Executive Summary

Habitat alteration and fragmentation are leading causes of species decline and are particularly problematic for species with specific habitat preferences and narrow niche requirements. The Blanding's turtle, *Emys blandingii*, is a semi-aquatic freshwater species well adapted to slow-moving wetland habitats. However, this species has declined in recent years as a result of wetland draining and conversion to agricultural lands. To aide in the conservation of this species, this project, conducted on a population of Blanding's turtles in the Upper Mississippi River National Fish and Wildlife Refuge (UMRNFWR), had three main objectives:

1) Determine the home range size and movements within the habitat
2) Determine the habitat preference and composition of home ranges
3) Determine the impact of human presence on home range size, movement and mortality

The first objective was accomplished by attaching radio transmitters to 17 Blanding's turtles in the UMRNFWR. The turtles were followed, using standard radio-telemetry methods, for one or two years. Data were analyzed to determine size and movement within home ranges using minimum convex polygon and kernel density estimators. Results indicate that the home ranges sizes of Blanding's turtles within the UMRNFWR are larger than previously published results on other populations throughout their range and that home range sizes do not differ between male and female Blanding's turtles, which is consistent with previously published results. This result is not attributable to differences in methodology, but rather is thought to be a product of the continuity of the wetland habitat of the UMRNFWR. That is, the home range sizes of Blanding's turtles

within the refuge are so much larger because of the availability of continuous wetland habitat.

The second objective was accomplished by compositional analysis performed at two levels. The first level compared home range selection within the study area and the second level compared habitat use within home ranges. Analyses at both levels revealed that neither home range nor habitat use within home range is selected at random. Wetland habitat was the most preferred, followed by forested areas, indicating that these turtles spend a large amount of time in terrestrial habitats, possibly foraging, thermo-regulating, or moving between activity centers. Interestingly, human habitat was the third most preferred habitat in the first level of analysis, but this effect disappeared at the second level of analysis, and was the least preferred habitat.

To quantify the impact of humans on the demography of Blanding's turtles, mark-recapture efforts have been conducted since 1995. Although more data need to be collected, physical damage to Blanding's turtles from boat propellers and other human activities has been detected. An adult male turtle was observed tangled in fishing line. Also, road mortality presents a significant threat to this species. Since turtle populations disproportionately depend on survival of adults, additional sources of adult mortality present especially significant threats for the survival of populations of this species.

This project was designed to aid in the conservation of Blanding's turtles, and used several well-developed methods to investigate several aspects of Blanding's turtle's biology in the UMRNFWR. As a result, productive management strategies are evident: 1) although a semi-aquatic species, the Blanding's turtle spends a large portion of time on land. Therefore, in addition to providing continuous wetland habitat, there must also be

safely accessible terrestrial habitat and 2) contact with humans should be limited by either restricting human activities within critical Blanding's turtle habitat or providing alternative routes, such as tunnels, for turtles to avoid crossing roads and engaging in other negative interactions with humans.

HOME RANGE SIZE, MOVEMENT AND HABITAT USE FOR A POPULATION OF BLANDING'S TURTLES (EMYS BLANDINGII) IN THE UPPER MISSISSIPPI RIVER NATIONAL FISH AND WILDLIFE REFUGE

by

Lindsay M.C. Kasuga and Fredric J. Janzen

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TABLE OF CONTENTS

LIST OF FIGURES iii

LIST OF TABLES iv

HOME RANGE SIZE, MOVEMENT AND HABITAT USE FOR A POPULATION OF BLANDING'S TURTLES (EMYS BLANDINGII) IN THE UPPER MISSISSIPPIR RIVER NATIONAL FISH AND WILDLIFE REFUGE 1
- Introduction 1
- Methods 3
- Results 8
- Discussion 11
- Acknowledgements 16
- Works Cited 17

APPENDIX A. HOME RANGE AND HABITAT COMPOSITION MAPS FOR ALL 17 RADIO-TRACKED TURTLES IN THE UPPER MISSISSIPPI RIVER NATIONAL FISH AND WILDLIFE REFUGE 36

APPENDIX B. PRELIMINARY MARK-RECAPTURE ANALYSIS OF BLANDING'S TURTLES IN THE THOMSON CAUSEWAY RECREATION AREA 53
- Introduction 53
- Methods 53
- Results 54
- Works Cited 56

LIST OF FIGURES

HOME RANGE SIZE, MOVEMENT AND HABITAT USE
FOR A POPULATION OF BLANDING'S TURTLES (EMYS BLANDINGII)
IN THE UPPER MISSISSIPPI RIVER NATIONAL FISH AND
WILDLIFE REFUGE

1. Study Site 21
    1.1. Thomson Causeway Recreation Area 21
    1.2. Mickelson's Landing
2. Home range 23
    2.1. Home range for all 12 Blanding's turtles of the TCRA 23
    2.2. Home range for all 3 Blanding's turtles of Mickelson's Landing 24
    2.3. Home range for adult male Blanding's turtle 25
    2.4. Home range for non-gravid female Blanding's turtle 26
    2.5. Home range for gravid female Blanding's turtle 27
    2.6. Home range for juvenile Blanding's turtle 28
3. Straight-line distance and movement 29
    3.1. Straight-line distance and movement for non-gravid adult female Blanding's turtle 29
    3.2. Straight-line distance and movement for adult male Blanding's turtle 30
    3.3. Frequency distribution for straight-line distance for all Blanding's turtles 31
4. Habitat availability and habitat use for compositional analysis 32
    4.1 Habitat availability (study area) 32
    4.2 Habitat use for 1st level of compositional analysis 32
    4.3 Habitat use and availability of 2nd level of compositional analysis 32

LIST OF TABLES

HOME RANGE SIZE, MOVEMENT AND HABITAT USE FOR A POPULATION OF BLANDING'S TURTLES (EMYS BLANDINGII) IN THE UPPER MISSISSIPPI RIVER NATIONAL FISH AND WILDLFE REFUGE 1

1. Home range size estimate using MCP and fixed kernel density estimators for all Blanding's turtles 33
2. Home range use and habitat availability for all radio-tracked Blanding's turtles 34
3. Compositional analysis results and interpretation 35

HOME RANGE SIZE, MOVEMENT AND HABITAT USE FOR A POPULATION OF BLANDING'S TURTLES (EMYS BLANDINGII) IN THE UPPER MISSISSIPPI RIVER NATIONAL FISH AND WILDLIFE REFUGE

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Introduction

Recent decades have witnessed the decline of numerous species throughout the world. Of the many threats faced by these species, habitat fragmentation and alteration have been cited as the leading causes of decline (Andrén 1994, Gibbons et al. 2000, Hobbs and Yates 2003, Araújo et al. 2006, Carrete et al. 2007, McKenzie et al. 2007, Mora et al. 2007, Nichols et al. 2007). Population declines often occur initially due to habitat fragmentation and alteration. This initial decline then results in higher susceptibility to exogenous and endogenous stochastic effects, such as natural catastrophes, environmental stochasticity, and genetic and demographic stochasticity (Fischer and Lindenmayer 2007). The detrimental effects of these stochastic threats are much more pronounced in small populations, and create the situation where, even if populations are able to recover in numbers, they may persist in having lowered genetic diversity (Packer et al. 1991). Although all threats warrant detailed examination, starting with investigations into how habitat fragmentation and alteration are impacting a population has several advantages: 1) may provide information that could ultimately be used to prevent further decline (via exogenous and endogenous threats) and 2) may provide testable hypotheses for genetic studies.

Conservation biologists and managers are thus charged with not only investigating the threats faced by imperiled species, but also suggesting and implementing strategies to mitigate damage. There are numerous tools available for this task, including landscape based

approaches such as radio-telemetry or geographic information systems (GIS). Landscape tools also allow for investigation of a variety of questions, but vary in the scope. Specifically, radio-telemetry studies allow for detailed analysis of habitat use and movement of individuals within populations. In contrast, GIS studies allow for much larger scale analysis of how landscape alteration affects populations across a wide range of habitat conditions and also provide a platform for much more powerful analyses of landscape scale data (Clark and Slusher 2000, Fernandez et al. 2006, Fischer et al. 2007, Thompson et al. 2006).

Turtles have been particularly decimated by recent habitat fragmentation and alteration because they have several life-history characteristics that make them susceptible to anthropogenic disturbances. Because of delayed sexual maturity, low survival in early life-history stages and specific habitat requirements, turtles may be unable to respond quickly to the rapidly changing habitat (Congdon et al. 1993). Therefore, to combat further declines in turtle populations, more research is needed to understand how anthropogenic habitat alterations are impacting these populations. One approach for investigating the effects of habitat alteration is radio-telemetry studies. Results from these investigations are critical in developing effective conservation plans by providing information on the minimum amount of habitat required for sustaining individuals in populations or identifying other critical areas of habitats, such as nesting or foraging grounds.

One North American chelonian threatened by habitat fragmentation is the Blanding's turtle, *Emys* [formerly *Emydoidea*] *blandingii*, a semi-aquatic, freshwater species with a range centered in the Great Lakes region of North America, extending north into southern Canada, west through Nebraska, with scattered populations along the eastern seaboard

(McCoy 1973). This wetland-dwelling species is specific in its habitat requirements, requiring slow-moving, shallow water areas and surrounding terrestrial habitat for overland migrations and nesting (Ross and Anderson 1990, Rowe and Moll 1991, Pappas et al. 2000, Piepgras and Lang 2000). Previous research shows three types of movement: 1) movements within activity centers, 2) movements among activity centers and 2) long-distance nesting migrations and terrestrial forays (Ross and Anderson 1990, Rowe and Moll 1991, Piepgras and Lang 2000, Refsnider 2005). Because of the draining of wetlands for conversion to agriculture land and other significant habitat alterations, Blanding's turtle is listed as endangered, threatened, of special concern or in need of conservation throughout most of its range (Hartwig and Kiviat 2007, Kofron and Schreiber 1985, Rubin et al. 2004, Mockford et al. 2005). In Illinois, this species is listed as threatened (Rubin et al. 2004)

The purpose of this study is two-fold. Previous radio-telemetry studies for this species have been conducted in wetland matrix (Ross and Anderson 1990, Rowe and Moll 1991, Piepgras and Lang 2000); in contrast, this study investigates Blanding's turtle movement in a continuously aquatic environment. Secondly, this study also examines this turtle's terrestrial habitat use in a human-impacted area.

