	131	60	5.3	9.4	44	1723
WC2	106	184	61	3.7	5.0	45	21400
WC3	107	202	185	14.2	19.3	155	134166
WC4	143	364	142	30.3	35.3	263	355168
WC5	139	395	61	6.3	10.3	53	2308
WC6	108	203	166	12.6	21.8	206	164779
Average	**116**	**247**	**113**	**12.1**	**16.8**	**128**	**113257**

HS = Head-started turtle, WC= Wild Caught turtle, CL=Carapace Length, # Loc = number of locations, MDD=average distance moved per day, MDPM=mean distance per move, MAX= maximum distance traveled in 24 hr, AA=activity area size

Table 3.3.2. Movement values for hatchling Blanding's Turtles equipped with radio transmitters in 2008. Locations is number of times tracked, MAX is the maximum move in a 24 hour period, MDD is the mean daily distance moved (with standard error), MDPM is mean distance per move (with standard error), and Total is total distance moved during the time that the individual was tracked. All distance units are meters.

ID	Duration (days)	Locations	MAX	MDD (se)	MDPM (se)	Total
01L-10L-01R	61	45	75	9.8 (3.3)	17.5 (5.5)	578
01L-10L-10R	61	44	111	7.9 (2.8)	20.1 (6.4)	483
01L-10L-11R	63	44	141	9.6 (3.1)	14.3 (4)	572
01L-10L-02R	45	39	101	9.7 (2.3)	14.3 (4.6)	428
01L-11L-03R	50	43	16	3.1 (0.1)	4.9 (0.1)	157
01L-11L-08R	36	35	29	5 (1.5)	3.8 (1)	141
01L-11L-09R	50	39	92	7.1 (2.8)	4.7 (1.9)	234
01L-11L-10R	56	41	94	10.3 (4.1)	5.5 (2.8)	299
01L-11L-11R	34	27	29	4.6 (1.9)	2.2 (0.6)	74
02L-03L-03R	57	41	35	5.7 (1.8)	3.3 (0.8)	187
02L-03L-08R	47	35	20	5.4 (0.9)	3 (0.6)	139
02L-03L-11R	58	42	30	5.4 (1)	3.3 (0.7)	188
02L-08L-02R	50	37	64	10.1 (3.4)	5.2 (1.7)	262
Average	51	39	64	7.2	7.9	288

Figure 3.3.1. Change in mass of hatchling Blanding's Turtles overwintered under laboratory conditions. Lines represent the average mass of each of the four clutches for the given date.

