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BEHAVIORAL AND ECOLOGICAL STUDY OF THE
SPOTTED TURTLE, CLEMMYS GUTTATA (SCHNEIDER)

presented by

DIANA JANE LUTZ

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BEHAVIORAL AND ECOLOGICAL STUDY OF THE SPOTTED TURTLE, CLEMMYS GUTTATA (SCHNEIDER)

By

Diana Jane Lutz

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ABSTRACT

BEHAVIORAL AND ECOLOGICAL STUDY OF THE SPOTTED TURTLE, CLEMMYS GUTTATA (SCHNEIDER)

By

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The specific objectives of this study were to determine habitat requirements, movement patterns, population dynamics, demography and seasonal activities of the Spotted Turtle, *Clemmys guttata* in a southwestern Michigan fen. Habitat areas were identified with lower fen elevation areas which contained low-growing hydrophytes preferred. Population overlapping and homing were found to occur, with male home ranges larger than female home ranges. Population size appeared to be a 1:1 sex ratio. Morphometric measurements and male and female comparisons are presented, with females shown larger than males. Aestivation was found to occur. Communal hibernaculae and site fidelity also occurred with preferred hibernaculae habitats described.

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My passion and love for turtles started at a very early age. Every waking minute growing up at Rose Lake (in Branch County, MI) was spent catching, observing and then releasing turtles. This passion has never stopped-nor will it ever. Now that I am older, being able to spend my time working and studying these amazing creatures is a dream come true.

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Introduction

The Spotted Turtle, *Clemmys guttata* (Schneider), is a semi-aquatic North American turtle in the family Emydidae. Spotted Turtles are endemic to eastern North America and range from southern Great Lakes region (Illinois, lower Michigan, Indiana, Ohio, southern Ontario) east through Pennsylvania and New York to southern Quebec, and New England, and southward along the eastern seaboard (piedmont and coastal plain east of the Appalachian Mountains) to northern Florida (Ernst *et al*, 1994; Conant and Collins, 1991).

C. guttata is a small turtle with a smooth, keeless, low, oval black/brown carapace overlaid with small rounded yellow spots. The carapace is widest at the posterior. Occasionally appearing rust colored from staining, which may result from dissolved tannins or iron deposits. Spot number varies with some specimens lacking spots, while others have up to 125 scattered across the carapace and face (Roach, 2006). The hingeless, orangish-yellow plastron may display variable black/brown blotching. Secondary sexual characteristics are usually marked: males typically with tan chins, brown eyes, slightly concave plastra, and long, thick tails with vent beyond posterior carapacial rim. Females with yellow chins, orange eyes, flat or convex plastra, and shorter, thinner tails with vent beneath posterior marginals (Blake, 1922; Roach, 2006). In both sexes, heads mostly black with usually a few yellow spots and laterally one or more irregular orange or yellow blotch. The outer surfaces of legs are black,

usually with a few yellow spots, while the lower leg surfaces, neck and other soft parts often orange or pinkish mottled with black (Harding, 1997).

At hatching, the blue-black young Spotted Turtle is about 2.8 cm long. Carr (1952) reports that its width may be up to 95% of its length, making it appear almost round. Coloration that of the adult, but with usually one yellow spot per carapace scute; although, initially, some hatchlings may lack carapace spots. The head always spotted, with possible neck spotting (Ernst *et al*, 1994). Plastron yellowish-orange with central dark blotch (Harding, 1997). Hatchling's tail proportionally longer than adult. The egg tooth (caruncle) drops off by end of the first week (Ernst *et al*, 1994).

Unfortunately, Spotted Turtles are small and colorful, as well as shy, timid creatures with an easy-going disposition, exhibiting no trace of aggressiveness, thus creating a high demand as an aquarium or terrarium pet (Cahn, 1937). Roach (2006) describes the Spotted Turtle as, "... one of God's greatest creations; one of the prettiest turtles on the face of the earth." This kind of testament contributes to its over-collection and pet trade popularity. In addition, overgrazing (Minton, 1972), agricultural equipment such as plows, excavators (Fowle, 2001) and mowers (Ernst, 1976), vandalistic shooting (Harding, 1997), predation of individuals and nestlings by raccoons (*Procyon lotor*) and skunks (*Mephitis mephitis*) (Ernst, 1976; Cahn, 1937), along with road-crossing mortalities (Ernst, 1976) are additional major factors impacting population decline. Muskrat (*Ondatra zibethica*) predation has also been recorded in several populations of Spotted Turtles (Grant, 1936; Nemuras, 1966).

Based on the slow growth rate, delayed maturity, small clutch size, and low egg and juvenile survivorship, the species is considered especially vulnerable (Wilson *et al*, 1999; Harding, 1997). These factors further exacerbate local population susceptibility extinctions (Oldham, 1991).

C. guttata research has been conducted in other areas of its range, but remains poorly studied in Michigan. Prior to this study little has been documented on the Spotted Turtle in Michigan (Ruthven *et al*, 1928; Harding, 1997; Lutz, 2008). C. guttata studies and research have been conducted in Ontario (Litzgus *et al*, 1999; Litzgus, 1996; Chippindale, 1989; Haxton and Berrill, 2001), Maine (Joyal *et al*, 2001), Maryland (Nemuras, 1966; Ward *et al*, 1976), Massachusetts (Fowle, 2001; Graham, 1995), South Carolina (Lovich, 1990; Litzgus and Mousseau, 2004), Georgia (Folkerts and Skorepa, 1967), Connecticut (Perillo, 1997), Florida (Barnwell *et al*, 1997; Berry, 1978), Pennsylvania (Ernst and Zug, 1994; Ernst, 1970; Ernst, 1975), Ohio (Lewis and Ritzenthaler, 1997), Indiana (Minton, 1972) and Illinois (Cahn, 1937).

In the United States, the Spotted Turtle is not currently listed under the U.S. Federal Endangered Species Act; however, it is listed as endangered and threatened where it occurs in several states and Canada. *Nature Serve's Conservation Status Ranks* classify the species status anywhere from S5 (most secure) to S1 (critically imperiled). In Michigan, not only is the Spotted Turtle threatened, but it is listed as S2, meaning imperiled (six to twenty occurrences or restricted range) (www.natureserve.org)

Habitat

Previous Studies

Habitat requirements vary depending on range and topographic conditions. General habitat preferences include shallow ponds, wet meadows, tamarack swamps, bogs, fens, marsh channels, *Sphagnum* spp. seepages, slow streams and clear shallow water with mud or muck bottom and ample aquatic and emergent vegetation (Harding, 1997). Habitat preferences documented by other researchers are compiled in Table 1. Little data has been documented on preferred Michigan habitat requirements.

Females typically produce one, occasionally two clutches, of one to eight eggs per year (Ernst, 1970; Wilson, 1989, Ernst and Zug, 1994; Litzgus and Brooks, 1998). Besides some nests being dug into Sedge spp. tussocks (Ernst, 2001), nest sites include hummocks of moist *Sphagnum* moss and loamy soil of marshy pastures (Ernst, 1970; Belmore, 1980; Chippindale, 1989).

C. guttata is comparatively cold tolerant, actually preferring cooler environments (Ernst, 1982; Nemuras, 1966). It generally emerges earlier in spring, than other turtle species, often as soon as the snow cover melts (Ernst, 1982). It is considered most active in cool, early spring (Ward *et al*, 1976; Lovich, 1988; Litzgus and Brooks, 2000). Unlike other turtle species, the Spotted Turtle does not tolerate heat, with inactivity observed when an average mean temperature of 20.3˚C is reached (Ernst *et al*, 1994). Basking for long lengths of time is also minimized with increased temperatures. Being heliothermic, it can often be observed first thing in the morning basking in the sun, but will disappear

into the muck, mud or vegetation as the temperature begins to increase. Later, as temperatures fall, the turtle may once again emerge to bask.

Spotted Turtles are specialized in habitat preferences. Habitat choice may vary in different portions of its range. Unpolluted, shallow, mud and muck bottomed water bodies, such as marshes, bogs, swamps, small streams, drainage ditches, and vernal ponds (Ernst and Zug, 1994; Graham, 1995; Ditmars, 1933; Harding, 1997) are preferred. Other habitats may include fens (Lewis and Ritzenthaler, 1997; Lovich, 1987), grassy areas (Ward *et al*, 1976; Ditmars, 1933) and terrestrial environments (Berry, 1978; Fowle, 2001).

Many factors have led to decline of *C. guttata* populations correlating to their S2 ranking. Habitat destruction caused by development, marshland drainage, pollution, and fragmentation (roads, fences, curbs, railroad tracks, and retaining walls) are a few documented reasons for reported declines (Lovich and Jaworski, 1988; Cook *et al*, 1980; Harding, 1997; Conant and Collins, 1991; Fowle, 2001).

Introduction of invasive plant species (Conant and Collins, 1991; COSEWIC, 2004) also plays a major role in habitat destruction and is becoming a major threat to turtle populations. Once a habitat becomes overgrown with later successional plant species, it may be unsuitable for Spotted Turtles (Burke *et al*, 2000; Graham, 1995). These invasives include, but are not limited to, Glossy Buckthorn (*Rhamnus frangula*), Phragmites (*Phragmites australis*), and Purple Loosestrife (*Lythrum salicaria*).

Movement Patterns

Previous Studies

Cagle (1944) defines three major turtle movement categories: first, local activity resulting from food foraging, seeking basking sites, or mating impulse; second, seasonal migrations; third, irregular periods of migration.

Important studies in Pennsylvania of *C. guttata,* were conducted by Ernst (1976), who thought the annual activity cycle of *C. guttata* was apparently controlled by two major factors: water temperature and reproductive drive. Water temperature influenced all of the normal activities such as feeding, basking, and dormancy, and also possibly limited reproductive activity when too low. At normal seasonal temperatures in his study site, reproductive drive controlled many spring activities of *C. guttata.*

Ernst (1967) also reported that feeding does not occur until water temperatures reach 14°C. Active feeding continued as long as water temperature remained above this temperature. Initial activity after cold weather dormancy was spent mostly basking to gain heat and maintain relatively high body temperatures.

Ernst (1976) found daily periods of basking and foraging varied in length depending upon environmental conditions. In periods of cool weather, Spotted Turtles either bask for most of the day, and feed only sparingly or become inactive by burrowing into the mud or entering muskrat burrows. During rainy weather, few *C. guttata* were active.

Activity was not only triggered by temperature, but also daylight hours. As darkness approached, the turtles burrowed into the mud bottom of some waterway or crawled into muskrat burrows and became inactive after dusk (Ernst, 1976).