Methods

Study Site

This study took place at the Thomson Causeway Recreation Area (TCRA) and Mickelson's Landing, which is 3.5 km south of the TCRA. Both these sites are part of the Upper Mississippi River National Fish and Wildlife Refuge (UMRNFWR). The TCRA consists of an island, with the main channel of the Mississippi River bordering the western edge and a slough bordering the eastern edge (Figure 1.1). The slough was dredged in the

mid to late 1990s, with water depth averaging 2 m in dredge cuts and 0.3 m outside the dredge cuts. The main vegetation in the slough includes emergent plants, such as broad-leaved and stiff arrowhead (*Sagittaria* spp.), giant bur-reed (*Sparganium eurycarpum*), softstem and river bulrush (*Scirpus* spp.), submersed plants including coontail (*Ceratophyllum demersum*), Canadian waterweed (*Elodea canadensis*), curly-leaf, leafy, small and flatstem pondweed (*Potamogeton* spp.), water stargrass (*Zosterella dubia*), and wild celery (*Vallisneria americana*). Rooted floating leaved plants include American white waterlily (*Nymphaea odorata*) and American lotus (*Nelumbo lutea*) and non-rooted floating leaved plants, such as common, greater and star duckweed (*Lemna* and *Spirodela* spp.), and Columbian watermeal (*Wolfia columbiana*). The eastern shore of the slough is bordered by a narrow wooded area, and a sand prairie upslope. This sand prairie extends 75-150 m inland from the slough, and is bounded to the east by a bike path and fence. The predominant vegetation is needlegrass (*Stipa* sp.), prickly pear cactus (*Opuntia humifusa*), skunkbrush (*Rhus aromatica*) and Ohio spiderwort (*Tradescantia ohiensis*). Several houses are also located throughout the study site, and humans are allowed to bike and walk through the sand prairie. There is also potential for human contact in the TCRA, which largely consists of a recreational vehicle (RV) park. Often, turtles have to cross roads or campsites during movements between activity centers. Boating and fishing also occurs in the slough.

The Mickelson's Landing site consists of similar vegetation and channel characteristics described above. Similar to the TCRA, the Landing is bordered by a sand prairie extending 50-75 m inland. However, unlike the TCRA, there is no RV park at this site, rather, there are permanent human establishments and a sand road along the eastern edge of the slough (Fig. 1.2). These buildings are often used as weekend or vacation houses, but

there is still a significant human presence at this site, as boating and fishing also occur in this area.

Trapping and Transmitter Attachment

Blanding's turtles were either hand-captured during terrestrial encounters or trapped aquatically using baited lobster traps. There were two main trapping locations: 1) in the slough just east of the TCRA or 2) Mickelson's Landing, which is 3.5 km south of the TCRA but still part of the UMRNFWR. Traps were checked twice daily and were baited using carp, sturgeon and catfish heads, and beef liver. Both sites were trapped in May and June of 2005 and 2006.

Once captured, turtles were marked with notches in marginal scutes (Cagle 1939) and measured, and blood or tail clips were collected for use in future genetic studies. Females were palpated in the inguinal region for the presence of shelled eggs to determine reproductive status. Transmitters (Model #R1930, Advanced Telemetry Systems) were attached to turtles using superglue and quick-drying epoxy. Turtles were kept for 24 hours to ensure transmitter attachment and released at the site of capture.

Radio-telemetry

Once released, females were located everyday and males were located every other day in May and June of 2005 and 2006. Radio-telemetry was conducted using hand-held antennae. I used Location of a Signal (LOAS) 4.0.2.0 Beta (Biotas) and Global Positioning System (GPS, Garmin eTrex Legend and Trimble GeoXM) to triangulate turtle locations using ≥2 bearings taken within ten minutes of one another. I used the maximum likelihood algorithm in LOAS to estimate locations, which estimates a point location even if the bearings do not intersect (Millspaugh and Marzluff 2001). The program also estimates error

ellipses associated with a particular point estimate. Some points were excluded from further analysis if 1) error ellipses were too big (>1000 m) or 2) if estimated point locations were clearly outside the study area.

Home Range Estimation

Home range estimates were obtained by 1) minimum convex polygon (MCP) (Hayne 1949) and 2) fixed kernel density (Worton 1989). Minimum convex polygon is simply the smallest possible convex polygon to encompass all the known locations of a given individual (Hayne 1949). However, despite its simplicity and wide use, this estimator provides only a crude outline of the animal's home range and often includes areas the animal may never use (Powell 2000). Kernel estimators are used to examine the quantity of habitat use, and are the most consistent and accurate estimators available (Worton 1989). One downside of using this method is that the investigator must set several parameters, including the smoothing factor, h. Small changes in the smoothing factor can have large impacts on the home range size estimate (Kazmaier et al. 2002, Hemson et al. 2005). The least-square cross-validation method is often used to estimate the value of h that produces the minimum estimate error (Worton 1989, Millspaugh and Marzluff 2001), but problems with this estimation method arise when data are highly auto-correlated, as is often the case with herpetofauna radio-telemetry data (Row and Blouin-Demers 2006). I used both these methods (MCP and Kernel) to better understand Blanding's turtle home range estimates for this population.

I used ArcGIS 9.1 (ESRI) with the Hawth's Tools extension (Beyer 2004) to calculate minimum convex polygons and ArcView 3.3 (ESRI) Animal Movements v_2 extension (Hooge et al. 1999) to calculate 50% (core) and 95% (home range) kernels. These core areas correspond to the activity center(s) for these turtles. The student's t-test was used to test for

differences in home range sizes between the sexes and between gravid and non gravid females. I also calculated daily (or averaged) straight-line minimum, maximum, sum, average and the standard deviation for distances. All statistical analyses were performed using JMP (SAS Institute 2007).

Habitat Analysis

I performed compositional analysis (Aebischer et al. 1993) to investigate habitat use at two levels: 1) home range use within the defined study area and 2) habitat use within the home range. For the first level of comparison, I defined habitat use as the area of the home range polygon (95% kernel estimator) and defined habitat availability using a 1000 m buffer from the centroid of the home range polygon. This distance was selected because 1000 m is the maximum distance traveled by these turtles, and straight-line distances of 500 m or more are not uncommon for this species (Ross and Anderson 1990, Rowe and Moll 1991, Piepgras and Lang 2000). To determine habitat availability, I downloaded 2005 NAPP Digital Orthophoto Quarter Quadrangles from the Illinois Natural Resource Geospatial Data Clearinghouse. Using ArcGIS 9.1 (ESRI), home range polygons were used to clip the aerial photo, resulting in an aerial photo of just the home range for a specific turtle. Polygons were then created to classify the aerial photo into seven broad habitat types: 1) built (consisting of campground, roads and crops), 2) water (slough), 3) forest, 4) marsh, 5) sand prairie, and 6) river. The Xtools Pro 3.0 (Data East) extension was used to estimate the area of the created polygons. A similar procedure was used to determine habitat availability. Once the areas of the polygons were determined, the area for a particular habitat type across individual polygons was summed and then divided by the total area of the home range or habitat availability. This procedure yielded the proportion habitat type to total area.

For the analysis of habitat use within the home range, the number of estimated locations within each habitat type was divided by the total number of estimated points, defining the habitat use for an individual turtle. Habitat availability was defined as the 95% fixed kernel home range estimate (Figure 4). The program Resource Selection for Windows was used to perform the compositional analysis (Leban 1999).

Results

In 2005, nine females, four males and one juvenile were caught in the TCRA and fitted with transmitters; of these, eight were trapped aquatically and six were collected on land, either crossing a road or walking in the sand prairie. In 2005, no turtles were caught in the Mickelson's Landing area. In 2006, three additional turtles (two females, one male) from the Mickelson's Landing area were fitted with transmitters. These three turtles were trapped aquatically; however, there were terrestrial encounters with three additional turtles (all females), none of which were fitted with transmitters. No additional turtles from the TCRA site were fitted with transmitters in 2006. Four turtles with transmitters attached in 2005 were caught in 2006 without the transmitters still attached. Transmitter failure was assumed for at least one other turtle because the turtle was observed with the transmitter still attached but I was unable to detect signal. Transmitter loss/failure occurred during the winter from 2005 to 2006. Therefore, for 14 turtles (14), only one year of data was used to calculate home ranges and habitat use, whereas three turtles were successfully tracked for two years. For these turtles, 2005 and 2006 point locations were combined for all subsequent analyses.

Home Range Analysis

Two methods were used to estimate home range sizes; minimum convex polygon (Hayne 1949) and fixed kernel estimate (Worton 1989). The second method allows for

estimation of core (50% use) and home range (95% use) areas. A total of 322 points were estimated; 35 points were excluded, resulting in 287 points locations across all 17 Blanding's turtles. The number of estimated point locations per turtle ranged from 6 to 35 (mean = 19). All turtles were included in subsequent analyses; however, since only one juvenile was radio-tracked during this study, it was not possible to statistically compare home range sizes with other groups.

Home Range and Movement Patterns

Home range sizes varied widely (Table 1). Among all males (n=5), the average home range size (95%) using the fixed kernel approach, was 48.94 ± 37.04 ha, with core size estimate of 9.17 ± 8.71 ha. Among all females (n=11), the average home range size (95%) was 56.45 ± 45.68 ha, with core size (50%) estimate of 9.58 ± 6.78 ha. Among gravid females (n=2), the average home range size (95%), using the fixed kernel approach, was 44.78 ± 27.54 ha, with core size estimate of 7.29 ± 6.82 ha. Among non-gravid females (n=9), the average home range size (95%) was 59.04 ± 49.71 ha, with core size (50%) estimate of 10.08 ± 7.08 ha. Using the fixed kernel estimator, the average home range size for the Mickelson's Landing turtles was 29.11 ± 4.84 ha with core average of 7.19 ± 2.99 ha.

There was no significant difference in home range sizes between males and females or between gravid and non-gravid females, regardless of method used ($P>0.19$ in all six comparisons) (Figure 2). However, home range sizes (95%) of the TCRA turtles were significantly larger than home ranges (95%) of the Mickelson Landing turtles by both the MCP and kernel estimator (MCP, $t=4.04$, $P=.0012$; Kernel $t=2.41$, $P=0.0314$). This difference may be a product of the number of locations used to estimate home range size and

the smoothing factor used in kernel estimation, as core sizes did not differ statistically between these two groups (t=1.04, P=0.32).