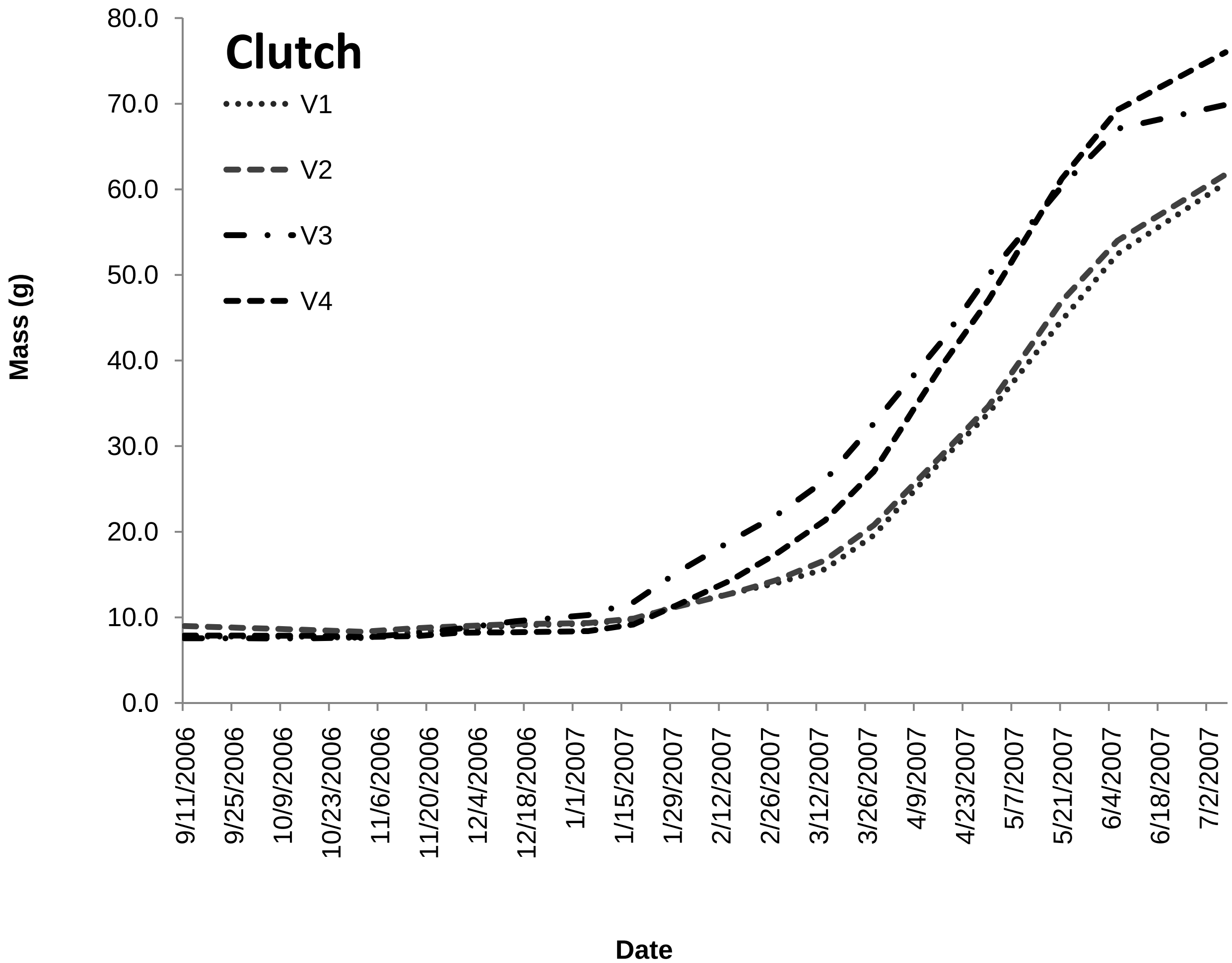
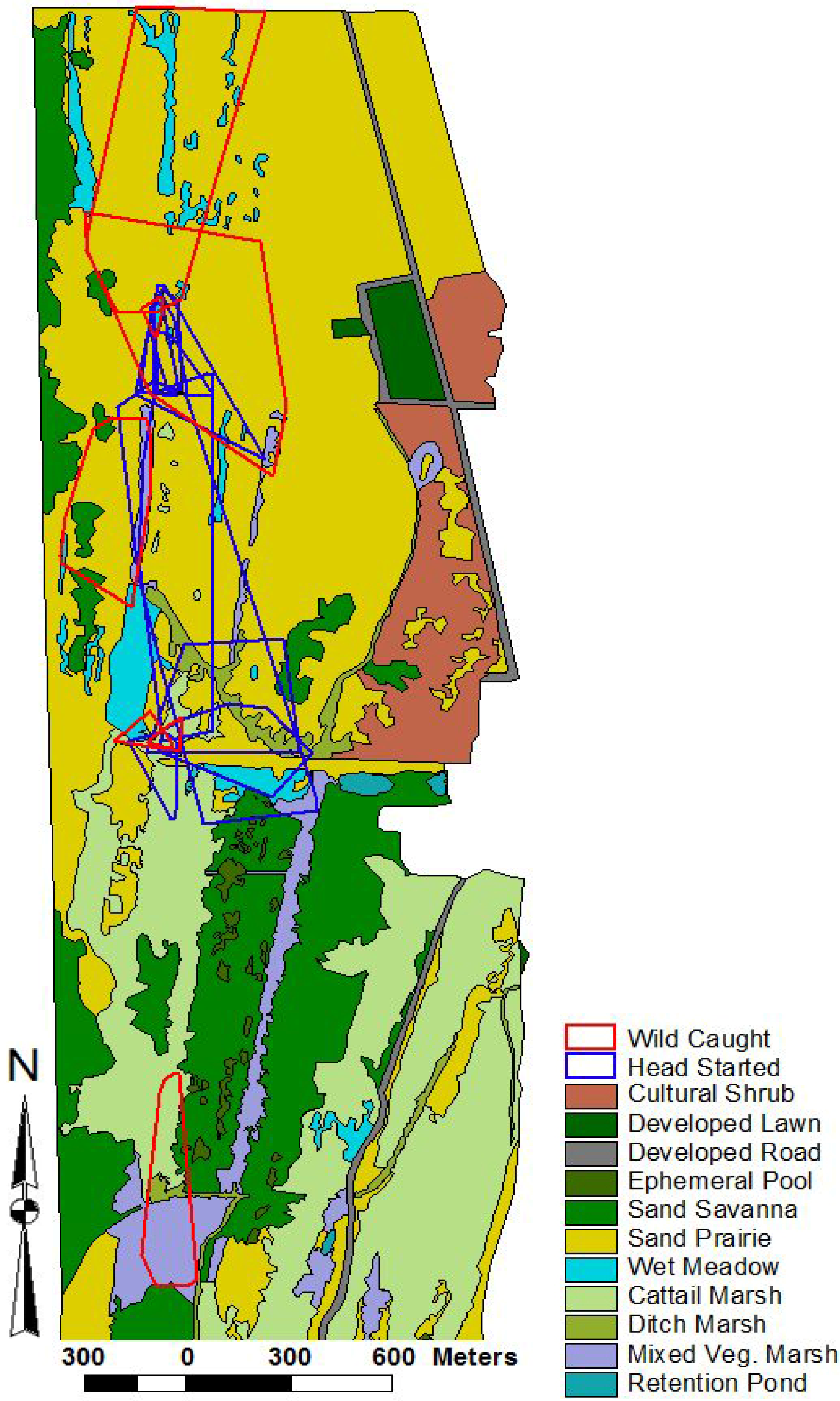