Home Range

Previous Studies

Home range is defined as the area in which turtles are observed during a given year (Ernst 1970). There are several methods to measure home range, constantly being revised and upgraded. Two common methods are Minimum Convex Polygon (MCP) and Kernel Home Range Analysis (KHRA), both were used for this study. Minimum Convex Polygon is the home range that includes outer boundaries (peripheral) of observation, including most outliers. It takes into account most location points, including 95% of those observed. MCP is well defined and straight forward.

Worton (1989) described Kernel Home Range Analysis as the utilization distribution (how much area an individual animal is using in a given time period) based on points observed. Kernel Home Range Analysis tends to give the most accurate home range data compared to other analyse (i.e. Minimum Convex Polygon). The 95%, 85%, 75%, and 50% Kernel estimation based on utilization distribution was used to eliminate any "outliers" that would artificially inflate home range.

Ernst (1970) used minimum and modified minimum home ranges which are similar to Minimum Convex Polygon and Kernel Home Range Analysis. The

two methods were used to measure home ranges of both male and female individuals. His study concluded that females had a mean minimum range of 1.31 acres (0.53 hectares) and a modified minimum range of 1.25 acres (0.509 hectares), while males had a mean minimum range of 1.3 acres (0.53 hectares) and a modified minimum range of 1.23 acres (0.498 hectares). His data suggested that there was no significant difference between male and female home ranges.

Home ranges studied by Ernst (1970) in Pennsylvania overlapped in time and space, but no territoriality was displayed. Territory defined as an area of defended space. Interest in other individual Spotted Turtles was shown only during the mating period. Home ranges of females usually did not include a suitable nesting area and individuals had to migrate out of their range to nest.

Litzgus (1996) determined home range estimates using Minimum Convex Polygon and found that the mean home range size for females was 3.22 hectares and 3.58 hectares for males. No significant difference between home range sizes for males and females was reported.

Breisch (2006), using combined data, stated that the mean home range for West Virginia male and female Spotted Turtles was 0.39 hectares using Minimum Convex Polygon. In Indiana, Barlow (1999) documented a home range of 2.03 hectares for males and 2.82 hectares for females also using Minimum Convex Polygon (MCP). No differences in home range sizes were found in her Indiana study, although overlapping of home ranges was extensive. On the other hand, Haxton and Berrill (1999) in Ontario, Canada found an average home

range using MCP of 3.7 hectares, with females having a significantly larger home range than males. Differences in numbers, methodology, locale, and habitat could explain the varied findings by Spotted Turtle researchers.

Homing

Previous Studies

In Michigan, Cagle (1944) reported a tendency for turtles to return to a given area, displaying homing behavior. The study showed seasonal movements away from the home range occurred during early spring and late fall, when either the need for hibernating quarters or "...the period of spring wandering led the turtle to new areas." Turtles, forced from their home area by aberrant habitat changes, either followed the last remnants of water or moved at random in search of a suitable environment. Cagle (1944) found individuals forced from their home ranges may return to them when conditions are again suitable.

Previous studies suggested some turtle species, including *C. guttata,* have homing ability even after being removed from their home range (Breder, 1927; Nichols, 1939; Medsger, 1919; Schneck, 1886; Grant, 1936). Ernst (1968) found small numbers of *C. guttata* in a Pennsylvania population returned to the original capture point 4 to 64 days after being moved 805 m upstream from his study site. He suggested that the turtles could have recognized the current, temperature gradient, and aromatic characteristics of a certain creek and followed it home, but provided no evidence as to which of these are most important.

Objectives

The specific goal of this study was to observe Spotted Turtles in their natural habitat with the purpose of determining:

- Habitat preferences:
    - hydrophyte identification
- Nesting
    - location
    - vegetation used
    - nest building activity
    - egg/hatchling observation
- Movement and movement patterns:
    - home range
    - homing ability (does it occur?)
    - Overlapping of home range (does it occur?)
    - comparisons between male and female movement
- Population dynamics and demography
    - Comparisons of male/female/juvenile
- Seasonal Activities:
    - Aestivation (does it occur?)
        - location
    - Hibernation
        - Location
        - Communal hibernaculum (does it occur?)

- Site fidelity (does it occur?)

This was accomplished through radio telemetry, hand capturing, mark and recapture methods and thousands of hours of observation and recording data.

Study Site Description

This study was conducted in a southwestern Michigan fen. Defined by Chadde (2002), a fen is a peat covered wetland with a constant flow of mineral rich groundwater which may appear dry at the surface in later summer months. During drier periods, the water table is present just below the ground surface. Fen soil is characterized as alkaline (pH ranging from 7.9 to 8.3) and hydric which means it is flooded or saturated long enough during the growing season so that anaerobic conditions develop in the upper strata. Groundwater contributes both calcium and magnesium minerals to the wetland.

Chadde (2002) also stated wetlands, which include fens, have at least one of the following three attributes regarding vegetation, soils and hydrology: (1) predominant plants are hydrophytes, (2) soils are largely undrained, hydric soils, and (3) water will either permanently or periodically cover the area during some or all of the growing season each year.

The fen in this study was approximately 30 hectares in size. In the early 1800's (presettlement era) land descriptions were recorded by people walking and surveying section lines. Areas where no survey section lines were available, a "best guess" was used. Extrapolation was determined from what little information was provided by surveyors. The habitat and area where today this study took place, was referred to as a "Shrub Swamp/Emergent Marsh" by Arc

View 9.2 (Figure 1); said to contain taller, woody hydrophytes, including Dogwood and Willow plant species. This suggests that the survey may have commenced from a section line that was near where the main road is today. If that is the case, the surveyor may not have been able to see beyond the taller shrub species to record an existing area of short vegetation.

The plant majority within the study site were hydrophytes, defined by Chadde (2002) as plants that grow in water or soil that is at least periodically deficient in oxygen resulting from high water saturation. Today, the study site center would be considered an open Sedge meadow; shorter hydrophytes (61cm) included *Sphagnum* spp., Sedge tussocks including Common Threesquare (*Scirpus pungens*), and Shrubby Cinquefoil (*Potentilla fruticosa*), which created safe havens for *C. guttata*.

Beyond the Sedge meadow, a taller (2 to 5 m) growth of vegetation containing both woody and non-woody plants included, but not limited to, cattails (*Typha latifolia* and *Typha angustifolia*) both of which will be referred to as *Typha* throughout the paper, Red-osier Dogwood (*Cornus sericea*), Poison Sumac (*Toxicodendron vernix*), Northern Swamp Dogwood (*Cornus racemosa*), Swamp Rose (*Rosa palustris*), and many species of Sedges and Rushes (Table 2 and Table 3). At the lake's edge, thick canopies of Glossy Buckthorn (*Rhamnus frangula*) dominated making some areas practically impenetrable (Figure 2). Prescribed burns by The Southwest Michigan Land Conservancy were initiated in the past near the lake's edge in attempt to eradicate the thick stand of Glossy Buckthorn.

Surrounding this area in presettlement times were Mixed Oak Savanna and Oak-History Forests. These areas are still visible but housing developments and infrastructure have altered the original habitat. During this study, all nearby surrounding habitats, including ponds, lakes, marshes, and wetlands were surveyed, but turtles were only observed in the study site.

The fen was surrounded by housing developments on two sides, a lake on the third side, and a main road on the fourth side. This was described as a "shelf" that attaches to a nearby lake, protected by The Southwest Michigan Land Conservancy and private land owners.

In addition, the site included various protected species plants which included, but were not limited to, Northern Grass-of-parnassus (*Parnassia palustris*) and Lesser Fringed Gentian (*Gentiana procera*).

Wildlife sighted in the fen included Coyote (*Canis latrans*), Red Fox (*Vulpes fulva*), Raccoon (*Procyon lotor*), Meadow Vole (*Microtus pennsylvanicus*) and Muskrat (*Ondatra zibethica*) (Table 4). Reptiles and amphibians documented included, but were not limited to, Eastern Box Turtle (*Terrapene carolina carolina*), Eastern Massasauga Rattlesnake (*Sistrurus catenatus catenatus*), Western Chorus Frog (*Pseudacris triseriata*) and Spring Peeper (*Pseudacris crucifer*) (Table 5). Lastly, the site included a variety of nesting wetland bird species including Willow Flycatcher (*Empidonax traillii*), Swamp Sparrow (*Melospiza Georgiana*), Common Snipe (*Gallinago gallinago*), Common Yellowthroat Warbler (*Geothlypis trichas*), and Yellow Warbler (*Dendroica petechia*) (Table 6).

On the fen's east side was a pond dominated by thick growths of algae *(Chara* spp.), characterized as a *Chara* pond (Michigan Dept. of Env. Quality Water Bureau, 2005). *Chara* spp. (common names: Stonewart, Muskgrass) is an advanced form of algae. It has a musky odor and gritty texture caused by mineral deposits on its surface. It grows in low, dense mats. In a *Chara* pond, water is clear and rich in calcium and some magnesium. The water remains relatively unaffected by intensive land use or other surface nutrients and most often found in areas supporting mosaics of semi-aquatic vegetation (Joint Nature Conservation Committee, 2005). *Chara* spp. grows densely because, like other algae filters dissolved nutrients out of the water instead of sediments. In this respect, *Chara* spp. are highly beneficial vegetation (Michigan Dept. of Env. Quality Water Bureau, 2005). However, *Chara* spp. develops underwater, grows rapidly, and as a dominant species, is usually considered undesirable, causing oxygen depletion (Brinlee 2009). Anchored to the bottom, it develops into large green mats with thin leaf-like structures, and has proven difficult for fish maneuverability (Peterson and Lee, 2005). It is very common and widely distributed throughout Michigan.

Muskrats and their burrows were present in the pond. This pond had loose, muddy, marl deposits which, when stepped on, seemed "bottomless" and made it very dangerous for humans and perhaps turtles. *Chara* spp. appeared to play an important role in the life history of this Spotted Turtle population. It was a factor in mortality of Spotted Turtles. Discussion in results section of Chapter 2.

Methods

Ernst (1970) defined sexual maturity in both sexes as when the individual reached a carapace length of 8.0 cm. For purposes of sexual determination at the start of this project, Ernst's 8.0 cm limit was used for obvious male and females. However, female characteristics are juvenile characteristics, and male characteristics (when it comes to secondary characteristics) are yet to be defined. Thus in this study, Ernst's definition may not hold true.