Movement patterns for females and males reveal that females were more likely to make long-distance movements, possibly associated with nesting forays (Figure 3). The frequency distribution of distance traveled between successive points reveals that the most frequent distance traveled was less than 200 m. Although it is not possible to perform a more quantitative analysis, preliminary results show that the average distance traveled by a female turtle between successive point locations was 280.6 m; the average distance traveled between successive points for males is 332.3 m. There is no statistically significant difference between these values (t=1.25, P=0.21).

Habitat Use

To determine habitat availability, an aerial photo and a 1000m buffer from the home polygon centroid was used to classify the habitat into six broad categories; water (slough), forest, swamp, built (campground, roads, cropland), river and sand prairie. For 12 turtles in the TCRA, the habitat polygons largely overlapped, and only one habitat availability polygon was created for these turtles. Since one female was always found north of the TCRA, and another was continuously located south of the TCRA, individual habitat availability polygons were created for these two females. For the Mickelson's Landing group, because of the significant overlap, only one habitat availability polygon was used in subsequent analysis. I divided the proportion of a particular habitat by the total area for the larger home range or habitat availability polygon to determine the percentage area. The percentages of habitat within a larger polygon vary greatly (Table 2). Since this analysis did not investigate differences between sexes, data for the juvenile turtle were included.

Compositional analysis at the first level revealed the home ranges are not selected randomly within the study area ($\Lambda = 0.1761$, $P < 0.0001$), and revealed distinct habitat selection patterns within the study area. Results indicate that the water (slough) habitat was selected over all other habitats (Table 3.1). Forested was selected over sand prairie, swamp and river; sand prairie was selected over river. Surprisingly, built habitat was selected over swamp and river. The swamp area of the TCRA is ephemeral in nature, and the area increases with the amount of rainfall. This selection pattern may be deceptive, though, because at the time the aerial photo was taken, the swamp may have been smaller, thus underestimating the area of the swamp during this study. It is not possible to determine from these data any seasonal changes in habitat selection; however, it may be possible that the swamp is used more in early spring when it is larger, and use may decrease as it dries up. This result could also be an artifact of the semi-arbitrary definition of the habitat availability.

Compositional analysis also indicates that habitat is used non-randomly within the home range ($\Lambda = 0.0822$, $P < 0.0001$). Once again, water was selected over all other habitat types (Table 3.2). Forested was ranked second, followed by sand prairie and then swamp. At this level of analysis, built habitat was ranked as the least used habitat, suggesting that these turtles are only located in this habitat when moving between activity centers or on long-distance nesting migrations.

Discussion

Given the recent, rapid declines observed in many reptilian species, more data are needed in order to develop effective conservation strategies for these species. This is especially true for chelonian species because of their reliance on both terrestrial and aquatic habitats throughout their life (Bodie and Semlitsch 2000). Therefore, in order to design

effective conservation strategies for these turtle populations, basic data on home range, movement and habitat use are needed. This is especially true for Blanding's turtles because unique life-history traits, such as delayed sexual maturity and specific habitat preferences, make them highly susceptible to anthropogenic disturbances (Congdon et al. 1993).

Results of home range and core (activity center) estimation from this study are one to several orders of magnitude larger than home range estimates from some of the other studies investigating Blanding's turtle habitat use and movement (Ross and Anderson 1990, Rowe and Moll 1991, Piepgras and Lang 2000). However, the home range estimates obtained from the TCRA are roughly equal to home range size estimates from a radio-telemetric study conducted in Weaver Dunes, Minnesota (Hamernick 2001). The difference is not attributable to the different calculation methods, but rather to the numerous biotic and abiotic factors associated with home range size. In turtles, home range size can be influenced by ecological factors, such as population density, carrying capacity, habitat composition and resource availability (Piepgras and Lang 2000). Although impossible to quantify, it is unlikely that any of the above factors are driving the large home ranges documented in this study. Resource availability is high in the slough, as evidenced by the large number of individuals, including other chelonian species, supported in the TCRA and surrounding environment (pers. obs.). I do not currently have an estimate of population density, but a separate mark-recapture effort conducted in the TCRA has revealed that 53 Blanding's turtles (31 females, 18 males and 4 juveniles) have been recaptured 99 times (unpl. results, see Appendix B). Therefore, the factor that is thought to be driving the size of the home range is the continuity and availability of aquatic habitat (Ross and Anderson 1990); that is, home ranges for this population are larger because continuously aquatic habitat is available. Despite the larger

home range sizes, there is no difference in home range size between the sexes, a result that is consistent with previously published results (Hamernick 2001, Piepgras and Lang 2000, Ross and Anderson 1990, Rowe and Moll 1991).

The lack of difference in home range sizes between the sexes has interesting implications for the survival of adult turtles in this population. Despite being located in a wildlife refuge, there is still the threat of mortality and damage cause by anthropogenic activities. One adult Blanding's turtle was found dead in the sand prairie because it had been run over by heavy machinery during construction of a bike path (F. Janzen, pers. comm.). There are several incidences where turtles have been caught crossing a road, and although this species has never been observed dead on the road, several painted turtles (*Chrysemys picta)* and common snapping turtles (*Chelydra serpentina)* have been run over by vehicles at the TCRA and Mickelson's Landing (pers. obs). An adult male Blanding's turtle was observed tangled in fishing line in the slough, and at least 11 adult turtles have been captured with damage to the carapace (Janzen, unpub. results), most likely the result of run-ins with outboard boat motors.

Also, adult female turtles are thought to have higher mortality risk because of terrestrial movement to nesting locations (Aresco 2005). However, the similarity in home range sizes and the lack of difference between average movement distances suggest that this is not the case for adult Blanding's turtles. Indeed, preliminary analysis of mark-recapture data suggests that survival is not influenced by sex of the individual (Kasuga, unpub. results). This, in turn, implies that the sex ratio of the population will not become male-biased as a result of differential adult survival between the sexes.

Habitat selection

Figure 2.2.

MCP and Kernel Home Range Estimate for the Blanding's Turtles of Mickelson's Landing

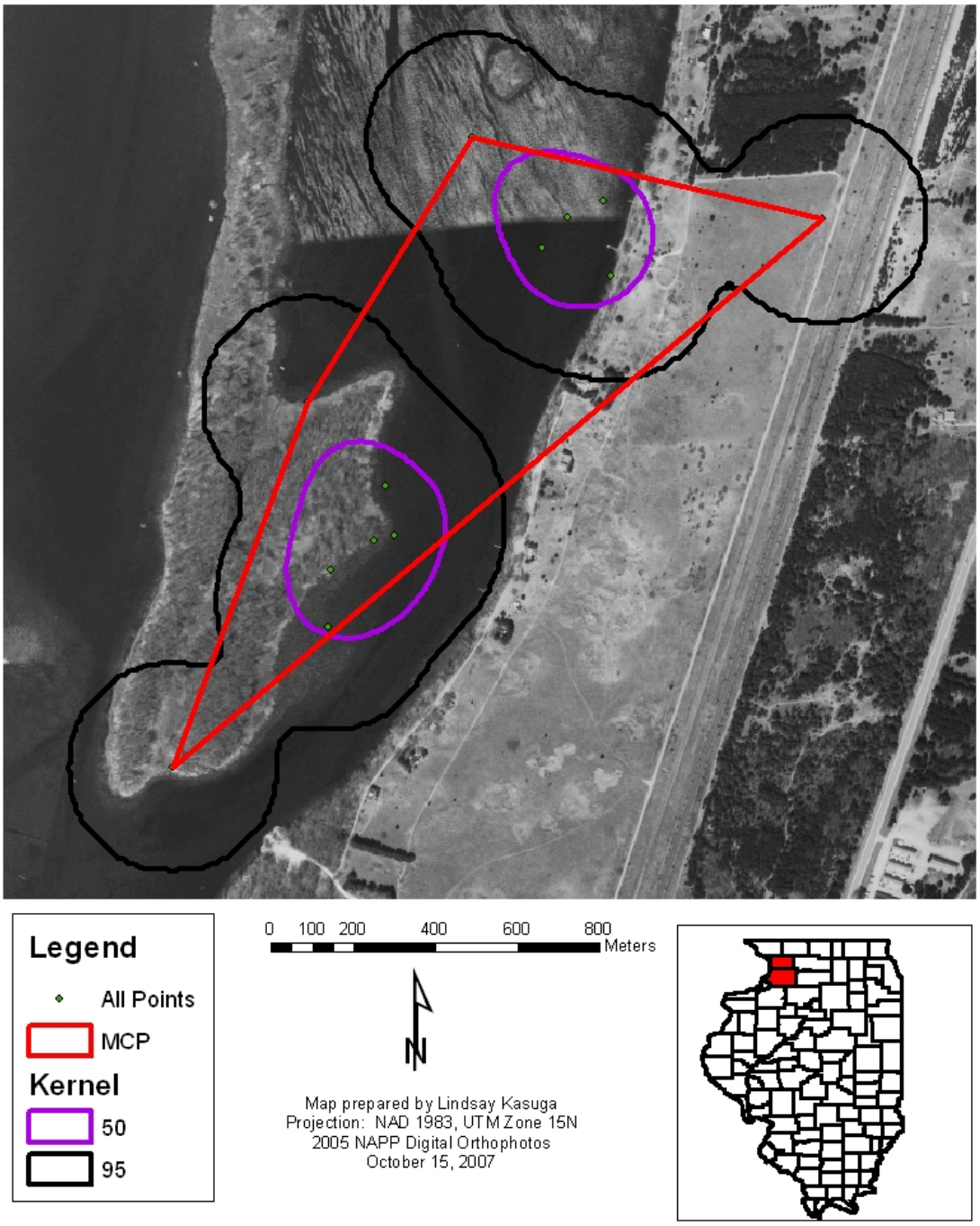


Figure 2.3.