Figure 3.3.2 Activity area locations of head-started and wild caught Blanding's Turtles



Job 4. SBNP Turtle Management Plan

4.1 Utilizing the conclusions drawn from the study, design a long-term management plan to continue the effort to stabilize the population.

Based on data collected from 2004 - 2010, it appears that, while the population of Blanding's Turtles at SBNP is the largest recorded in Illinois, there is cause for concern about the long-term viability of the population. Although there is evidence of successful recruitment occurring at Spring Bluff, population viability analysis shows a negative stochastic growth rate and a high likelihood of extinction of the populations within the next 50 years. Efforts to prevent extinction should focus on increasing survivorship of all age classes, habitat restoration, and augmenting the population with head-started individuals.

General threats to the population.

- All documented nests have occurred outside of SBNP. (RR ROW, 1st St ROW, Marina lawn, Homeowner lawns, CPNP)

- High nest predation rates.

- Several of the utilized nesting areas are linear (RR ROW and 1st St ROW) which could increase the likelihood of nest predation.

- Encroachment of invasive plants are a threat to nesting areas making them unsuitable

    - (sweet clover (*Melilotus*) and wild grape (*Vitis*) along 1st St ROW, sweet clover in CPNP nesting area).

- Roads and rail lines with frequent heavy traffic pass through and around SBNP increasing the likelihood of vehicle mortalities.

    - Females may cross roads to reach their desired nesting locations and hatchlings would then be forced to cross roads to make it to wetland habitat.
    - Three Blanding's Turtle vs vehicle events were documented during this project. Two resulted in mortality and the third resulted in an approximately 12 month rehabilitation of an adult female who was struck when crossing a road to reach her preferred nesting habitat.

- Large volume of visitors to North Point Marina increases the likelihood of turtles being observed and taken home as pets and has occurred at least once (G.Glowacki, *pers com*).

Increasing Hatchling Survivorship. **–**Seigel and Dodd (2000) recommend a gradient approach to conservation of turtle populations ranging from public education and habitat protection to the protection of nests *in situ*, to captive propagation in zoos. In their scheme the least manipulative tactics for hatchlings are habitat protection and public education. The majority of habitat at SBNP is already protected with the exception of the 1st St. right of way. Further, it is unclear what effect the public is having on hatchling survival. Unleashed domestic dogs were observed digging up nests in our artificial arrays on the 1st St ROW, and nests that occur in North Point Marina might meet the same fate. Posting signs indicating that these areas are important nesting areas for threatened turtle species and a request to keep pets leashed and prevent pets from digging might aid in this regard. It is unknown whether marina and beach users are aware that they pass along IBSP and SBNP on their way to the Marina. A display in the North Point Marina alerting slip-holders to the Nature Preserve and State Park and the threatened and endangered species that rely on this habitat might sway some to slow down on their way into the marina. While this may save a few nests per year, it is likely that the majority of nest predation occurs from meso-predators inhabiting the site and that simple education and therefore signage will do little to increase overall survival of hatchling turtles.