From March 2007 to March 2009, telemetry equipment was used for tracking movement of selected male and female Spotted Turtles. In early spring (late March, early April), adult turtles were equipped with transmitters. During the two year study period, 29 turtles with an average age of 12.3 years and carapace length of 9.1 cm were telemetered. In 2007, twelve transmitters (model # 51-2FT Holohil Systems Ltd., Ontario, Canada) were attached to the study turtles. Transmitter battery life was at least ten months, lasting an entire year. Two small holes on the carapace's posterior left side were drilled into the marginal scutes. The transmitter with a 22.9 cm whip antenna was attached using fine gauge copper wire. The transmitter was additionally secured with a waterproof epoxy to keep out debris, or prevent catching on vegetation. Black permanent marker was used to camouflage the epoxy for better blending into carapace color. When complete, the transmitter weight was 12 g or approximately 10% to 11% of the turtle's original body weight (Figure 5). This was within the range used by other researchers. For example, Breisch (2006) described transmitter weight to be 10.2% body weight. The receiver used in this study was a Telonics TR-4

(Telonics Inc. Products, Mesa, AZ). A hand-held Yagi 3 element folding antenna (Wildlife Materials International, Murphysboro, IL) was also used in conjunction for tracking.

Turtles were tracked two to three times a week until November, then once a month. When a turtle was located, morphometric data was recorded. Using dial calipers, carapace length, plastron width at the bridge, plastron length and height were recorded. Sex determinations, as well as weight calculated with Salter Housewares Ltd. Scale, and age (by counting annuli) were also recorded. Also documented were injuries, behavior at capture time, GPS coordinates at observed location (Garmin etrex) and vegetation description.

Carapace temperature (Pro Exotics Tempgun), as well as air temperature (Kestrel 2000), and water temperature (if not available, substrate temperature was recorded); also recorded were general weather conditions. All data were recorded in a field notebook, then transferred to Microsoft Excel data sheet for each individual turtle (Table 7). Radio telemetry data for each of the transmittered turtles were also transferred to a Microsoft Excel data sheet (Table 8).

All turtles were hand captured and data were obtained and recorded during daylight hours. Most turtles were located by traversing through the fen. During fall, turtles were found by "mucking", which is the process of probing through the mud, muck and water by hand to locate turtles.

Turtles were marked by filing notches in the marginal scutes. A marking system using the alphabet letters was used (Figure 6, Figure 7, and Figure 8).

For hatchlings, a pair of small scissors was used to clip a single triangular shaped notch into the marginal scute.

In 2008, six additional transmitters (model SB-2 modified, Holohil Systems Ltd., Ontario, Canada) were employed. Transmitter attachment, with a 15.2 cm whip antenna, was done by drilling one hole into a marginal scute. A fine gauge copper wire was used to attach the transmitter to the carapace, with waterproof epoxy for final transmitter securement. The transmitter battery life was six months, thus, transmitters were removed before turtles proceeded with hibernation. Total transmitter weight was 6 g which was approximately 4.5% to 6% of the total body weight (Figure 9).

Turtles were tracked one to three times per week until November, then one to two times per month. Morphometric protocol and data collection methods were the same as 2007.

During 2007 and 2008, the transmitters (model # S1-2FT) provided pulses, which when counted, applied to a calculation, then plotted to a temperature graph (supplied by Holohil Systems Ltd.) identified the turtle's hibernaculum temperature. Litzgus and Brooks (2000) suggested a correlation between turtle's hibernaculum temperature and actual body temperature.

Maps of Spotted Turtle distribution and analysis were created using Arc Map 9.2 and Arc View 3.3 (ESRI, Redlands, CA). The Arc View programs were used to determine MCP and Kernel Home Range Analysis for turtles with transmitters. Only MCP was generated for turtles without transmitters. MCP included outer boundaries of observation including most outliers, taking into

account most location points. On maps, yellow dots represent turtle observations and may include more than one observation.

Habitat Results

One of the study objectives was to discover Spotted Turtle habitat preference. Aggregations and possible preferred habitat locations were indeed identified. A diagram of the entire fen, pointing out areas of heavy aggregations was presented (Figure 10).

Turtles with and without transmitters, located during 2007, were plotted in the study area (Figure 11 and 12). Two 50% Kernel estimation areas were identified. The first area included was centrally located at the lowest elevation. Even with 2007's drought-like conditions, the substrate was similar to saturated mud. This area, during drier times, tended to be more saturated than most other areas and aggregations of Spotted Turtles occurred here. The main hydrophytes varied in height from short (less than one meter) which included *Sphagnum* spp., Sedge, and Shrubby Cinquefoil to taller heights (2-3 meters) including *Typha*, Willow, Northern Swamp Dogwood and Red-osier Dogwood.

Within the second 50% Kernel estimator area was an overflow channel, referred to as "the outlet." This originated at the lake's edge and allowed lake water to flow approximately 15 meters inland. Even during the driest part of 2007, the outlet generally had water in it or was thoroughly saturated, leaving a thick, organic, mucky substrate. Channel 4 (HKU- female) was tracked and located deep beneath this muck on several occasions.

The area around the outlet was populated by taller (2-5 m) woody and non-woody hydrophytes including Glossy Buckthorn, Swamp Rose, Poison Sumac, Northern Swamp Dogwood, Red-osier Dogwood, Sedge, Fern and *Sphagnum* spp.

Included within one of the four 75% Kernel estimator areas was a locale designated "the ditch." The ditch was located at the fen's southern end, running east and west perpendicular to a nearby road. Besides rainfall and overflow from the fen, it collected run-off water. In 2007, during the driest of times, 10 cm of water was recorded in the ditch. At no time during the two year study was this location completely dry. Adjacent to the edge, tall emergent vegetation included *Typha*, Willow, Poison Sumac, Red-osier Dogwood and Northern Swamp Dogwood, Sedge, Bulrush and Shrubby Cinquefoil. Turtles with and without transmitters, frequented this area.

The other three 75% Kernel estimator areas were lower elevation areas, where turtle aggregations were documented. This included areas where substrate moisture was present, even during drier months. One of these areas contained approximately 3 m high, thick canopies of *Typha*. The second area was located in a more open area of the fen, just north of the ditch and contained Bulrush, Sedge and *Typha*. The third area was referred to as the *Chara* pond, dominated by dense *Chara* species.

Maps of all turtles with and without transmitters found during 2008 study are found in Figures 13 and 14. This was a much wetter year, with rainfall far exceeding 2007. Activity and frequency of individuals with and without

transmitters were more scattered. This suggests larger area utilization may have been the result of additional precipitation.

Using Kernel Home Range Analysis, the 50% Kernel estimator area, was located in two areas of the fen. The first included the study site center a low elevation area described earlier.

The second area was a 2 m wide trail to the lake, located on the southeastern edge. This path appears to have been made years ago by the property owners as an access to the lake. On either side of this path, tall woody and non-woody plant vegetation was present. The hydrophytes included, but were not limited to, Swamp Rose, Poison Sumac, *Typha*, Red-osier Dogwood, Glossy Buckthorn, Sedge and Bulrush. The mud and muck path was trampled down, forming depressions that allowed for water collection. Tall emergent vegetation, next to the trail, consisted of many deer trails. These trails also supported trapped water. These trails opened to the lake's edge, where there was low growing vegetation including Sedge, Shrubby Cinquefoil and Bulrush. With the large amounts of rainfall in 2008, the lake was at capacity causing shore overflow. In 2008, the turtle activity level was heavy with and without transmitters in this area.

The 75% Kernel estimation was determined in three fen areas in 2008. The first area was known as the ditch, which was described above in 2007. The second area contained short hydrophytes that were less than 1 m in height in a low elevation area. The main hydrophytes included Sedge, *Sphagnum* spp., and Shrubby Cinquefoil. The third area was located near the southwestern lake

edge, a low vegetation area which included Shrubby Cinquefoil, Sedge and Bulrush. Water was present throughout the year.

Sphagnum mounds, with Sedge and Shrubby Cinquefoil growth on top of the mounds, appeared to provide nesting locations for Spotted Turtles. Although no turtles were observed nesting in this study, six presumable successful nest sites were located. Eggshells found deep in the soil indicated successful hatching seemed likely. All of these nests were found in the previously described vegetation. Nests were placed in well drained areas exposed to full sunlight. One predated nest was found in 2008, soon after the eggs had been deposited. This nest had been dug up, with eggshells on top of the substrate (Figure 15).

On 16 June 2008, a single egg was observed lying on top of a *Sphagnum* spp. mound, with Shrubby Cinquefoil growing from the top of the mound. With further investigation, a nest with additional eggs was located buried in the *Sphagnum* spp. mound. The egg observed had a weight of 4 grams, length of 3 cm, and width of 1.7 cm. Major rain storms deluged the site on 2 July 2008 and most deer trails contained at least 20 cm of water. On 4 July 2008, the nest was observed underwater, submerged for at least three days. On 4 September 2008, a hatchling was located with the empty eggshell from one additional hatchling (suggesting successful emergence). Also included in this nest, was a dead embryo still in its shell (Figure 16). Ernst *et al* (1994) reported Spotted Turtle incubation periods between 70-83 days in length. The incubation period for this nest was 81 days which fell within this range.

Movement Results

2007 Radio Telemetry and Climatic Conditions

Transmitters were attached to 12 turtles in 2007. This included four males and eight females. In 2007, the total annual rainfall was documented at 33.82 inches (approximately 86 cm). During summer months, the precipitation was well below normal, causing drought-like conditions throughout the fen. Only areas of lower elevation contained standing water during this drought period. Included were six areas previously described in Chapter 1: 1) outlet, 2) area containing approximately three meter high canopies of *Typha*, 3) open area in middle of fen, 4) *Chara* pond, 5) ditch, and 6) area just north of ditch which contained hydrophytes Bulrush, Sedge and *Typha*.

A short summary of each radio telemetered turtles' movements and habitat utilization is described below.

Channel 0 – IKL (Male)

Male IKL was first captured and telemetry attached 24 March 2007. He was observed a total of 72 times throughout the 2007 season. Using Minimum Convex Polygon (MCP), total area of habitat utilization was 1.60 hectares (Figure 17). Main activity occurred in the ditch. Hydrophytes occupying this area included *Typha*, Red-osier Dogwood, Sedge, Willow, and Shrubby Cinquefoil. Throughout this season, the ditch usually contained more than 10 cm of water.

Male IKL was originally captured coming out of hibernaculum in the ditch. At the end of the 2007 season, he returned to the ditch to hibernate suggesting hibernaculum site fidelity.

Channel 1 – KVW (Male)

Male KVW was first captured and telemetry attached 25 March 2007. He was observed a total of 76 times throughout the 2007 season. Using Minimum Convex Polygon (MCP), total area of utilization was 2.37 hectares (Figure 18). Main activity occurred in the open area in middle of fen. This area of lower elevation held water more frequently than other areas. Hydrophytes occupying this area included *Typha*, Red-osier Dogwood, Sedge, Willow, and Shrubby Cinquefoil.