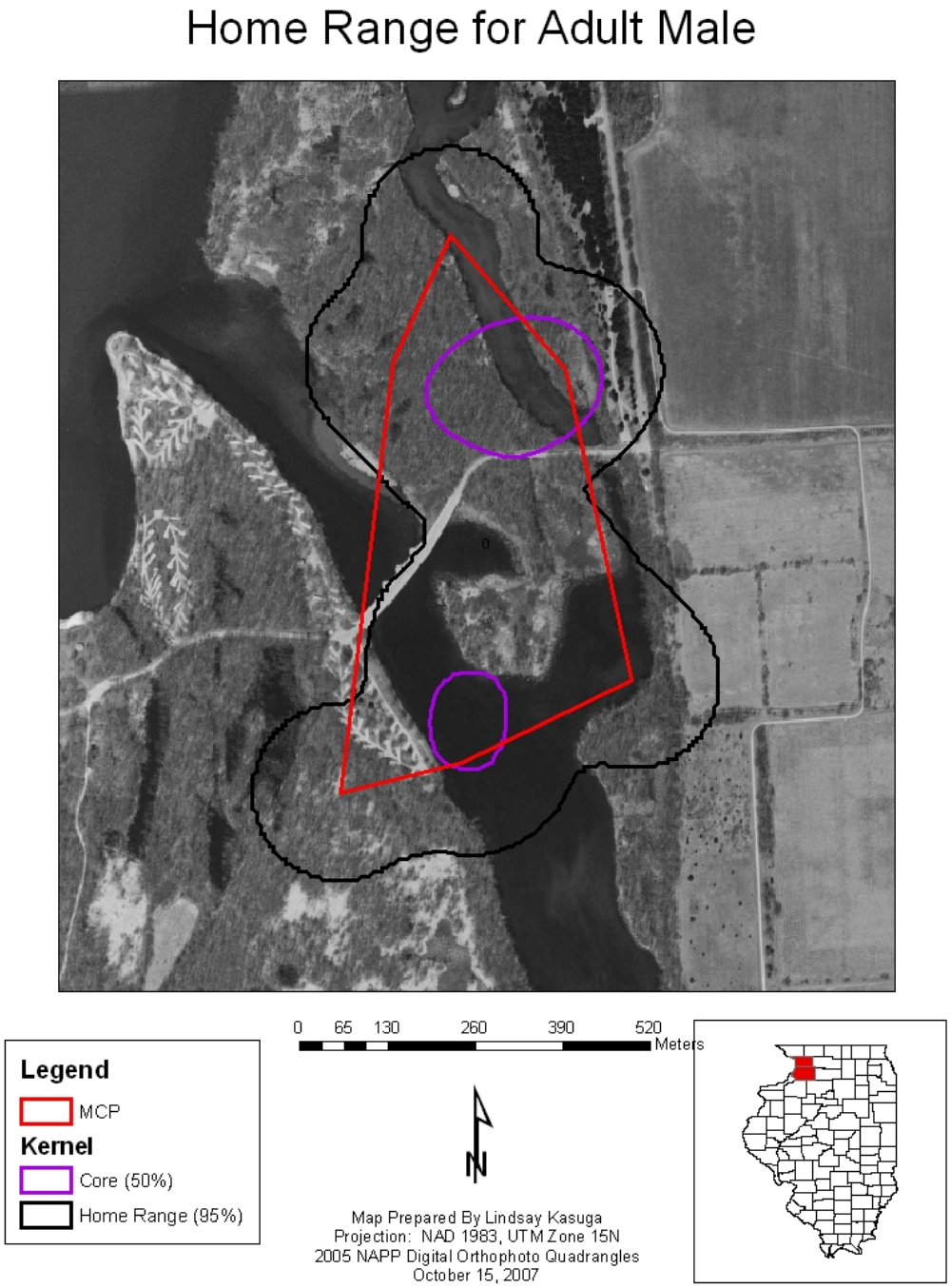

Home Range for Adult Male
Legend
MCP
Kernel
Core (50%)
Home Range (95%)
0 65 130 260 390 520
Meters
N
Map Prepared By Lindsay Kasuga
Projection: NAD 1983, UTM Zone 15N
2005 NAPP Digital Orthophoto Quadrangles
October 15, 2007

Figure 2.4.

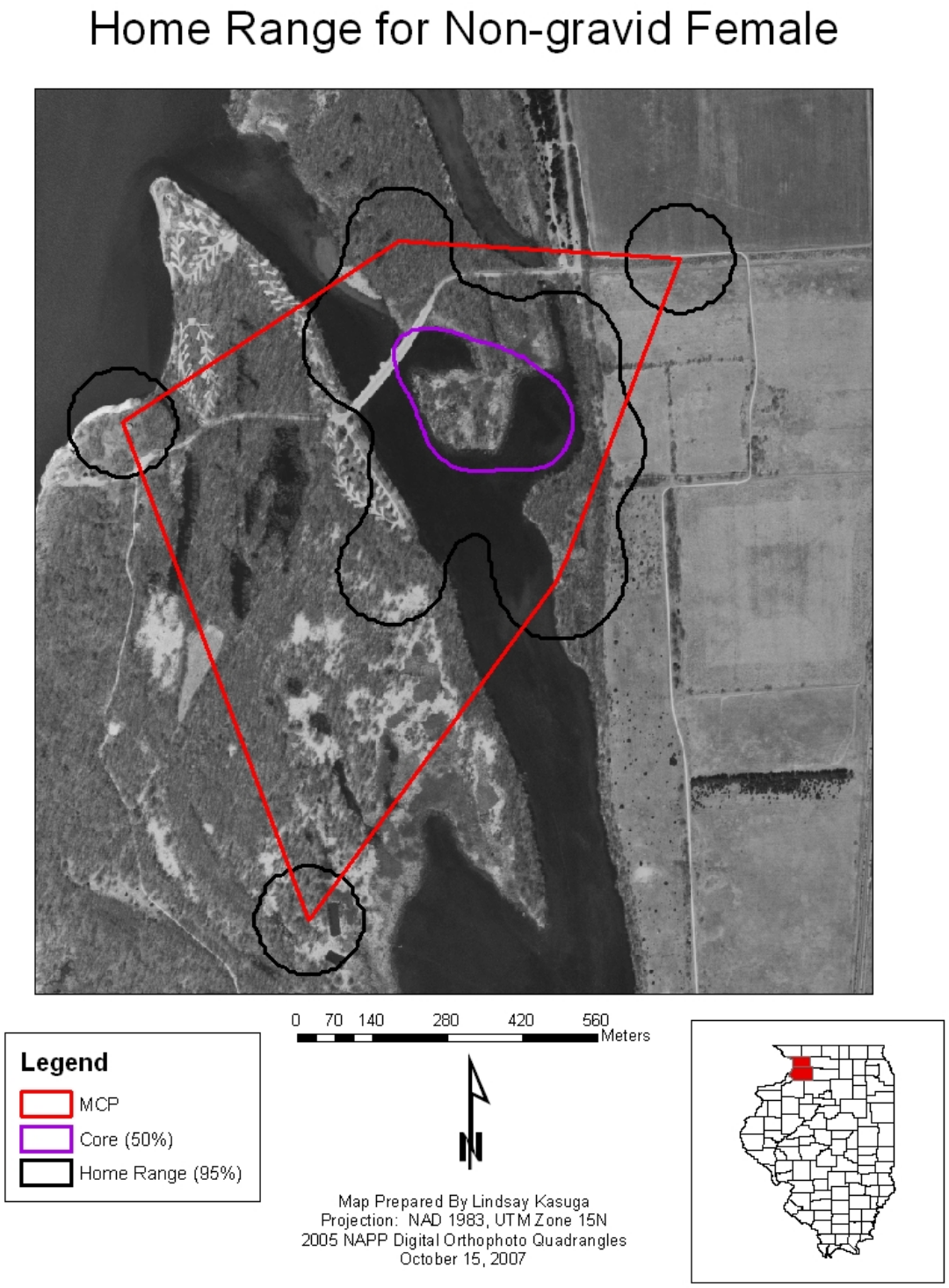

Home Range for Non-gravid Female
Legend
MCP
Core (50%)
Home Range (95%)
0 70 140 280 420 560
Meters
N
Map Prepared By Lindsay Kasuga
Projection: NAD 1983, UTM Zone 15N
2005 NAPP Digital Orthophoto Quadrangles
October 15, 2007

Figure 2.5.