Further, population trajectory modeling has shown that these methods alone will not be enough to ensure the populations persistence and that a more manipulative approach is warranted. In this instance, Seigel and Dodd (2000) recommended protection of natural nests. Although most efforts at nest protection have been directed toward sea turtles (Adamany, et al. 1997; Addison 1997; Mroziack, et al. 2000), one study exists on Blanding's Turtles. Over a ten year study of Blanding's turtles in Nova Scotia, 101 nests were protected and only one (<1%) was depredated (Standing, et al. 2000). Of the 23 nests that were not protected, 15 (65%) were depredated (Standing, et al. 2000). In our study, none of the 10 protected nests were predated and hatchling rates for these nests were 83%. (Caveat: I excluded the nest that was protected but destroyed/predated by a tractor.)

Caging and protecting Blanding's Turtle nests at SBNP is difficult for several reasons. This method is time-consuming, expensive, and, in this study, has around a 50|% success rate of finding and protecting the nest the night it is laid. Technicians must be available seven days (and nights) a week for approximately six weeks (early June through mid July). Technicians will again be needed from mid-August through September to mark, measure, and release emerging hatchlings. Because there is not a single nesting area that most SBNP females use, it is not feasible to simply walk a nesting area or two and be able to protect numerous nests in a given night. Therefore, females will need to be equipped with radio-transmitters and tracked during the day to see if they are moving to nesting areas, and then again at night to see if they have left the water to begin nesting. Even with diligence and a large crew of technicians, the success rate of observing and protecting nests in this study was less than 50% (ARK unpublished data).

The final and most manipulative strategy for increasing hatchling survival is to incubate eggs in the lab for future release (Seigel and Dodd 2000). Termed head-starting, this method entails raising hatchling turtles in captivity to attain a larger body size more quickly than would be possible naturally. This presumably alleviates a large portion of hatchling predation (Heppell *et al.* 1996). Several county forest preserves in northeastern Illinois have implemented head-starting programs for Blanding's Turtles. However, there have been little to no follow-up surveys to determine if these head-starting projects are having the desired effects. Further, chelonian experts warn that head-starting is not a proven conservation technique and should be considered experimental (Seigel and Dodd 2000). Unfortunately, this advice is often unheeded and no monitoring of released head-started turtles is undertaken.

In this study, we experimentally released head-started individuals and monitored them through telemetry and recapture surveys. Preliminary results indicated that hatchlings released after being head-started for 10 months have similar movement, home range sizes, and survival estimates to that of juveniles that were not head-started (above). Since Blanding's Turtles do not reach sexual maturity until the minimum age of 13, we do not know whether this cohort of head-started turtles will ultimately be successful. At present, indicators suggest that their spatial ecologies are similar to wild hatched juveniles, and their survival rates are similar to older wild caught individuals.

Despite its controversial nature, this method appears to be the best available management technique for increasing hatchling survival at SBNP at this time. Modeling population trajectories in the section above indicated that head-starting approximately 100 individuals per year, in conjunction with reducing adult mortality, greatly decrease the likelihood of population extirpation. However, it should be noted that under every model, the population began to decline immediately after population augmentation through head-starting was ceased. Therefore, while we suggest that head-starting may be a valuable tool for ensuring population persistence, it is a stop-gap method that will not lead to a stable population without a concurrent increase in survival rates of other age/stage classes.

We suggest continuing the head-starting program initiated with this project with the goal of releasing approximately 100 turtles per year into the population. Because of the time and resource consuming nature of finding and protecting natural nests (see above), the most feasible method of attaining these hatchlings at this time is to radio-equip adult female turtles and track them occasionally throughout the year to keep a bearing on their movements. We recommend using large bolt on transmitters with a battery life of +30 months. Currently these transmitters are available at a price of < $250 each. Efforts should be made to place transmitters on all adult females (currently there are transmitters on 22 female Blanding's Turtles and these transmitters should remain operational for two more nesting seasons). Starting in mid May, females should be tracked once or twice a week and palpated to determine if they are gravid. Once shelled eggs are felt, females should be brought in to nesting cages and allowed to nest naturally. Eggs can then be transferred to incubators and the female released. Head-started individuals should be released the following year once they have attained a size of +80mm Carapace Length. (Suggestions for writing up lab protocols are provided in section 4.2). Not only will this method allow for the collection of eggs for head-starting but it will allow for the continued and revised estimations of adult female survival rates through occasional radio-telemetry of the females.