Male KVW was originally captured coming out of hibernaculum in the fen's open middle area. At the end of the 2007 season, he hibernated in same area from which he emerged earlier in spring, suggesting hibernaculum site fidelity.

Channel 2 – ABCK (Male)

Male ABCK was first captured and telemetry attached 24 March 2007. He was observed a total of 77 times throughout 2007 season. Using Minimum Convex Polygon (MCP), total area of utilization was 3.30 hectares (Figure 19). Channel 2 movement was extensive throughout fen in 2007, covering a wide variety of habitats. Two main areas of activity included big trail to lake and lake's edge, as well as fen's open middle area. The big trail to lake was a wide trail that led from an open area to lake. Both sides of this trail had tall hydrophytes including Red-osier Dogwood, Poison Sumac, *Typha* and Glossy Buckthorn. Hydrophytes occupying the middle open area included *Typha*, Red-osier Dogwood, Sedge, Willow, and Shrubby Cinquefoil. This area of lower elevation held water more frequently than other areas.

The exact initial spring emergence location of Channel 2 was not observed but he was found near the middle area of fen with a lower elevation. The hibernation locale was documented in this same area. This suggests possible hibernaculum site fidelity.

Channel 3 – KVX (Female)

Female KVX was first captured and telemetry attached on 20 April 2007. She was observed a total of 65 times throughout the 2007 season. Using Minimum Convex Polygon (MCP), total area of utilization was 0.48 hectares (Figure 20). Main activity occurred near the road. Hydrophytes included *Typha*, Red-osier Dogwood, Swamp Rose and Willow. This turtle was originally located in close proximity to the main road. After the transmitter was attached, she was released into a more open area, located some distance from the main road, to ensure safety. In less than 24 hours, the turtle returned to its original home range. This finding suggests that homing ability may be present in Spotted Turtles in this southwestern Michigan fen.

At the end of the 2007 season, she was sighted going into a hibernaculum near the same location where originally captured in the spring. Further studies of this turtle need to be completed to assess hibernaculum site fidelity.

Channel 4 – HKU (Female)

Female HKU was first captured and telemetry attached 11 May 2007. She was observed a total of 58 times throughout the 2007 season. Using Minimum Convex Polygon (MCP), total area of utilization was 0.35 hectares (Figure 21). Main activity occurred near the lake. Hydrophytes occupying this area included

Glossy Buckthorn, Sedge, Fern, Purple Loosestrife, *Sphagnum* spp. and Willow. Even during drought-like conditions, water was evident below the substrate. Also near this location was the outlet, which generally contained standing water. Documented sightings of female HKU, occurred throughout most of the season in this area. Female HKU was not captured until late spring, making her initial spring emergence location unknown. At the end of the 2007 season, she was found hibernating in fen's open area. Hydrophytes were predominantly Sedge, *Typha* and Shrubby Cinquefoil. Caused by low elevation, this area held water longer than other areas. Future studies need to be completed to determine if this turtle had hibernaculum site fidelity.

Channel 5 – BKW (Female)

Female BKW was first captured and telemetry attached 21 April 2007. She was observed a total of 22 times throughout the 2007 season. On 4 June 2007, the transmitter malfunctioned and was removed. Minimum Convex Polygon (MCP) was not conducted due to incomplete data.

Channel 6 – DKVWX (Female)

Female DKVWX was first captured and telemetry attached 17 May 2007. She was observed a total of 54 times throughout the 2007 season. Using Minimum Convex Polygon (MCP), total area of utilization was 0.29 hectares (Figure 22). Main activity occurred in the outlet and open area in middle of fen. Main hydrophytes included *Typha*, Red-osier Dogwood, Sedge, Willow, and Shrubby Cinquefoil. Due to lower elevation, the substrate was more saturated than other areas. This turtle was originally captured late spring, making her initial

spring emergence location unknown. At the end of 2007, documented hibernation was in fen's open area. Future studies need to be completed for determination of hibernaculum site fidelity.

Channel 7 – KLU (Female)

Female KLU was first captured and telemetry attached 18 May 2007. She was observed a total of 55 times throughout the 2007 season. Using Minimum Convex Polygon (MCP), total area of utilization was 0.40 hectares (Figure 23). Main activity occurred in the ditch. Main hydrophytes included *Typha*, Red-osier Dogwood, Sedge, Willow, Bulrush, and Shrubby Cinquefoil.

This turtle was originally captured late spring, making her initial spring emergence location unknown. At the end of 2007, documented hibernation was in the ditch. Future studies need to be completed for determination of hibernaculum site fidelity.

Channel 8 – HKV (Female)

Female HKV first captured and telemetry attached 18 May 2007. She was observed a total of 34 times throughout the 2007 season. Using Minimum Convex Polygon (MCP), total area of utilization was 1.12 hectares (Figure 24). On 25 June 2007, she was found in the *Chara* pond, caught in *Chara* spp. The turtle was untangled, and it was noted the epoxy was loose and may have caused the transmitter to "catch" on the *Chara* spp. With repairs made, the turtle was released at a safer location, a distance from the *Chara* pond, in the outlet. Within 10 days of original move, female turtle HKV had returned to the *Chara* pond, suggesting homing ability. On 19 July 2007, the turtle was found dead with

its antenna tangled in *Chara* spp. Main activity occurred in the *Chara* pond. Main hydrophytes included *Typha* and *Chara* spp.

Channel 9 – KLW (Female)

Female KLW was first captured and telemetry attached 17 May 2007. This turtle was originally captured near the *Chara* pond, and observed nine times. After these nine sightings, female KLW was never observed again. The turtles' telemetry location did not change positions after 30 May 2007. With the inter-connected networks of underground muskrat burrows, the turtle was believed to be in the burrows and inaccessible for observation. On 17 June 2007, lacking turtle movement for several weeks, the telemetry location was thoroughly investigated for whereabouts of the missing turtle. Remains were found in deep water of the *Chara* pond, with head missing and transmitter still attached to carapace. Two, possibly three eggs were observed within turtle. Considering water depth where turtle was found, it is believed that it was predated by a muskrat. Because data was incomplete, Minimum Convex Polygon was not conducted.

Channel 10 – IKW (Male)

Male IKW was first captured and telemetry attached 21 May 2007. He was observed a total of 42 times throughout the 2007 season. Using Minimum Convex Polygon (MCP), total area of utilization was 0.45 hectares (Figure 25). Main activity occurred in the outlet and ditch. Main hydrophytes included *Typha*, Red-osier Dogwood, Sedge, Willow, and Shrubby Cinquefoil. Both locations had documentation of water throughout the dry season. This turtle was originally

captured in late spring, making his initial spring emergence location unknown. The turtle was documented hibernating in the ditch at the end of 2007. Future studies need to be completed to determine hibernaculum site fidelity.

Channel 11 – KV (Female)

Female KV was first captured and telemetry attached 30 May 2007. She was observed a total of 46 times throughout the 2007 season. Using Minimum Convex Polygon (MCP), total area of utilization was 0.07 hectares (Figure 26). Main activity occurred in open area in middle of fen. Main hydrophytes included *Typha*, Red-osier Dogwood, Sedge, Willow, and Shrubby Cinquefoil. This area was lower in elevation and held water longer than other areas.

This turtle was originally captured in late spring, making her initial spring emergence location unknown. At the end of 2007, documented hibernation was in open area of fen. Female KV returned to the same hibernaculum at the end of the 2008 season, suggesting hibernaculum site fidelity.

2008 Radio Telemetry and Climatic Conditions

In 2008, 17 turtles had telemetry attached. This included 14 females and three males. Unlike 2007, the 2008 season was much wetter with higher levels of rainfall documented throughout summer months. Total rainfall for entire year equaled 54.1 inches (approximately 137 cm). This was substantially higher than 33.82 inches (approximately 86 cm) documented for 2007. Most areas throughout the site contained standing water during 2008. The lower elevation areas had increased water levels, and higher concentrations of turtles than the higher elevation areas of the fen. These lower elevation areas included: 1) open

area in middle of fen, 2) wide trail to lake including lake's edge, 3) ditch, 4) an area of short hydrophytes, and 5) far southwestern edge of lake.

Channel 0- KMW (Female)

Female KMW was first captured and telemetry attached 9 June 2008 near lake's edge. She was observed a total of 15 times throughout the 2008 season. During the 15 times this turtle was observed, it was found moving towards the *Chara* pond. On 4 September 2008, she was rescued from the middle of the *Chara* pond where she was caught in *Chara* spp. Telemetry equipment was removed, in order to avoid a repeat situation, similar to the one which occurred in 2007, with Channel 8. Due to minimal number of sightings, Minimum Convex Polygon (MCP) was not generated for this turtle.

Channel 1 – HJKV (Female)

Female HJKV was first captured and telemetry attached 13 May 2008. She was observed a total of 39 times throughout the 2008 season. Using Minimum Convex Polygon (MCP), total area of utilization was 1.20 hectares (Figure 27). Main activity occurred in area of big trail to lake, a wide trail that led from open area to lake. Both sides of this trail had tall hydrophytes including Red-osier Dogwood, Poison Sumac, *Typha* and Glossy Buckthorn. Main hydrophytes included Sedge, Bulrush and Shrubby Cinquefoil.

This turtle was originally captured in late spring, making her initial spring emergence location unknown. Documented hibernation was near lake's edge. Future studies need to be completed to determine hibernaculum site fidelity.

Channel 2 – KUV (Male)

Male KUV was first captured and telemetry attached 10 June 2008. He was observed a total of 13 times. The turtle was originally located in the ditch and migrated towards the *Chara* pond. On 23 July 2008, he was found dead in the *Chara* pond. Main hydrophytes in the ditch area included *Typha*, Sedge, Bulrush, Shrubby Cinquefoil and Gray Twig Dogwood. Hydrophytes in the *Chara* pond included *Typha* and *Chara* spp. Even though Channel 2 was only observed 13 times, total area of utilization (using Minimum Convex Polygon) was generated. Home range for this turtle was 0.65 hectares (Figure 28).

Channel 3 – HJK (Female)

Female HJK was first captured and telemetry attached 23 May 2008. She was observed a total of 35 times throughout the 2008 season. Using Minimum Convex Polygon (MCP), total area of utilization was 0.71 hectares (Figure 29). Main activity occurred in an area which contained a tall canopy of *Typha* near main road. Hydrophytes included *Typha*, Swamp Rose, Willow, Fern, Sedge, and Shrubby Cinquefoil.

This turtle was originally captured late in spring making her initial spring emergence location unknown. Documented hibernation included a tall canopy of *Typha*, Swamp Rose, Willow, *Sphagnum* spp. and Sedge. Future studies need to be completed to determine hibernaculum site fidelity.