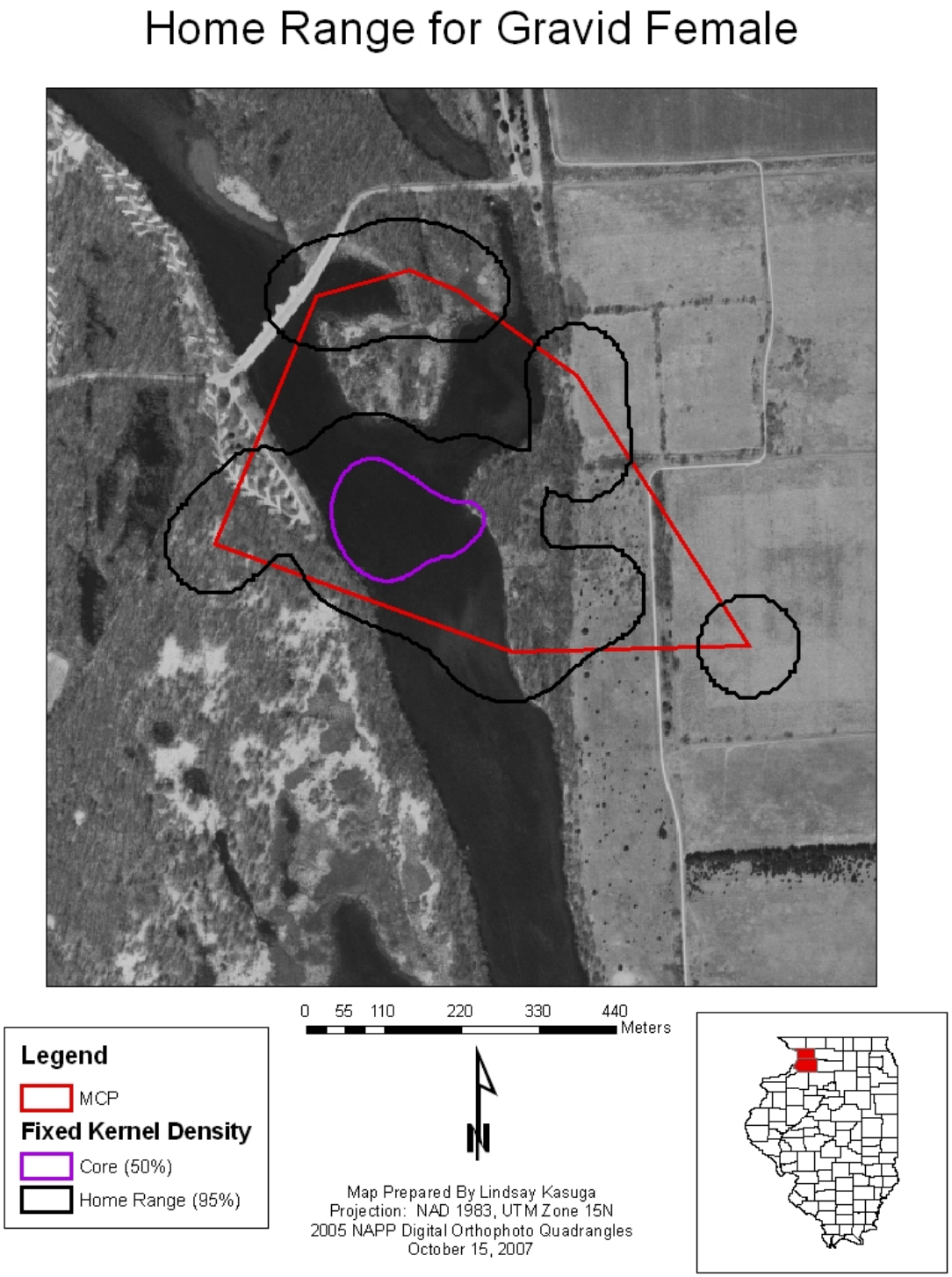

Home Range for Gravid Female
Legend
MCP
Fixed Kernel Density
Core (50%)
Home Range (95%)
0 55 110 220 330 440
Meters
N
Map Prepared By Lindsay Kasuga
Projection: NAD 1983, UTM Zone 15N
2005 NAPP Digital Orthophoto Quadrangles
October 15, 2007

Figure 2.6.

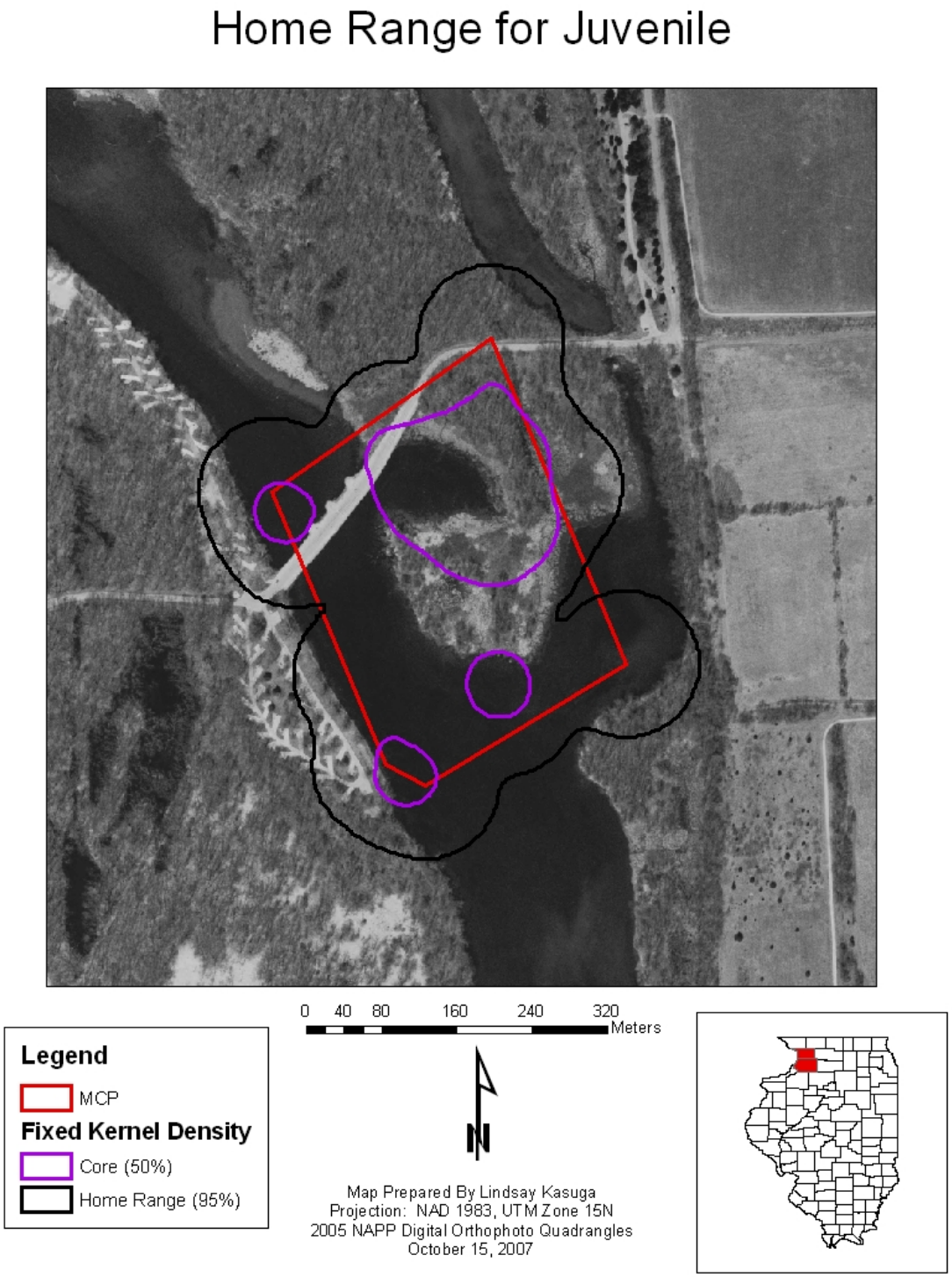
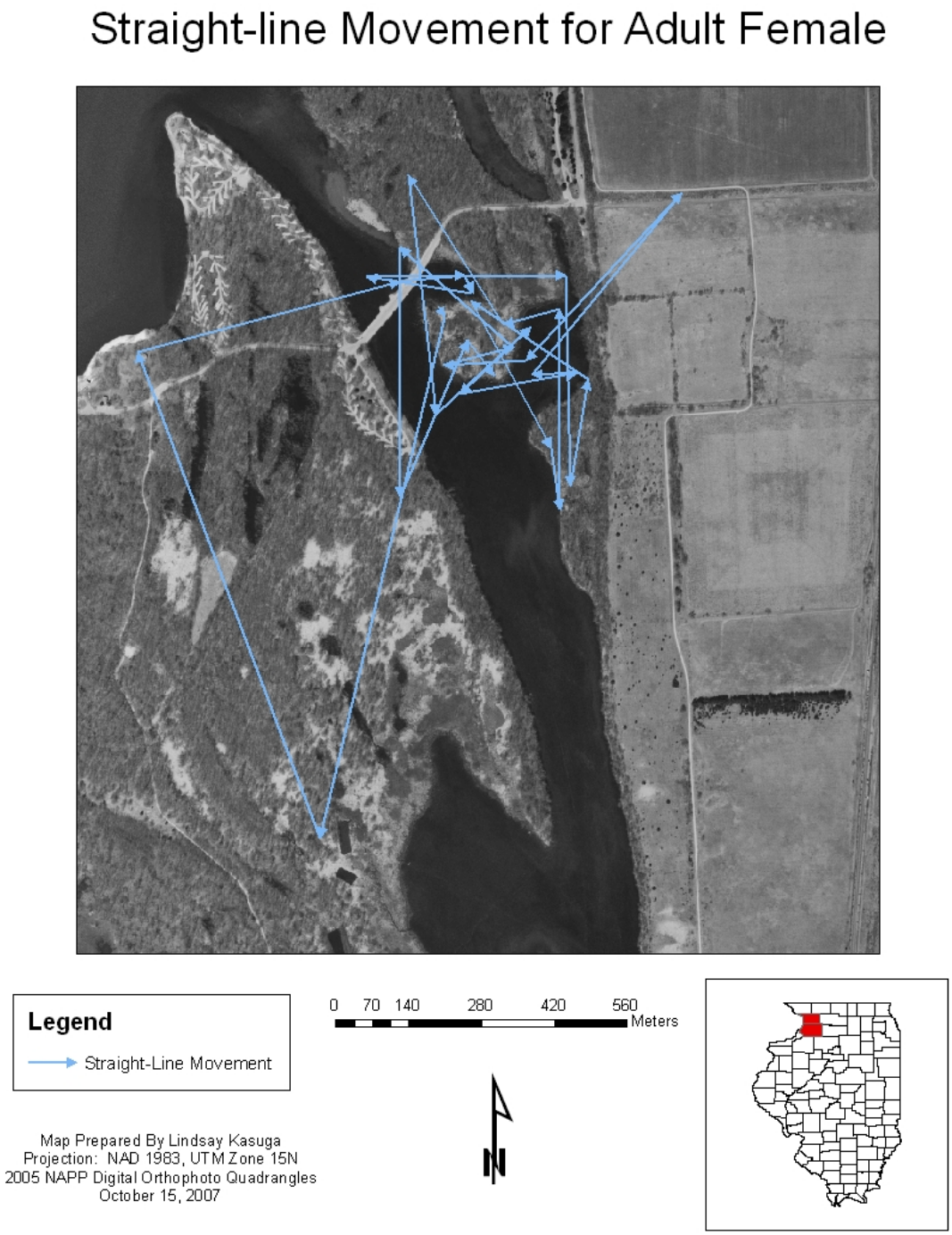
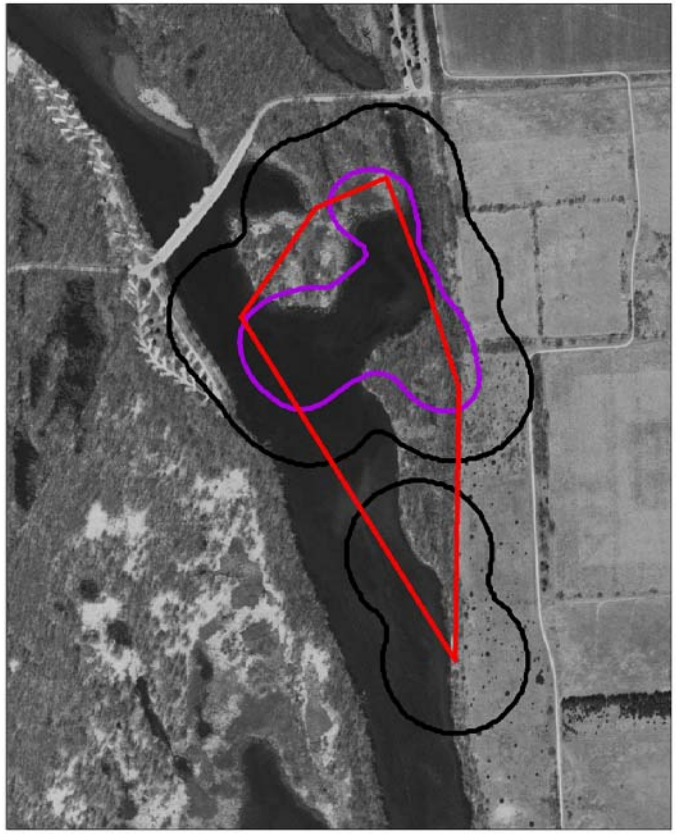