Increase Juvenile & Adult Survivorship.– As with most turtle species, maintaining high adult survivorship is crucial to viability. Conservation measures that do not include an adult component will, at best, only maintain stability. Research indicates that slight increases in adult mortality will negate any benefits of strategies aimed at protecting nests or hatchlings (Congdon, et al. 1994; Heppell, et al. 1996). Conservation efforts aimed at reducing adult mortality are most likely to stabilize populations (Heppell 1998).

Therefore, it should be considered imperative to increase the survival rates of Blanding's Turtle's in SBNP. Three sources of mortality have been documented in the course of this study: refuse, vehicles (cars and potentially trains), and predators. Over the course of our study, we observed only two adult mortalities, both of which occurred in Wisconsin. In one instance, a deceased adult female was found drowned by becoming stuck in a tire that had been tossed into a wetland pool. In the other instance, a female was found in the fall with a severely cracked carapace. This female was recovered after the thaw the following spring, dead and pinned against debris in a flowing ditch. It is assumed this individual was struck by an automobile or train prior to our initial capture. A third female turtle was struck on the road while moving to her nesting area but survived after a yearlong rehabilitation with McHerny County Conservation District's Wildlife Resouce Center. Finally, a juvenile Blanding's Turtle was found dead on Spring Bluff Drive in 2008. The shells of several juveniles were found during this study where it appears that some predator had consumed the soft body parts. However, it is unknown if these turtles were killed or scavenged.

Of the three documented sources of mortality, the easiest one to remedy is to remove all large pieces of trash from the preserves. While only one mortality was documented attributed to trash, mortality of this manner may occur more frequently in deep-water areas where it is not easily documented. In 2005, water levels were very low and we were able to opportunistically remove quite a few tires and other debris from the preserve. We recommend that when water is low enough again to go through and try to remove as much refuse as possible from wetlands within the preserves.

Road mortality presents a bigger obstacle for population management. Again considering management options from least to most invasive, the first step should be to educate the public about the presence of threatened and endangered species in habitat directly adjacent to North Point Marina. The proposed display in the Marina may make marina and beach visitors more aware of the diverse fauna of the preserves and hopefully more likely to drive cautiously when entering and travelling through the marina. Additional signage could be posted along roads at the edge of the preserves alerting motorists to be vigilant for crossing wildlife. Signage could be posted along Seventh St., which bisects SBNP to the north and Illinois Beach State Park to the south and is the only access road to North Point Marina. While no mortality of Blanding's Turtles was documented from this road, several painted turtles were observed dead on the road and two radio equipped Blanding's turtles did cross from SBNP to IBSP and back on at least three occasions (six crossings). Further, this road is frequently travelled by marina maintenance personnel, who may have disposed of dead turtles prior to us documenting them. A drainage ditch flows under the road and connects the two sites so some movement may occur under the road. Efforts should be considered to increase the possibility of safe passage for turtles travelling between IBSP and SBNP while decreasing the likelihood of road mortality.

Spring Bluff Drive bisects SBNP from north to south and was the location of one juvenile mortality. During the course of our studies we regularly observed turtles crossing this road (ARK unpublished data). This drive is normally gated shut but in 2008, it was used as the main access road to the marina for the majority of the season as road construction and repairs were being done to North Point Marina. During the first few years of the study, this road was occasionally used to haul exceptionally large boats to the marina; but I am unsure if this practice still occurs with the new road alignment in place. This road currently does not appear to be needed and therefore should be kept gated. Additionally, LCFPD should look into the possibility of having the road removed. Even if mortality is not occurring frequently, roads have been shown to retard the movement of wild animals including turtles (Shepard et al 2009). Removal of this road might result in several positives for the site; 1) increase habitat permeability for Blanding's Turtles, 2) restore a more natural hydrology to the site, and 3) if the asphalt is removed, there is the potential for this site to be used as nesting habitat as is the case of the 1st St. ROW in Wisconsin.

Meso-predators such as raccoon, fox, and coyote appear to be having a negative impact on both eggs and young adult turtles in the population studies. The collapse of the fur industry in Michigan in the 1980's resulted in a decrease in nest survival rates of Blanding's Turtles from 45% to 4% (Congdon et al. 1993). However, no estimates of meso-predator abundance are available for that study. It would advisable for LCFPD - preferably in conjunction with TNC-Wisconsin, which manages the south unit of SBNP, and IDNR, which manages IBSP - to implement a meso-predator management strategy concurrently with continued surveys for Blanding's Turtles. Ideally this study would be able to document the effects of meso-predator management on the Blanding's Turtle population inhabiting the preserves.