Channel 4 – ABKW (Female)

Female ABKW was first captured and telemetry attached 31 May 2008. She was observed a total of 34 times throughout the 2008 season. Using

Minimum Convex Polygon (MCP), total area of utilization was 0.23 hectares (Figure 30). Main activity occurred in middle open area of fen. Main hydrophytes included Sedge, Shrubby Cinquefoil and *Sphagnum* spp. moss mounds.

This turtle was originally captured in late spring, making her initial spring emergence location unknown. Documented hibernation was in the open area of the fen. Female ABKW was buried in a hibernaculum below a *Sphagnum* spp. moss mound covered with Shrubby Cinquefoil and Sedge. Investigations from last year showed this turtle hibernating in an area in close proximity to its 2008 hibernaculum, indicating hibernaculum site fidelity.

Channel 5 – CHJKLVW (Female)

Female CHJKLVW was first captured and telemetry attached 10 June 2008. She was observed a total of 26 times throughout the 2008 season. Using Minimum Convex Polygon (MCP), total area of utilization was 0.22 hectares (Figure 31). Main activity occurred in an area consisting of a tall canopy of *Typha*, Swamp Rose, Willow, Sedge, Shrubby Cinquefoil and *Sphagnum* spp. moss mounds.

Channel 5 was originally captured in late spring, making her initial spring emergence location unknown. Documented hibernation was in the same area with the tall canopy of *Typha*. Future studies need to be completed to determine hibernaculum site fidelity.

Channel 6 – BDKW (Female)

Female BDKW was first captured and telemetry attached 31 May 2008. She was observed a total of 34 times throughout the 2008 season. Using

Minimum Convex Polygon (MCP), total area of utilization was 0.60 hectares (Figure 32). Main activity occurred in open area in middle of fen, with several sightings occurring in thick areas of Glossy Buckthorn near lake. Main hydrophytes included *Typha*, Willow, Sedge, Shrubby Cinquefoil and *Sphagnum* spp. moss mounds.

Channel 6 was originally captured in late spring, making her initial spring emergence location unknown. Documented hibernation was in middle open area of fen. Future studies need to be completed to determine hibernaculum site fidelity.

Channel 7 – AKX (Female)

Female AKX was captured and telemetry attached on 12 June 2008. She was observed a total of 24 times throughout the 2008 season. Using Minimum Convex Polygon (MCP), total area of utilization was 1.09 hectares (Figure 33). This turtle was initially found in 2008 near the edge of lake and migrated, as the season progressed, toward middle open area of fen. Main hydrophytes in this area included *Typha*, Bulrush, Sedge, Shrubby Cinquefoil and *Sphagnum* spp. moss mounds.

In March 2007, Female AKX was observed leaving a hibernaculum in open area of fen. She was documented entering a hibernaculum in this same area at the end of 2008, suggesting hibernaculum site fidelity.

Channel 8 – FKS (Female)

Female FKS was first captured and telemetry attached 10 June 2008. She was observed a total of 26 times throughout the 2008 season. Using

Minimum Convex Polygon (MCP), total area of utilization was 1.33 hectares (Figure 34). Main activity occurred in lower elevation area which included *Sphagnum* spp., Sedge, and Shrubby Cinquefoil. Later in the season, female FKS migrated to the ditch, where hibernation was documented. Main hydrophytes included *Typha*, Red-osier Dogwood, Sedge, Willow, Bulrush and Shrubby Cinquefoil. Channel 8 was captured in late spring; her initial spring emergence location was unknown. Future studies need to be completed to determine hibernaculum site fidelity.

Channel 9 – BKW (Female)

Female BKW was first captured and telemetry attached 12 June 2008. She was observed a total of 26 times throughout the 2008 season. Using Minimum Convex Polygon (MCP), total area of utilization was 0.16 hectares (Figure 35). Main activity occurred on big trail that led from open area to lake. Both sides of this trail had tall hydrophytes which included Red-osier Dogwood, Poison Sumac, *Typha* and Glossy Buckthorn.

This turtle was originally captured in late spring, making her initial spring emergence location unknown. Female BKW was documented hibernating near entrance of big trail to lake. Future studies need to be completed to determine hibernaculum site fidelity.

Channel 11 – CKU (Female)

Female CKU was first captured and telemetry attached 10 June 2008. She was observed a total of 26 times throughout the 2008 season. Using Minimum Convex Polygon (MCP), total area of utilization was 1.08 hectares

(Figure 36). Main activity occurred in a tall canopy of *Typha,* Swamp Rose, Willow, Sedge, Shrubby Cinquefoil and *Sphagnum* spp. moss mounds.

This turtle was originally captured in late spring, making her initial spring emergence location unknown. Documented hibernation was in same area of a tall canopy which included *Typha*, Swamp Rose, Willow, Sedge, Shrubby Cinquefoil, and *Sphagnum* spp. moss mounds. Future studies need to be completed to determine hibernaculum site fidelity.

Channel 12 – ABCKW (Female)

ABCKW was captured and telemetry attached 11 May 2008. She was observed a total of 37 times throughout the 2008 season. Using Minimum Convex Polygon (MCP), total area of utilization was 0.49 hectares (Figure 37). Main activity occurred in open area in middle of fen. Several sightings occurred near lake, in thick areas of Glossy Buckthorn. Main hydrophytes included *Typha*, Bulrush, Sedge, Shrubby Cinquefoil and *Sphagnum* spp. moss mounds.

Female ABCKW was first observed 29 March 2007 coming out of a hibernaculum in middle open area of fen. On 5 October 2007, ABCK was observed entering a hibernaculum, identified as same spring emergence location. In 2008, ABCKW was documented hibernating in middle open area of fen, suggesting hibernaculum site fidelity.

Channel 13 – DKP (Female)

Female DKP was captured and telemetry attached 11 May 2008. She was observed a total of 39 times throughout the 2008 season. Using

Minimum Convex Polygon (MCP), total area of utilization was 1.08 hectares (Figure 38). Main activity occurred in an area which included a tall canopy of *Typha*, Willow, Swamp Rose, and Glossy Buckthorn. On 3 October 2008, the turtle was found dead in deep water surrounded by a tall canopy of *Typha* and Willow. No visible signs or cause of death were noted.

Channel 14 – BHK (Female)

Female BHK was first observed 24 March 2007 emerging from a hibernaculum in middle open area of fen. She was captured and telemetry attached 11 May 2008. She was observed a total of 35 times throughout the 2008 season. Using Minimum Convex Polygon (MCP), total area of utilization was 0.79 hectares (Figure 39). Main activity occurred in open area in middle of fen, with several sightings occurring near lake in thick areas of Glossy Buckthorn. Main hydrophytes included *Typha*, Bulrush, Sedge, Shrubby Cinquefoil and *Sphagnum* spp. moss mounds.

In September of 2008, the transmitter was removed; preferred hibernaculum was undetermined. Future studies are needed to determine hibernaculum site fidelity.

Channel 15 – ADKO (Female)

Female ADKO was captured and telemetry attached 15 May 2008. She was observed a total of 36 times throughout the 2008 season. Using Minimum Convex Polygon (MCP), total area of utilization was 0.22 hectares (Figure 40). Main activity occurred in an area of Shrubby Cinquefoil, Sedge, Glossy Buckthorn and *Sphagnum* spp. moss mounds. This turtle was

documented in a possible hibernaculum buried deep in mud and water, beneath thick brush and Sedge pile. Future studies need to be generated to determine hibernaculum site fidelity.

Channel 16- ABCK (Male)

Male ABCK was Channel 2 in 2007. He was captured again and telemetry reattached on 16 May 2008. He was observed a total of 30 times throughout the 2008 season. Using Minimum Convex Polygon (MCP), total area of utilization was 1.81 hectares (Figure 41). Main activity occurred in big trail to lake and its edge, and open area in middle of fen. Both sides of this trail had tall hydrophytes which included Red-osier Dogwood, Poison Sumac, *Typha* and Glossy Buckthorn. Main hydrophytes included *Typha*, Red-osier Dogwood, Sedge, Willow, and Shrubby Cinquefoil. This area of the fen was lower in elevation, which held water longer than other areas.

In 2007, ABCK was documented emerging and hibernating in the middle open area with lower elevation. In 2008, he was documented emerging from the same locale as 2007, but hibernated in big trail near lake. Site fidelity was suggested from 2007 data but was not found in 2008.

Channel 17 – IKW (Male)

Male IKW was Channel 10 in 2007. He was recaptured and telemetry reattached 1 June 2008. He was observed a total of 31 times throughout the 2008 season. Using Minimum Convex Polygon (MCP), total area of habitat utilization was 1.33 hectares (Figure 42). Main activity occurred along the lake's

edge and ditch. Main hydrophytes included *Typha*, Red-osier Dogwood, Sedge, Willow, *Sphagnum* spp. moss mounds and Shrubby Cinquefoil.

In 2007, IKW was documented emerging from a hibernaculum in the ditch. He was recorded later in the season returning to ditch to possibly hibernate. In 2008, he was recorded returning again to ditch for possible hibernation. This information suggested hibernaculum site fidelity.

The area of utilization of all turtles with and without transmitters in 2007 and 2008 was 13.30 hectares. Area of preferred habitat was described in Chapter 1. Each individual turtle's home range included nesting locations, areas of aestivation (when applicable), and hibernation.

Radio telemetry was used to track turtles in the 2007 and 2008 season. Radio telemetry turtles were observed more than 1500 times. More females than males had transmitters attached to them with hopes of acquiring a better understanding of nesting activity. This proved to be difficult, with no females being observed nesting.

The home ranges of males were larger than females. The mean home range in 2007 using Minimum Convex Polygon (MCP), for males, was 1.9 hectares and for females 0.5 hectares. The mean home range in 2008 using Minimum Convex Polygon (MCP) for males, was 1.3 hectares and for females 0.7 hectares. Barlow (1999) and Litzgus (1996) found no significant difference in home range sizes between males and females. Haxton and Berrill (1999) found females to have a significantly larger mean home range.

In 2007, the home range of ABCK Channel 2 male was 3.30 hectares. Male ABCK, again, was equipped with telemetry in 2008, this time as Channel 16. His home range was observed to be 1.81 hectares (Figure 43). The 2007 home range was distinctly larger than 2008. It should be noted that in 2007, ABCK's transmitter was a larger model. In 2008, a smaller transmitter was attached to the turtle.

In 2007, Male IKW was equipped with a larger model transmitter (Channel 10). In 2008, the smaller transmitter (Channel 17) was attached. The home range in 2007, with the larger transmitter, was 0.45 hectares. In 2008, the distance covered with the smaller transmitter was 1.33 hectares (Figure 44). The 2008 home range was distinctly larger than the 2007 home range.