Home Range for Juvenile
Legend
MCP
Fixed Kernel Density
Core (50%)
Home Range (95%)
0 40 80 160 240 320
Meters
N
Map Prepared By Lindsay Kasuga
Projection: NAD 1983, UTM Zone 15N
2005 NAPP Digital Orthophoto Quadrangles
October 15, 2007

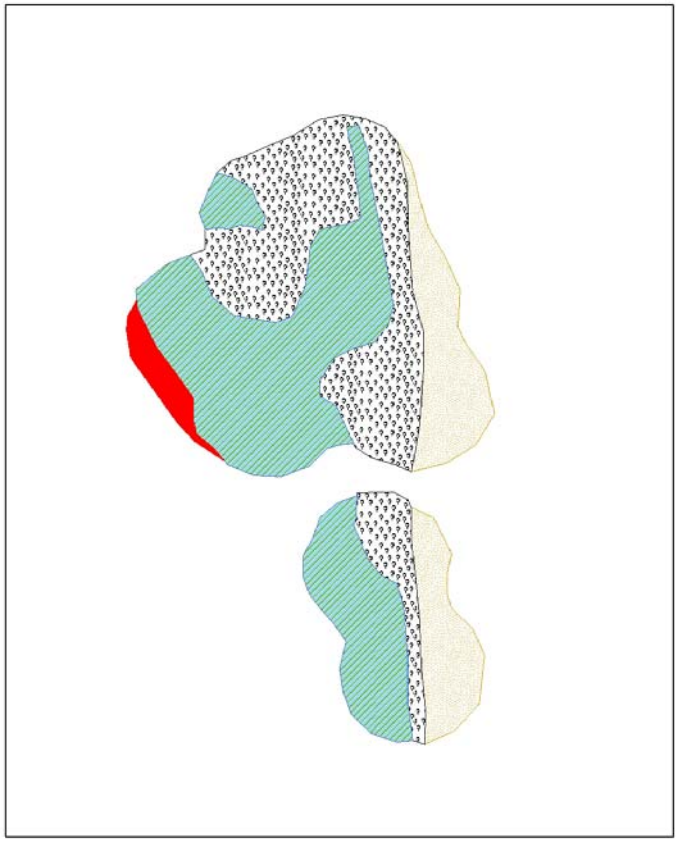
Figure 3. Map of study area depicting straight line movement for one female (Figure 3.1), one male (Figure 3.2). Figure 3.3 is a graph depicting frequency distribution of straight-line distance movements.

Figure 3.1.



Home Range and Habitat Composition for Leroy Brown





Legend

- MCP
- Kernel
- Core (50%)
- Home Range (95%)

N

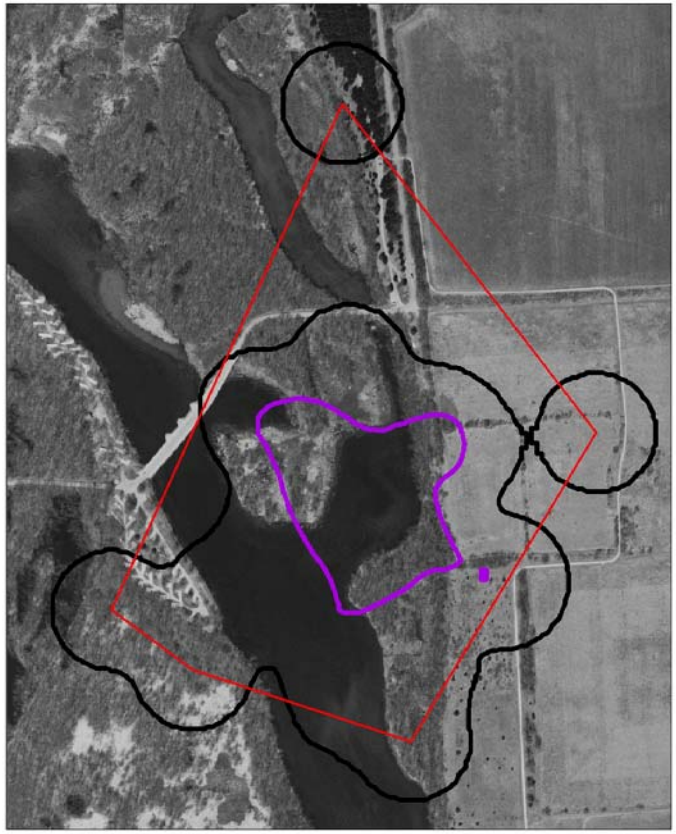
290 145 0 290 Meters

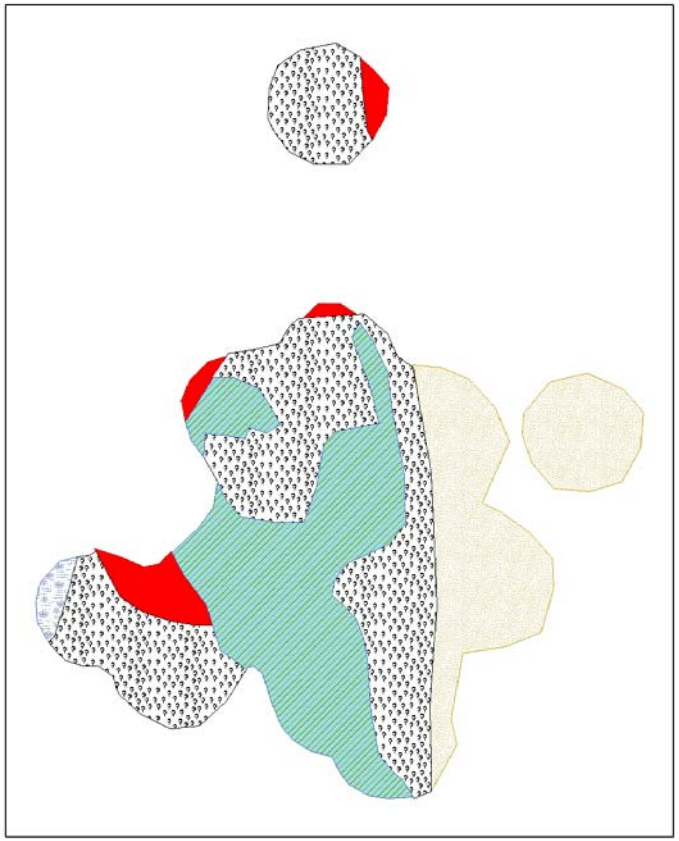
Prepared by Lindsay Kasuga
Projection: NAD 1983, UTM Zone 15N
2005 NAPP Digital Orthophoto Quadrangle
October 15, 2007

Legend

- Forest
- Built
- Sand Prairie
- Water

Home Range and Habitat Composition for Lola





Legend

- Minimum Convex Polygon
- Kernel
- Core (50%)
- Home Range (95%)

N

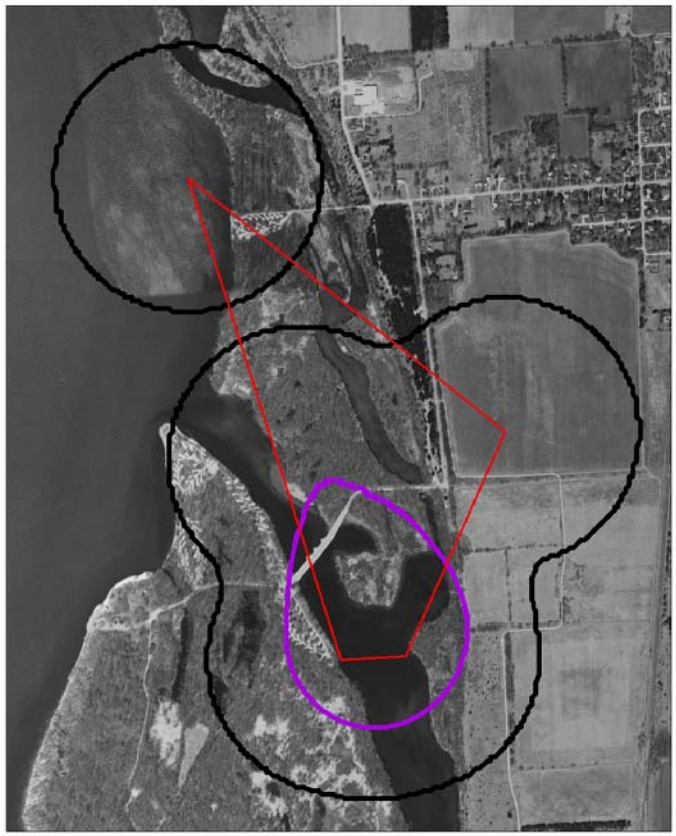
290 145 0 290 Meters

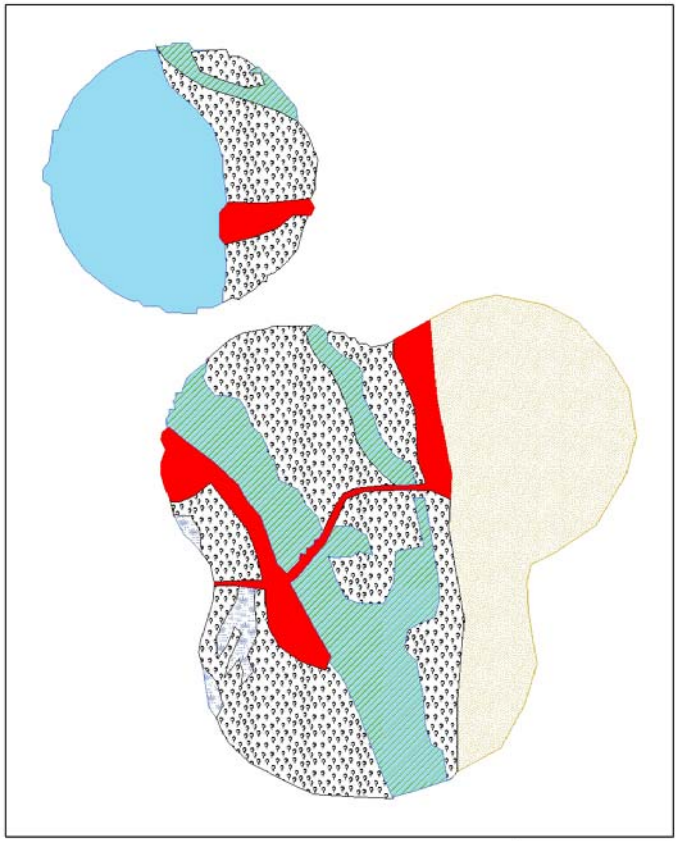
Prepared by Lindsay Kasuga
Projection: NAD 1983, UTM Zone 15N
2005 NAPP Digital Orthophoto Quadrangle
October 15, 2007