Finally, we recommend follow up monitoring to determine the effects of any management strategies employed on this population. Hopefully, monitoring of both head-started and adult Blanding's Turtles at SBNP can be incorporated into LCFPD's current wildlife monitoring initiative. At a minimum, this should occur one generation time after the head-starting program has been initiated. Ideally, monitoring would continue annually or bi-annually I would suggest trapping for several one-week sessions from mid-May through mid-July. This eight week time period is the most successful trapping time at SBNP (Benda et al 2007). Gravid females do not readily come to hoop traps but are often captured directly after nesting in early June. Further, by trapping for at least three independent sessions, standard Lincoln Peterson population estimates could be calculated as a means of tracking the population size.

Translocations- One of the primary reasons for initiating this project in 2004 was to examine the feasibility of initiating a head-starting program to translocate Blanding's Turtles into other LCPFD properties. Modeling of a translocation/release in an earlier report suggested that the most reasonable translocation strategy was to release 25 head-started turtles for 20 years, or 50 head-started turtles for 10 or 20 years (Benda et al 2007). However, similar to the population trajectory models I report here, the translocation models only displayed positive population growth for the duration of supplementation and began to decline immediately after stocking ceased (Benda et al 2007).

Given that the population trajectory for Blanding's Turtles at SBNP appears to be in decline, it would be unwise to use individuals from SBNP to begin a reintroduction program at other LCPFD properties. The majority of efforts should go into maintaining the population at SBNP. In 2010, a few adult Blanding's Turtles were captured in Singing Hills, a newly acquired LCPFD property (G. Glowacki pers com). It would be possible to add these individuals into the head-starting program but hatchlings from clutches from Singing Hills should go back to the Singing Hills Preserve until the viability of the population is ascertained. Management at Singing Hills should look at expanding the preserve size and documenting, improving potential nesting habitats.

If LCFPD wishes to continue with initiating a translocation program by introducing Blanding's Turtles into its preserves, it would be best to do so with "homeless" turtles or young individuals from adults in captivity. This undertaking should be done on an experimental basis only with a trial release of individuals fitted with radio-transmitters so that general health, movements, habitat use and survival can all be monitored. Released individuals should be monitored via radio-telemetry for at least one year. If at the end of the trial release, survival rates fall below the corresponding survival rate for that age in the survival curve presented in Figure 2.1.2, the project should be tabled until decisions can be made to determine how to increase the survival rates of the released individuals.

4.2 Implement management plan by providing it to District staff and providing any training on specific techniques (trapping, monitoring, etc.) Gary Glowacki has become experienced with both radiotelemetry and trapping while working with us in the field over the past few years. Additionally, G. Glowacki initiated the construction of head-starting pens at Rollins Savanna and is currently caring for a number of individuals from the 2009 cohort. I recommend that G. Glowacki continue his work with Bill Zeigler Brookfield Zoo (Chicago Zoological Society) in the construction of the head-starting facilities and also confer with Dan Thompson, Wildlife Ecologist-DuPage County Forest Preserve District, to discuss the head-starting program for Blanding's Turtles at Willowbrook Center. Hatchling rates in the DuPage County program regularly exceed 90% (D. Thompson *pers com*); much higher than the hatch rates for our study.

Job 5. Prepare final report.

Literature Cited

Adamany, S.L., M. Salmon and B.E. Witherington. 1997. Behavior of sea turtles at an urban beach III. Costs and benefits of nest caging as a management strategy. Florida Scientist. 60:239-253.

Addison, D.S. 1997. Galvanized wire cages can protect nest depredation. Marine Turtle Newsletter. 76:8-11.

Benda, C.D., A.R. Kuhns and C.A. Phillips. 2007. Population and spatial ecology of Blanding’s Turtels in northeastern Lake County with feasibility of initiating a head-starting program. INHS Technical Report 2007(4) 1-104 + vii.

Burke, V. J., and J. W. Gibbons. 1995. Terrestrial buffer zones and wetland conservation: a case study of freshwater turtles in a carolina bay. Conservation Biology **9**:1365-1369.

Christiansen, J. L. and B. J. Gallaway. 1984. Raccoon removal, nesting success, and hatchling emergence in Iowa turtles with special reference to *Kinosternon flavescens* (Kinosternidae). Southwestern Naturalist **29**:343-348.

Congdon, J. D., D. W. Tinkle, G. L. Breitenbach, and R. C. van Loben Sels. 1983. Nesting ecology and hatching success in the turtle *Emydoidea blandingi*. Herpetologica **39**:417-429.