Homing and Overlapping Results

Homing behavior is the ability of an animal to return to its home range when removed (Cagle 1944). This was documented on two occasions in this study. In April 2007, female KVX was captured in close proximity to a main road. After attachment of transmitter, the turtle was released in another area of the habitat, out of her home range, to ensure the turtle's safety. In less than 24 hours, the turtle had returned to its home range where originally captured.

The second instance of homing behavior occurred with Channel 8. Female HKV was found tangled in *Chara* pond, 25 June 2007. She was untangled; repairs were made to transmitter (new epoxy) and released out of her home range from *Chara* pond. On 15 July 2007, Channel 8 was tracked and located back at *Chara* pond. This suggested homing behavior.

In 2007, overlapping of female and male home ranges was documented (Figure 45 and Figure 46). The largest male home range (Channel 2) was 3.30 hectares. Overlapping occurred with four transmittered females. The home range of Channel 0 (male) was 1.6 hectares which overlapped with four transmittered females. Channel 10 (male) had the smallest home range with 0.45 hectares. Although home range was small, it overlapped with five transmittered females. Home range of KVW Male (Channel 1) was 2.37 hectares. Although home range for Channel 1 was not as large as Channel 2 (3.30 hectares), what is noteworthy is home range overlapped with all eight transmittered females (Figure 47). This suggested that searching and encountering of females would have been more productive. Although Channel 5 (BKW) and 9 (KLW) were not tracked for the entire 2007 season, their home ranges for the beginning of the season were documented to overlap with Channel 1 and Channel 0. Channel 10 (IKW) overlapped with Channel 5.

The home range of Male ABCK (Channel 16) was 1.81 hectares, and overlapped with seven transmittered females in 2008. Male IKW (Channel 17) home range was 1.3 hectares, and overlapped with seven transmittered female turtles in 2008. Home range for Male KUV (Channel 2) was documented as 0.65 hectares, and overlapped with two transmittered female turtles in 2008 (Figure 48 and Figure 49).

Habitat Discussion

In this study, the area of distribution of all Spotted Turtles with and without transmitters was observed for two years (2007 and 2008). Areas of preferred

habitat were generally those with lower elevation, and standing water or mucky, wet substrate. Shorter, more accessible vegetation was generally preferred. Areas of tall, thick vegetation were avoided. Fen areas that included massive, thick stands of Glossy Buckthorn were generally uninhabited by *C. guttata*. Only Channel 2, appeared to use the deer trails for providing quick and easy movement through the thick Glossy Buckthorn canopy.

Drier areas were generally avoided throughout the fen. It is possible that turtles avoided these areas lacking water for feeding, mating, and risk of desiccation. The prescribed burn area was also avoided, with no turtles found. The conservancy owns only a small portion of the study site, with the remaining portion owned by private land owners. Thus, these controlled burns have proven to only slow the growth of the Glossy Buckthorn, due to dominance and ability of Glossy Buckthorn to encroach from the private land owner's property. This area contained thick stumps of Glossy Buckthorn that were impenetrable for turtles. The burn area was extremely dry, also explaining the absence of turtle sightings.

Throughout the area of preferred habitat, where standing water or muck was available, shorter vegetation was present. This vegetation included *Sphagnum* spp., Sedge tussocks (*Scirpus pungens*), *Typha*, and Shrubby Cinquefoil (*Potentilla fruticosa*).

Small mounds of *Sphagnum* spp. were observed with Sedge and Shrubby Cinquefoil growing on top of these mounds, with a total height up to 61 cm (Figure 50). There appeared to be a positive relationship between this type of vegetation and the survival of the Spotted Turtle. Spotted Turtles hide within this

vegetation, burrowing beneath the *Spaghnum* spp. mounds. With the growth of Sedge and Shrubby Cinquefoil, root systems in the *Sphagnum* spp. mounds and in the mucky substrate were prevalent. These root systems, along with groundwater flow, provided small, below surface tunnels and air pockets. These areas provided a means of movement and protection from predators in addition to locations for aestivation and hibernation, which are further discussed in Chapter 3.

Turtles were found basking on mounds (Figure 51). In 2008, after heavy rainfall, most vegetation in the low areas was underwater, providing fewer basking locations. Shrubby Cinquefoil was observed in some areas above the water line. Channel 4 was located basking near the top branches of this hydrophyte, sharing prime basking space with a Northern Water Snake.

In late summer, with elevated air temperatures, Spotted Turtles needed protection from heat. Crawling under the "umbrella-like" growth of Shrubby Cinquefoil provided protection from the sun for *C. guttata*. Not only was Channel 4 observed using Shrubby Cinquefoil for sun protection, but also for both aestivation and hibernation, by burrowing deep into the mud beneath these *Sphagnum* spp. mounds (Figure 51). Nesting in this type of vegetation was also documented in these mounds covered with the growth of Sedge and Shrubby Cinquefoil.

Sphagnum spp. mounds, Sedge and Shrubby Cinquefoil are important vegetative components needed to provide a successful habitat for *C. guttata*. A positive correlation between this vegetation and turtle movement, predation

avoidance, camouflage, basking, nesting, temperature control, aestivation and hibernation have been found during this study.

Duckweed (family Lemnaceae), is a floating, leaved plant found in most *C. guttata* habitats (Ross and Lovich, 1992). Ross and Lovich (1992) proposed that the carapacial cryptic patterns of *C. guttata* mimicked the color and form of this plant species. Natural selection, with the use of cryptic coloration, helped to protect this species from predation. Although Lemnaceae occurs throughout most of Michigan (Voss, 1972), it was absent from this study site.

Since duckweed was not present in this *C. guttata* site, camouflage may have been accomplished with Shrubby Cinquefoil (*Potentilla fruticosa*), a predominant fen hydrophyte. Shrubby Cinquefoil is a much-branched shrub that is 0.5 –1.0 m tall which when it blooms produces yellow summer flowers (Chadde, 2002). As the flower petals drop, the mud and substrate was covered with yellow polka dots. Distinguishing carapacial patterns of *C. guttata* from that of fallen petals might be difficult for would be predators (Figure 53 and Figure 54). Shrubby Cinquefoil may have provided camouflage for Spotted Turtles and help protect from predation. No previous studies support this finding.

Bloom length of Shrubby Cinquefoil may not be as long as the duckweed season, but may have a positive effect on *C. guttata*. Ross and Lovich (1992) stated that since juveniles and sub-adults of both species are patterned like adults, it is possible that the duckweed-like pattern effectively concealed younger turtles from would-be predators. Shrubby Cinquefoil appeared to provide this same concealment for *C. guttata*.

Whitetail deer trails were prevalent throughout the research site (Figure 55). These trails appeared to facilitate *C. guttata* movement. Constant use by deer created depressions in the hydric soil. Saturation and standing water in these depressions provided "mini highway" systems for Spotted Turtles. These systems allowed for movement with ease through the fen. Movement may have increased food availability by exposing more foraging area and opportunities for mating and better population dispersal. For Spotted Turtles, predation is a major cause of mortality. The opportunity of escape using deer trails may have "hedged the bet" for survival. Also, the submergence of *C. guttata* in water may have provided a scent cover-up, keeping it safe from predator detection.

In times of low precipitation or drought, deer trails are one of the last resorts for the provision of water. Spotted Turtles feed almost entirely underwater (Ernst *et al*, 1994; Harding, 1997). This allows for extended availability of open water allowing continuation of feeding. Also, mating generally occurs underwater (Ernst, 1967). When no water was present in the deer trails, the substrate remained the consistency of mud or muck. This appeared to allow for easier burrowing or movement for *C. guttata*.

Disturbed areas of a habitat are more vulnerable to invasive plant species. In this study site, one invasive plant species of most concern is the Glossy Buckthorn, found in human-impacted areas. Movement through Glossy Buckthorn is difficult for Spotted Turtles. Monitoring and controlling invasive species must be a priority. If habitats are entirely encroached by invasive species, turtle populations will suffer.

One of the most effective techniques for Glossy Buckthorn removal was suggested by Nate Simons, Executive Director and plant ecologist of Blue Heron Ministries in Indiana. Simons (pers. comm.) suggested using a hatchet to create a wound at the base of the plant. Wounds then should be treated using a squirt bottle filled with a strong herbicide. A onetime treatment of the herbicide performed during the winter season was found effective at eradicating Glossy Buckthorn.

Movement Discussion

In 2007, initially, time was spent traversing the entire habitat in search of *C. guttata.* It became apparent there were areas where no turtles were observed. Efforts were reduced in these areas, and focused more on habitat where turtles were observed. Telemetry data supported this decision of not equally covering the habitat. Figure 56 represents a reasonable assessment of turtle utilization of the area.

In this study, Minimum Convex Polygon (MCP) and Kernel Home Range Analysis were used in determining home range and its specific preferred habitat, homing, and overlapping. Cagle (1944) referred to the "homing behavior" of Spotted Turtles after being "forced" from their home areas during spring and late fall, later returning to their home range. He states the reason for these peripheral movements may have been the attempt of mate locating and/or hibernation.

With the use of MCP or Kernel Home Range Analysis, these peripheral movements or "outliers" have been included in this study's home range, and not considered homing behavior. Using spatial analysis, the animal's entire

utilization distribution of an area can be documented, all providing more knowledge needed for *C. guttata* preservation.

Comparing 2007 to 2008 data from the Spotted Turtle Distribution and Analysis of All Transmittered Turtles, the utilization of habitat in 2008 increased by approximately 1.3 hectares, which was not significant (Figure 11 and Figure 13). It is important to note that an additional six turtles were outfitted with telemetry equipment in 2008. This may be one explanation for small, but slightly increased area covered by Spotted Turtles in 2008. Standing water is necessary for Spotted Turtles to forage and mate, both occurring underwater. High amounts of rainfall and standing water were documented in 2008. With the addition of six telemetered turtles in 2008 and additional rainfall, one would surmise that the area of distribution would be substantially larger than 2007. This was not the case. Even with additional water in 2008, turtles did not venture far from 2007 data coordinates. This would suggest that basic needs were met without traveling any additional distance.

Comparing 2007 to 2008 data from the Spotted Turtle Distribution and Analysis of All Nontransmittered Turtles in 2007, showed a slight increase in habitat utilization in 2008 by approximately 0.9 hectares, which was also not significant (Figure 12 and Figure 14).

In 2007, male ABCK equipped with large transmitter (Channel 2), displayed a home range of 3.30 hectares. In 2008, male ABCK was again equipped with a transmitter (Channel 16), this time the small model. Home range recorded was 1.81 hectares.

In 2007, male IKW equipped with large transmitter (Channel 10), displayed a home range of 0.45 hectares. In 2008, Male IKW was again equipped with a transmitter, this time the small model (Channel 17). Home range recorded was 1.33 hectares.