Legend

- Forest
- Built
- Marsh
- Sand Prairie
- Water

Home Range and Habitat Composition for Mustang Sally





Legend

- Minimum Convex Polygon
- Kernel
- Core (50%)
- Home Range (95%)

N

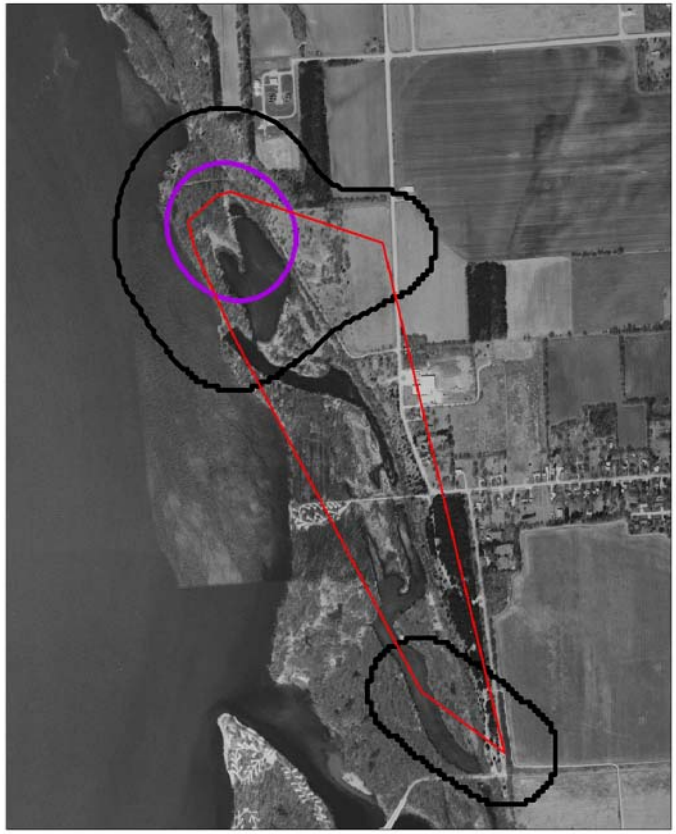
510 255 0 510 Meters

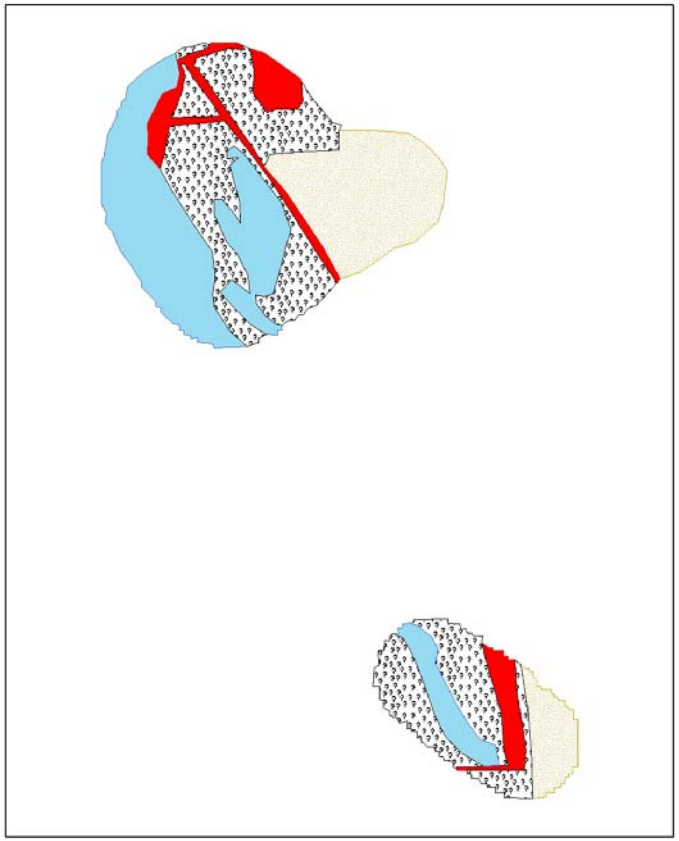
Prepared by Lindsay Kasuga
Projection: NAD 1983, UTM Zone 15N
2005 NAPP Digital Orthophoto Quadrangle
October 15, 2007

Legend

- Forest
- Built
- Marsh
- River
- Sand Prairie
- Water

Home Range and Habitat Composition for Roxanne





Legend

- Minimum Convex Polygon

Kernel

- Core (50%)
- Home Range (95%)

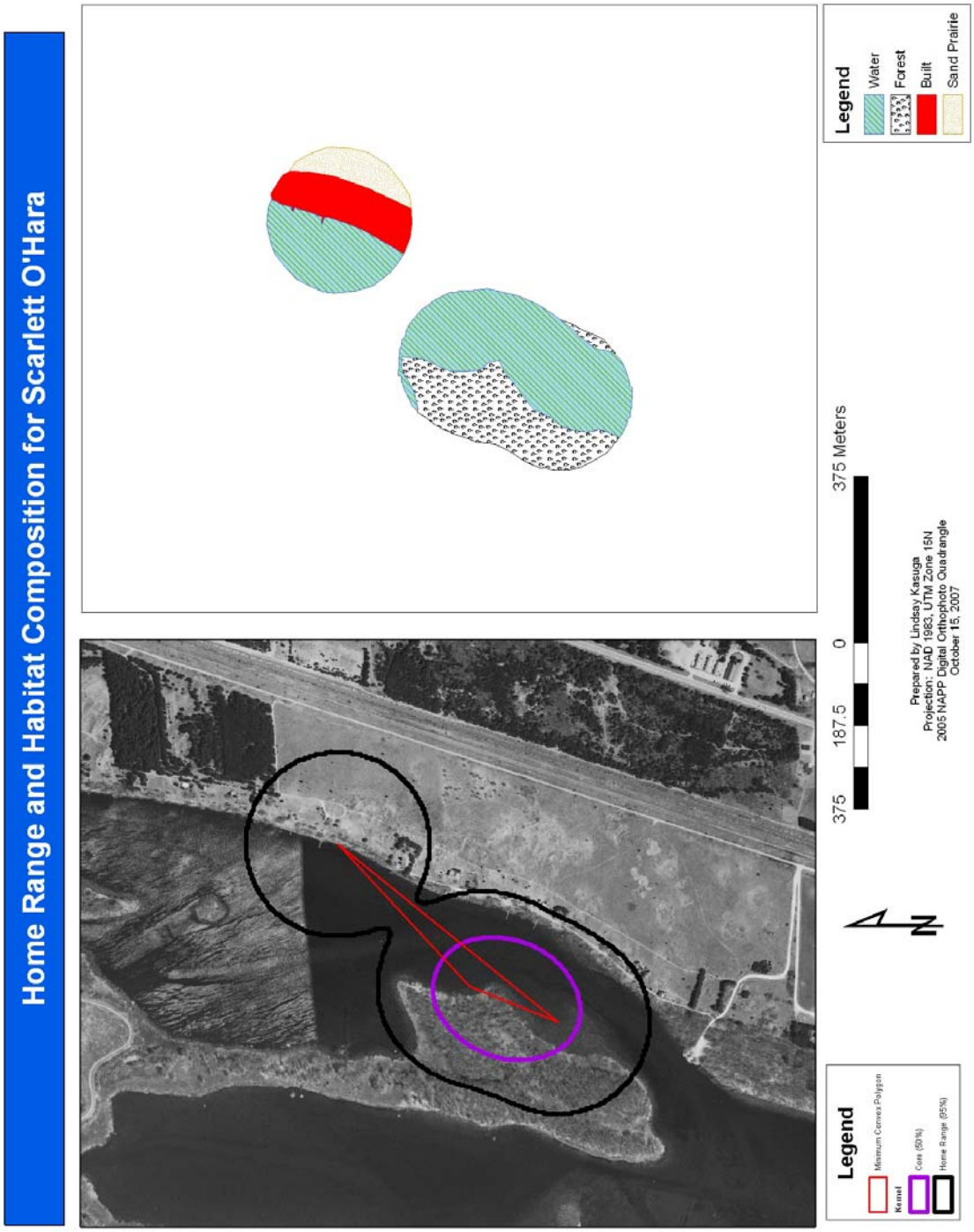
N

510 255 0 510 Meters

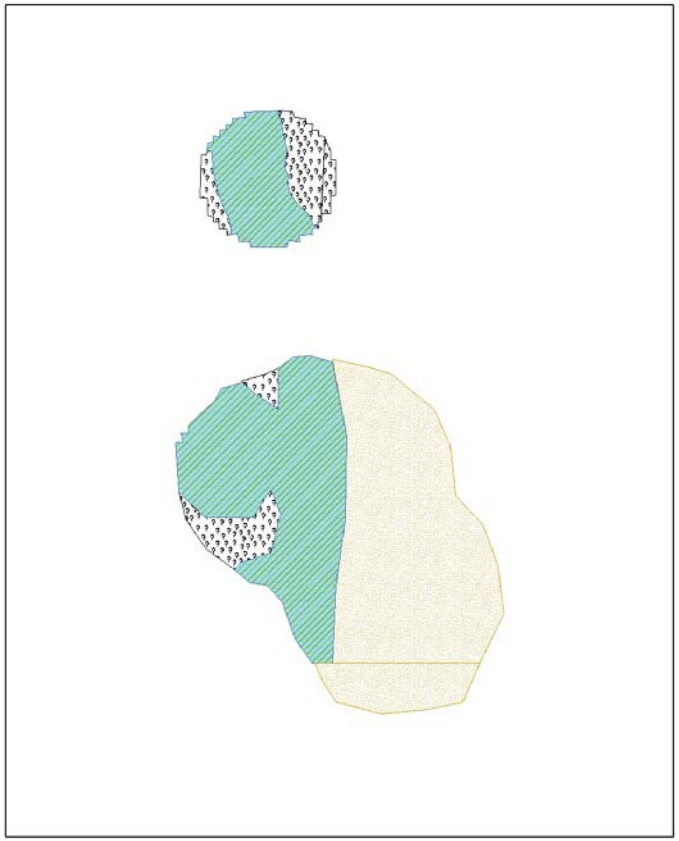
Prepared by Lindsay Kasuga
Projection: NAD 1983, UTM Zone 15N
2005 NAPP Digital Orthophoto Quadrangle
October 15, 2007