Congdon, J. D., and R. C. van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's turtles (*Emydoidea blandingii*): Implications for conservation and management of long-lived organisms. Conservation Biology **7**:826-833.

Congdon, J.D., A.E. Dunham and R.C. van Loben Sels. 1994. Demographics of common snapping turtles (*Chelydra serpentina*): implications for conservation and management of long-lived organisms. American Zoologist. 34:397-408.

Congdon, J. D., R. D. Nagle, O. M. Kinney, M. Ostenoski, H. W. Avery, and R. C. van Loben Sels. 2000. Nesting ecology and embryo mortality: Implications for hatching success and demography of Blanding's Turtles (*Emydoidea blandingii*). Chelonian Conservation and Biology **3**:569-579.

Engeman, R.M., R.E. Martin, H.T. Smith, J. Woolard, C.K. Crady, S.A. Shwiff, B. Constantin, M. Stahl, and J. Griner. 2005. Dramatic reduction in predation on marine turtle nests through improved predator monitoring and management. Oryx 39:318-326.

Fieberg, J and S.P. Ellner. 2000. When is it meaningful to estimate an extinction probability? Ecology 81: 2040-2047.

Fisher, P. 2003. Locating new venipuncture site in chelonians. Exotic DVM Veterninary Magazine **4**:8.

Greenwood, J.J.D. 1996. Basic Techniques, pp 11-110 *In:* Sutherland, W.J. (ed.) Ecological Census Techniques. Cambridge: Cambridge University Press.

Heppell, S.S., L.B. Crowder and D.T. Crouse. 1996. Models to evaluate headstarting as a management tool for long-lived turtles. Ecological Applications. 6:556-565.

Heppell, S.S. 1998. Application of life-history theory and population model analysis to turtle conservation. Copeia. 1998:367-375.

Kennicott, R. 1855. Catalogue of animals observed in Cook County, Illinois. Illinois State Agricultural Society Transactions for 1853-1854. 1:577-595.

Krebs, C.J. 1989. Ecological Methodology. New York: Harper Collins, 654 pp.

Kuhns, A.R., W.J. Banning, M.J. Dreslik, and C.A. Phillips. 2007. Ecology of the state threatened Blanding's Turtle, *Emyodidea blandingii*, in the Chicago wilderness area. INHS Technical Bulletin 2007(23):1-115+iii.

Kuhns, A. R., C. D. Benda, M. J. Dreslik, and C. A. Phillips. 2006. Annual Report 2005: Status of Blanding's Turtles in Lake County Forest Preserve District and feasablility of initiating a head-starting program at Rollins Savanna. Illinois Natural History Survey Center for Biodiversity Technical Report 2006:1-55.

Levell, J.P. 1997. A field guide to reptiles and the law. Serpent's Tale, Lanesboro, Minnesota. 270 pp.

Ludwig, D.R., M. Redmer, R. Domazlicky, S. Kobal and B. Conklin. 1992. Current status of amphibians and reptiles in DuPage County, Illinois. Transactions of the Illinois State Academy of Sciences. 85:187-199.

Moon, P. F. and S. M. Hernandez-Divers. 2001. Reptiles:Aquatic turtles (Chelonians).*in* H. D., editor. Zoological Restraint and Anesthesia. Veterinary Information Service, Ithica, NY.

Mroziack, M.L., M. Salmon and K. Rusenko. 2000. Do wire cages protect sea turtles from foot traffic and mammalian predators? Chelonian Conservation and Biology. 3:693-698.

Pollock, K.H., J.D. Nichols, C. Brownie, and J.E. Hines. 1990. Statistical Inference for Capture-Recapture Experiments. Wildlife Monographs 107. 97pp.

Redmer, M. 1998. Trapping survey for the Blanding's turtle (*Emydoidea blandingii*) at three prairie parkland sites, Summer 1998, p. 1-17.

Redmer, M. and G. Kruse. 1998. Updates to the list of Illinois' endangered and threatened amphibians and reptiles. Bulletin of the Chicago Herpetological Society. 33:244-245.

Ross, D. A. and R. K. Anderson. 1990. Habitat use, movements, and nesting of *Emydoidea blandingi* in central Wisconsin. Journal of Herpetology **24**:6-12.

Rubin, C.S., R.E. Warner, D.R. Ludwig and R. Thiel. 2004. Survival and population structure of Blanding's turtles (*Emydoidea blandingii*) in two suburban Chicago forest preserves. Natural Areas Journal. 24:44-48.