ABCK's home range varied significantly in 2007 compared to 2008. This was also true for male IKW. Both individuals may be demonstrating home range site fidelity. Although ABCK's 2007 home range was larger than 2008, the 2008 home range was embedded within the 2007 home range. Although IKW's 2008 home range was larger than 2007, areas of these two home ranges overlapped. Having results from only two turtles using both small and large transmitters made it difficult to conclude whether or not there was a negative impact for turtles using large versus small transmitters. It is not necessarily true that a large transmitter impeded the turtle.

With the large water volume differences throughout the habitat in 2007 versus 2008, it could be suggested that movement was less confined in 2008. This suggests that with more water present, areas for foraging and mating were more accessible. It is also conceivable with available standing water throughout the site; traveling great distances for activities (such as foraging or mate-seeking) were not needed.

In 2007, home range sizes varied significantly, not only between males and females, but also among same sex individuals. Home ranges of male transmittered turtles varied from 0.45 hectares to 3.30 hectares. During the same season, female home ranges varied from 0.07 hectares to 1.12 hectares.

Each Spotted Turtle appeared to be individualistic, with no set movement pattern, covering the amount of land needed to fulfill requirements for survival. These requirements may have included foraging, mating, nesting, aestivation and hibernation. Ernst's (1970) findings were that home ranges of Spotted Turtles usually did not include a suitable nesting area; therefore, females had to migrate out of their home range. Not true in this study. Home ranges included not only the females' nesting area, but also areas for both male and female foraging, mating, aestivation (if applicable) and hibernation.

When comparing male 2008 home ranges, ABCK (Channel 16) and IKW (Channel 17) were similar in size. Male KUV's (Channel 2) recorded home range, in comparison, was smaller as he was found dead in July 2008. This small sample size makes it difficult to speculate commonalities of 2008 male home ranges.

However, home ranges for females in both 2007 (0.05-1.12 hectares) and 2008 (0.12-1.33 hectares) varied significantly. Because of large female sample size versus small male sample size, it is difficult to make any conclusions about home range without further study and data collection.

One noteworthy observation takes into consideration that habitat utilization by both transmittered males and females was within preferred habitat area previously discussed in detail.

Homing and Overlapping Discussion

During this study, two turtles (female KVX and female HKV) returned to their original home ranges, suggesting homing ability. This supports the findings

of Breder (1927), Nichols (1939), Medsger (1919), Schneck (1886), Grant (1936) and Ernst (1968). Continued research in this area would be useful in determining if more turtles utilize homing ability.

Overlapping of home ranges by both males and females were documented in 2007 and 2008. This suggests there was no territoriality in this study site, which agrees with Ernst's (1970) findings. This may prove to be advantageous to both males and females, keeping the sexes in close proximity to one another for mating purposes. Also, encountering of food may prove to be easier when foraging within close proximity to other individuals. Locating of communal hibernaculae may prove to be a positive result with overlapping of home ranges. A disadvantage of overlapping Spotted Turtle home ranges makes them vulnerable to predators and collectors.

Chapter 2: Population Dynamics and Demography

Introduction

Population breakdown of males, females and juveniles vary in *C. guttata* studies. Breisch (2006) found in her West Virginia study, a population of 21 Spotted Turtles. This population included 38% males, 19% females, and 43% juveniles. In Ontario, Litzgus (1996) found males and females to be consistent at 47% each, and juveniles were 6% of the population of 171 turtles. In 2004, Litzgus and Brooks (1997) reported 118 Spotted Turtles in their Georgian Bay, Ontario site. This population included 42% males, 49% females, and 9% juveniles. In South Carolina, Litzgus and Mousseau (2004) studied a population of 44 Spotted Turtles. This study included a population breakdown of 39% males, 48% females, and 14% juveniles.

In previous studies, the sex ratio for male and female *C. guttata* was found to be of approximately equal distribution, with a 1:1 ratio. These studies included: Litzgus (1996), Litzgus and Brooks (1997), Graham (1995) and Litzgus and Mousseau (2004). Breisch (2006) found a sex ratio of males to females of 2:1.

The occurrence of sexual dimorphism varies with populations. Documented average carapace length for males and females varies depending on the population. Average carapace lengths for males have been recorded as 10.26 cm (Breisch, 2006), 11.69 cm (Litzgus, 1996) and 11.33 cm (Graham, 1995). Average carapace lengths documented for females were 9.92 cm (Breisch, 2006), 11.517 cm (Litzgus, 1996) and 11.02 cm (Graham, 1995).

Gibbons and Lovich (1990) found that on average, female *C. guttata* were larger than males, but Breisch (2006), Litzgus (1996) and Graham (1995) found male dominated sexual size dimorphism.

Ernst (1970) stated that sexual maturity in both sexes of the Spotted Turtle is obtained when the carapace length of the turtle reaches 8.0 cm. Ditmars (1933) stated that *C. guttata* were fully mature when the carapace length reached four inches long (10.16 cm). Sexual maturity was obtained in both sexes between 7 and 14 years of age (Harding, 1997; Ernst, 1975; Graham, 1970).

Population density has been studied in areas of the Spotted Turtles' range. In West Virginia, Breisch (2006) reported a density of 6.8 turtles per hectare. Litzgus and Mousseau (2004) estimated the population density in South Carolina as 0.36 turtles per hectare. Litzgus (1996) reported a population density of 0.62 turtles per hectare in Ontario.

Because Spotted Turtle research is ongoing, mortality rates of populations have been poorly documented. Litzgus (1996) found a relatively "high adult mortality rate" in her Ontario population.

Objectives

The specific objectives contained in this chapter were to determine Spotted Turtle population dynamics and demography. Population size, population breakdown of males, females and juveniles and their morphometric data were specifically researched. Obtaining sex ratios, understanding sexual dimorphism and stability were also investigated.

Methods

Methods were previously described in Chapter 1.

Results

From March 2007 until March 2009, 187 Spotted Turtles were documented in this study site (Table 9). This number represented 72 juveniles (38%), 61 males (33%) and 54 females (29%) (Figure 57). The sex ratio for males and females appeared to be 1:1, further supporting the approximately equal sex distribution ratio stated by Litzgus (1996), Litzgus and Brooks (1998), Graham (1995) and Litzgus and Mousseau (2004).

At the onset of this study 79 juveniles were documented with seven being identified as males. For purposes of sexual identification, Ernst's (1970) defined sexual maturity as carapace length of 8.0 cm and above. However, female characteristics (for example, flat plastron and shorter tail) are juvenile characteristics and male characteristics (concave plastron and longer tail) are obtained during the maturation process. Current data showed sexual maturity of these seven males were obtained before reaching this 8.0 cm carapacial length. Thus, these seven juvenile males were documented as adult males, lowering the number of juveniles to 72.

Annuli were counted to determine the minimum age of the Spotted Turtle (Litzgus and Brooks, 1998). Older adult turtles would show worn or smooth annuli and cessation of annuli growth; making it difficult to calculate their exact age. Therefore, the age of older adults may be the minimum age, not the maximum. The minimum possible age of the oldest turtle documented at the site

was a 22 year old female. The lowest mean minimum age of an adult Spotted Turtle was 9.2 years in this site.

Mean morphometric measurements were documented for most Spotted Turtles observed in the study site. If strictly conforming to Ernst's (1970) definition of sexual maturity (adult having the 8 cm or above carapacial length), the seven turtles documented as males would have been juveniles. In this study, turtles with male characteristics (concave plastron and longer tails) were recorded as males, making the average female larger than the average male. This supports the findings of Gibbons and Lovich (1990) which show female Spotted Turtles to be larger than male Spotted Turtles. The mean carapace length for male Spotted Turtles was 8.9 cm, with the largest male having a carapace length of 10.9 cm (range 6.5-10.9 cm). The mean carapace length for females was 9.0 cm, with the largest female having a carapace length of 10.3 cm (range 8.0 – 10.3 cm). Breisch (2006), Litzgus (1996) and Graham (1995) found males to have a larger average carapace length than females.

The mean carapace width for males was 6.4 cm (range 5.1 – 7.7 cm), with females having a mean of 6.6 cm (range 5.9 – 7.8 cm). Males recorded a mean plastron width of 7.5 cm (range 5.7 – 8.6 cm) while a mean of 8.0 cm was recorded for females (range 7.2 – 8.5 cm). Mean height in males and females was 3.3 cm (range 2.6 – 3.7 cm) and 3.7 cm (range 3.0 – 4.1 cm), respectively. Males recorded an average weight of 0.10 kg (range 0.05 – 0.16 kg). Females recorded an average weight of 0.11 kg (range 0.08 – 0.14 kg).

This study took place in a fen with an approximate size of 30 hectares. Representative sampling of the entire fen was accomplished at the onset of the study. It was noted earlier in Chapter 1, that the outlying areas of the fen were void of turtles, and as stated earlier, continuing to traverse through these areas was not time well spent. Population density was based on 30 hectares, even though the area of actual turtle concentration was less. The turtle population density was calculated at approximately 6.2 turtles per hectare.

During the 2007 and 2008 research, a total of 10 turtles (with and without transmitters) were found dead due to various reasons. Two Spotted Turtles died by becoming entangled in the *Chara* Pond. One turtle found dead in the *Chara* Pond had been predated upon by a probable Muskrat. Two turtles were found dead due to unknown causes. Two empty, fully intact shells were found during the two year study, along with shell fragments (which may have been very old) of three other turtles. The mortality rate of this study site was calculated to be 0.05%.

Discussion

Females were larger than males in this study site. The results of this study support findings of Gibbons and Lovich (1990). It should be noted that turtles in this Michigan study site appear to be smaller overall than findings of other Spotted Turtle researchers. One explanation may be turtles are maturing at an earlier age than in other sites, therefore, not reaching their maximum size capability.

It was recorded that males and females have a similar average weight. Although, the mean average was approximately equal, one must take into consideration gravid female's weight fluctuation due to egg storage. If females were recorded prior to ovipositioning, their weights would be higher than after they have nested.

The population density calculated from this study was similar to findings found by Breisch (2006) but was larger than those recorded by Litzgus and Mousseau (2004).

With a high hatchling and juvenile rate of 38%, and overall adult mortality rate of 0.05%, the mortality rate of *C. guttata* appeared to be low. This study was conducted for two years. More long term data is needed to determine if this mortality rate remains consistent. Considering only ten dead animals were found and the large percentage of juveniles and hatchlings sighted, *C. guttata* appeared to be a stable or growing population in this study site.