Legend

- Forest
- Built
- River
- Sand Prairie
- Water


Home Range and Habitat Composition for Scarlett O'Hara
Legend
Minimum Convex Polygon
Kernel
Core (50%)
Home Range (95%)
N
375
187.5
0
375 Meters
Prepared by Lindsay Kasuga
Projection: NAD 1983, UTM Zone 15N
2005 NAPP Digital Orthophoto Quadrangle
October 15, 2007
Legend
Water
Forest
Built
Sand Prairie

Home Range and Habitat Composition for Sweet Caroline



Legend

- MCP
- Kernel
- Core (50%)
- Home Range (95%)

N

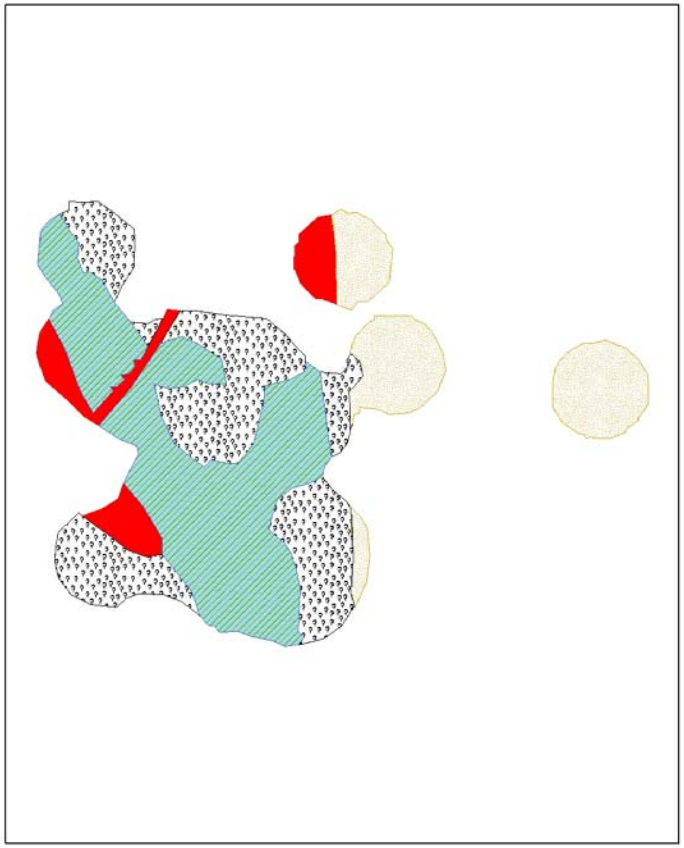
450 225 0 450 Meters

Prepared by Lindsay Kasuga
Projection: NAD 1983, UTM Zone 15N
2005 NAPP Digital Orthophoto Quadrangle
October 15, 2007

Legend

- Forest
- Sand Prairie
- Water

Home Range and Habitat Composition for Sweet Jane



Legend

- Minimum Convex Polygon
- Kernel
- Core (50%)
- Home Range (95%)

N

340 170 0 340 Meters

Prepared by Lindsay Kasuga
Projection: NAD 1983, UTM Zone 15N
2005 NAPP Digital Orthophoto Quadrangle
October 15, 2007

Legend

- Forest
- Built
- Sand Prairie
- Water

APPENDIX B. PRELIMINARY MARK-RECAPTURE ANALYSIS OF BLANDING'S TURTLES IN THE THOMSON CAUSEWAY RECREATION AREA

By Lindsay Kasuga[1] and Fred J. Janzen[1]

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Introduction

Mark-recapture studies provide a method for investigating various aspects of population demography, including survival (Φ), recruitment (f) and the population growth rate (Λ) (Lebreton et al. 1992). These studies have been performed on a variety of animals, including mammals (Wilson et al. 2007), birds (Sidhu et al. 2007) and even reptiles (Bowen et al. 2004) and offer insights into the demography of these populations. Mark-recapture studies may be especially useful in reptile species, as understanding survival and recruitment in populations is critical for ensuring long-term survival (Congdon et al. 1993). This analysis offers a preliminary investigation of survival (Φ) and recruitment (f) for the population of Blanding's turtles in the Thomson Causeway Recreation Area (TCRA), part of the larger Upper Mississippi River National Fish and Wildlife Refuge (UMRNFWR).

Methods

Trapping efforts have been conducted in the TCRA beginning in1997 and continuing through the present. A variety of aquatic traps, including fyke and lobster traps, were placed in the slough just east of the TCRA (for a more detailed description of the trapping area, see Methods section of Chapter 2). Blanding's turtle were also encountered and caught terrestrially. Once captured, turtles were uniquely marked by filing notches in the marginal scutes (Cagle 1939). Various measurements, such as carapace length, sex and reproductive status were collected on each turtle. Tissue samples were collected for genetic analysis, and turtles were released at the site of capture. Mark-recapture data were analyzed using Pradel's

reverse time model, which allows for estimation of survival (Φ) and recruitment (f) parameters (Pradel 1996), using the program MARK (White and Burnham 1999)

Results

Between 1997 and 2007, 56 turtles (18 males, 29 females, 4 juveniles and 5 of undetermined sex) were capture 99 times. Within the 10 years, 36 individuals were captured only once, 7 turtles were captured twice, 6 turtles were captured 3 times, 5 turtles were capture 4 times, 1 turtle was capture five times and one other turtle was capture six times. Below is a table depicting the number of new captures (never captured before) and recaptures (captured and marked in a previous year) by sex across years (Table B.1).

Before running any additional analyses in program MARK (White and Burnham 1999), program RELEASE GOF (goodness-of-fit) tests were run. Goodness-of-fit tests several of the key assumptions, such as equal probability of capture and survival among individuals from time t to time $t+1$, which must be met in order to accurately estimate parameters of interest. However, using these data, the goodness-of-fit test fails, indicating that the key assumptions of equal probability and equal survival of individuals from time t to time $t+1$ are not met. For a variety of reasons discussed above (see Chapter 2), it is unlikely that there are differences in probability of survival or capture. The more likely case is that the data are over-dispersed, or we have not yet collected enough data to accurately obtain estimates of survival and recruitment for this population of Blanding's turtles. In long-lived species, such as the Blanding's turtle, long-term data are needed to accurately estimate population parameters of interest and although this work has been conducted at the TCRA for the past ten years, more data are needed. It is possible to perform analyses to obtain estimates of population size; however, this requires the assumption that populations are

closed, or there is no migration in or out of the population, during the study. Given the number of individuals that are only captured once and never seen again, we do not feel that this is a valid assumption for this population.

For some species, mark-recapture analyses provide one method for estimating key population parameters, such as survival and recruitment. However, in long-lived species, such as the Blanding's turtle, long-term studies are needed to accurately estimate parameters of interest. With additional data collection, mark-recapture analyses can be used to understand how anthropogenic activities are impacting survival and recruitment for the population of Blanding's turtles in the TCRA.

Table B.1. Table depicting number of new capture (never captured before) and recaptures (captured and marked in previous year) by sex across all ten years.

		Number of Recaptures by Sex				Number of New Captures by Sex			
Year	Number of Captures	Males	Females	Juveniles	Unknown	Males	Females	Juveniles	Unknown
1997	2	0	0	0	0	1	0	0	1
1998	7	0	0	0	0	2	3	0	2
1999	9	0	1	0	0	2	3	0	1
2000	15	3	4	0	0	4	4	0	0
2001	5	3	1	0	0	0	1	0	0
2002	12	4	2	0	0	2	2	1	1
2003	6	0	2	0	0	1	3	0	0
2004	3	1	1	0	0	0	1	0	0
2005	14	3	4	0	0	1	4	2	0
2006	15	3	5	1	0	2	4	0	0
2007	12	3	1	0	0	3	4	1	0

Works Cited

Bowen, Kenneth D., Paul L. Colbert and Fredric J. Janzen. 2004. "Survival and Recruitment in a human-impacted population of Ornate Box Turtles, *Terrapene ornate,* with recommendations for conservation and management." *J. Herp.* 38(4): 562-568.

Cagle, F. R. 1939. "A system for marking turtle for future identification." *Copeia.* 170-173.

Congdon, Justin D., Arthur E. Dunham, 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(4): 826-833.

Lebreton, J.D., K.P. Burnham, J. Clobert and D. R. Anderson. 1992. "Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies." *Ecological Monographs.* 62: 67-118.

Pradel, R. 1996. "Utilization of capture-mark-recapture for the study of recruitment and population growth rate." *Biometrics*. 52: 703-709.

Sidhu, L.A., E.A. Catchpole, and P. Dann. 2007. "Mark-recapture recovery modeling and age-related survival in Little Penguins (*Eudyptula minor*). *AUK*. 124(3): 815-827.

White, G.C. and K.P. Burnham. 1999. Program MARK: survival estimate from populations of marked animals. *Bird Study*. 46: 120-139.

Wilson, D.J., M.G. Efford, S.J. Brwon, J.F. Williamson and G.J. McElrea. 2007. "Estimating the density of ship rats in New Zealand forests by capture-mark-capture trapping." *New Zealand Journal of Ecology*. 31(1): 47-59.