Schnabel, Z.E. 1938. Estimation of the total fish population of a lake. American Mathematics Monthly. 45:248-352.

Schumacher, F.X. and R.W. Eschmeyer. 1943. The estimation of fish populations in lakes and ponds. Journal of the Tennessee Academy of Science. 18:228-249.

Seber, G.A.F. 1973. The estimation of animal abundance and related parameters. Macmillan Publishing Co., New York.

Seigel, R.A. and C.K. Dodd Jr. 2000. Manipulation of turtle populations for conservation: halfway technologies or viable options?, pp 218-238 *In:* Klemens, M.W. (ed.) Turtle Conservation. Smithsonian Institution Press, Washington, D.C.

Shepard, D. B. A. R. Kuhns, M. J. Dreslik, and C. A. Phillips. 2008. Roads as barriers to animal movement in fragmented landscapes. Animal Conservation 11:288-296.Smith, P.W. 1961. The amphibians and reptiles of Illinois. Illinois Natural History Survey Bulletin. 28:1-298.

Standing, K.L., T.B. Herman, M. Shallow, T. Power and I.P. Morrison. 2000. Results of nest protection program for Blanding's Turtle in Kejimkujik National Park, Canada: 1987-1997. Chelonian Conservation and Biology. 3:637-642.

TAMS Consultants. 1996. Lake County Forest Preserve District Blanding's turtle recovery project: The Blanding's turtle in Lake County, Illinois: An inventory and habitat assessment. Unpublished report to Lake County Forest Preserve District. 30 pp.

Temple, S. A. 1987. Predation on turtle nests increases near ecological edges. Copeia **1987**:250-252.

White, G.C. and K.P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46 Supplement:120-138.

Zak, H.A. 2003. Status of Blanding's Turtles, *Emydoidea blandingii*, and population ecology of Midland Painted Turtles, *Chrysemys picta marginata*, at Midewin National Tallgrass Prairie. Unpublished M.S. Northern Illinois University. DeKalb, IL. 54.

Appendix I.

Parameters entered into the Vortex Model

Duration of simulation: 50 years

Iterations: 1000

Extinction Definition: No individuals of at least one sex remaining

First age of Reproduction: 13 Females, 13 Males

Maximum Breeding Age: 73

Sex Ratio at hatchling: 1:1

Mating System: Polygynous:

# of Adults that are Male: 55%

% of Females that Breed Annually: 78% (SD=7.8)

Mean Clutch Size: 12 (SD=3.044387)

Mortality Rates Ages: 1 to 14: $0.96*(1-e^{-0.1972257*age})$

Initial Population Size: 162

Carrying Capacity: 5000 (EV=0)

Head-started individuals were calculated as being removed from the population at age 0-1 and returned to the population the following year at a survival rate equal to that of a 4 year old.

Appendix I (cont.)

The age distribution was calculated by dividing the population estimate by the actual number of individuals captured in our study. For Juveniles we then broke these numbers up to correspond to the number of juveniles we captured in each age class. Adult numbers were evenly dispersed throughout the age distribution matrix.

Age	Male	Female	Age	Male	Female	Age	Male	Female
1	27	27	**26**	0	0	**51**	0	0
2	9	9	**27**	1	1	**52**	0	0
3	5	5	**28**	0	0	**53**	1	1
4	2	2	**29**	1	1	**54**	0	0
5	2	2	**30**	0	0	**55**	1	1
6	1	1	**31**	1	1	**56**	0	0
7	1	1	**32**	0	0	**57**	1	1
8	1	1	**33**	1	1	**58**	0	0
9	0	0	**34**	0	0	**59**	1	1
10	1	1	**35**	1	1	**60**	0	0
11	1	1	**36**	1	1	**61**	1	1
12	0	0	**37**	0	0	**62**	0	0
13	1	1	**38**	1	1	**63**	1	1
14	0	0	**39**	0	0	**64**	0	0
15	1	1	**40**	1	1	**65**	0	0
16	1	1	**41**	0	0	**66**	1	1
17	0	0	**42**	1	1	**67**	0	0
18	1	1	**43**	0	0	**68**	1	1
19	0	0	**44**	1	1	**69**	0	0
20	1	1	**45**	0	0	**70**	1	1
21	0	0	**46**	1	1	**71**	0	0
22	1	1	**47**	0	0	**72**	1	1
23	1	1	**48**	1	1	**73**	0	0
24	0	0	**49**	0	0			
25	1	1	**50**	1	1			