Chapter 3: Seasonal Activities

Introduction

Aestivation

Ernst *et al* (1994) noted activity levels reached a peak when mean monthly air temperatures were between 13.1°C and 18.0°C (mean 15.5°C); at least two months before the highest mean air temperature month. Activity then declined when mean monthly air temperature was between 17.8°C and 22.3°C (mean 20.3°C), and then approached or reached a minimum level during the month with highest mean air temperature. This decline in activity was referred to as aestivation.

Perillo (1997) defined aestivation as a period of dormancy punctuated by periods of brief activity. Spotted turtles were documented to be able to survive months in this dormant state, which is considered a summer equivalent of hibernation (Carroll, 1991). It had been suggested that "summer dormancy" may be a more appropriate term than aestivation to describe the behavior of northern populations of Spotted Turtles when they become inactive in the late summer (COSEWIC, 2004).

Litzgus (1996) stated that aestivation is like a summer version of hibernation, in theory, to avoid increased temperatures rather than decreased temperatures. This behavior typically involved burying under leaf litter and pine needles in the shade of junipers or rock outcroppings or in forests. Populations of Spotted Turtles that live at more southern latitudes aestivated to avoid prolonged high summer temperatures. However, in northern populations, the

advantage of this behavior was less obvious. Litzgus (1996) found that turtles were not decreasing their body temperature by aestivating; therefore, they were not using aestivation to avoid increased temperatures. This behavior by Spotted Turtles in Georgian Bay, Ontario, suggested it may be carried over from a time when it served a completely different function.

In Pennsylvania, Ernst (1976) found that Spotted Turtles become inactive when water temperatures reached 32°C, seeking out cool refuges such as muskrat burrows or mud at the bottom of pools of running water. Most turtles remained inactive until the following March but some emerged during the cooler days of July, August and the fall, and the warmer days of winter.

Ernst (1982) stated *C. guttata* thermoregulate in their northern range by basking during cooler weather and by burrowing into the soft bottom of a waterway or by entering muskrat burrows and lodges to avoid extreme hot (aestivation) and cold conditions (hibernation). Water and substrate covering *C. guttata* formed an effective thermal shell which provided adequate insulation for avoidance of extreme temperatures both hot and cold. Muskrat burrows and lodges contained underwater entrances. In the summer, the evaporation of the water in these burrows and lodges provided a cooler microhabitat and high humidity that helped prevent moisture loss.

In Maryland, Ward *et al* (1976) stated aestivation sites varied depending on the location of the range of the Spotted Turtle. Aestivation sites included moist areas under dead and loosely matted reeds, grasses and ferns. He also documented turtles in early successional paludal woods. This form of

microhabitat was characterized by heavy organic soils, shallow water, and an overstory of dense leaves, grasses and ferns. Indentations in the substrate, referred to as "forms" used by *C. guttata* are filled with water so that only the top of the carapace are visible. Haxton and Berrill (2001) noted in central Ontario, turtles were found in forms similar to those discussed by Ward *et al* (1976). They found that the temperature of the turtles was no different than the water temperature, indicating avoidance of warm air temperatures may not be the primary objective of aestivation as suggested by Ernst (1976, 1982).

Other aestivation sites documented are muskrat burrows in banks of streams and lodges (Ernst, 1982), predominantly bogs (Haxton and Berrill, 1999), upland habitats and the dried edge of a vernal pool (Perillo, 1997), and terrestrial sites (Litzgus and Brooks, 2000; Ultsch, 2006; Barlow, 1999). Perillo (1997), whose Spotted Turtle research was conducted in Connecticut, noted dry summers with little rainfall, may stimulate turtles to aestivate upland for longer amounts of time than during a summer with more normal precipitation.

Time spent in aestivation varied depending on site location. In Massachusetts, Graham (1995) found aestivation to last from one to three weeks. In Indiana, Barlow (1999) found turtles aestivating from two days to two weeks, with some turtles not aestivating at all.

Hibernation

Ultsch (2006) found that most species of turtles faced harsh winters causing them to hibernate for extended lengths of time that may exceed over half of their lives (more than six months per year). The ability or lack of it, to

overwinter in hypoxic/anoxic conditions places limitations on where aquatic turtles can overwinter, and perhaps on where they can occur at all. Litzgus *et al* (1999) and Lewis and Ritzenthaler (1997) documented turtles entering a hibernaculum as early as mid-September and as late as April if ice had not sealed the entrance to the hibernaculum. Lewis and Ritzenthaler (1997) found that turtle departure positively correlated to the warming of water in hibernaculum and melting of ice in the hole.

Spotted Turtle hibernaculae were typically aquatic beneath a layer of ice and mud (Ward *et al*, 1976; Ultsch, 2006). These sites never froze completely, but were shallow enough to thaw quickly in spring (Ernst, 1982). The majority of hibernation took place in wetlands and small pools in various microhabitats; one common place being beneath hummocks in swamps (Ward *et al*, 1976; Graham, 1995; Perillo, 1997; Joyal *et al*, 2001; Litzgus *et al*, 1999; Milan and Melvin, 2001). Hibernaculae have been known to contain a saturated, organic muck layer (Lewis and Ritzenthaler, 1997).

Communal aggregations have been documented in central Ontario (Haxton and Berrill, 1999), Ohio (Lewis and Ritzenthaler, 1997), Pennsylvania (Ernst, 1967), Connecticut (Perillo, 1997) and northern Ontario (Litzgus *et al*, 1999). Small aggregations of Spotted Turtles were common, but groups have been documented to contain as many as 34 turtles (Lewis and Ritzenthaler, 1997). Hibernaculae near its northern limits in Ontario contained single turtles up to nine turtles. Litzgus *et al* (1999) noted that hibernaculae were of two types both in swamps: elevated *Sphagnum* spp. moss hummocks reinforced by roots

and stems of vegetation, including trees and shrubs; rock caverns near shore with a measured water depth of 30-40 cm.

Lewis and Ritzenthaler (1997) determined hibernaculae that contained three or less turtles were simple vertical holes that were approximately seven cm in diameter and no deeper than 70 cm. Larger hibernaculae were 15 by 20 cm at the surface entrance and contained some horizontal passages in addition to the primary vertical hole. Further, Lewis and Ritzenthaler (1997) found no sex biased hibernaculum use.

Although large aggregations present obvious vulnerabilities to predators and collectors, benefits were also found. Communal hibernation provided reproductive advantages by putting otherwise solitary turtles in close proximity during early spring for mating (Ernst, 1970; Lewis and Ritzenthaler, 1997; Perillo, 1997). Barlow (1999) found aggregations may have made it easier for males to find females and that these overwintering locations may have had some historical value of *C. guttata* when located near favorite spring breeding locations. Communal hibernation may have improved fitness of individuals by synchronizing emergence (Gregory, 1982; Ultsch, 1989).

Hibernaculum site fidelity was observed in Spotted Turtles. Research conducted in Central Ontario (Haxton and Berrill, 1999), Ohio (Lewis and Ritzenthaler, 1997), Northern Ontario (Litzgus *et al*, 1999), and Connecticut (Perillo, 1997), showed that this turtle species displayed high fidelity to hibernaculae.

Objectives

The objectives of this study were to determine seasonal activities of the Spotted Turtle which included aestivation (determining if it does occur, and if so, when, how long, habitat temperature, and type of habitat preferred). Hibernation of Spotted Turtles was also studied to determine the preferred hibernaculae. Also researched was whether or not the hibernaculae were communal, substrate properties, location, hibernaculae temperature, and possible site fidelity.

Methods

Methods were previously described in Chapter 1.

Aestivation Results and Discussion

Aestivation is a period of brief inactivity. In this fen, aestivation coincided with high air temperatures. In 2007, turtles were tracked throughout late summer, with rising air temperatures causing the land to warm and turtles to become inactive. The majority of telemetered turtles did aestivate. Length and period during which aestivation occurred varied between 4 and 26 days, with some turtles coming out of aestivation for a short period of time and then returning again to inactivity. Aestivation in this southwestern fen occurred within the months of June, July and August. Nine turtles aestivated, with six aestivating twice. Aestivation coincided with the drier parts of summer. Field data entries in mid June and July showed at these aestivation times, the substrate consisted of "dried mud" with only traces of precipitation recorded.

In 2007, turtles aestivated in areas which corresponded with areas shown in Figure 58. Areas included the open middle fen area, ditch, outlet, area of short

height hydrophytes, and a more open area just north of ditch. These areas were lower in elevation, with water levels just beneath the substrate, even during drier periods.

With water absent, mud temperatures were recorded. In June and July of 2007, seven turtles aestivated (some more than once) with mud temperatures ranging from 15.5°C to 29.0°C. Air temperatures ranged from 17.9°C to 32.4°C. Two turtles aestivated in August when the mud temperatures were recorded between 19°C and 26°C and the air temperatures recorded were between 21.4°C and 32°C.

There was more precipitation in 2008 than 2007. Seven turtles aestivated, most occurring late July thru early September. All turtles aestivated once during this season, except for one turtle (aestivation occurred twice). The majority of turtles aestivated for nine days when the mud temperature was 20.5°C to 29.1°C and the air temperature was 24.5°C to 37°C. Two turtles aestivated for a period of 20 days during which the mud temperature was 21.6°C to 27°C, air temperature was 23.5°C to 34.5°C, and water temperature (in one location) was 31°C.

Turtle aestivation locations in 2008 were found in areas of habitat where large turtle aggregations were located, as shown in Figure 59. These areas included the open middle fen area, ditch, and big trail to lake including the lake's edge and the area of short height hydrophytes. These areas were lower in elevation and contained water even throughout the drier months.

In both 2007 and 2008, turtles aestivated by burying themselves in mud covered with a variety of hydrophytes. These hydrophytes included Sedge, Shrubby Cinquefoil, *Typha*, Bulrush, Red-osier Dogwood, Willow and Fern.

Hibernation Results and Discussion

Radio telemetry was used to track fall season movement and location of Spotted Turtles. Locations were identified and documented as possible hibernaculae. Turtles were tracked late in summer and early autumn (September and October). Two areas were found to have a heavier aggregation which appeared to be hibernaculae locations. In spring (March), larger numbers of *C. guttata* were observed and captured in these same areas, suggesting emergence from close-by hibernaculae.

With less recorded precipitation during 2007, there was no standing water throughout the site; water table present just below substrate surface. At this time, turtles were no longer visible at surface and radio telemetry was used to locate turtles.

On 25 September 2007, using radio telemetry to locate transmittered female Channel 11, a possible hibernaculum was identified in a lower elevation fen area. The hydrophytes in this area included *Typha*, Sedge (*Scirpus* pungens) and Bulrush (*Scirpus acutus*). While attempting to locate Channel 11 (female KV) by its frequency, a hole, approximately 15 cm deep, was located in the substrate containing no water, only damp mud. Reaching into the hole, four turtles were stacked, one below the other, all in horizontal positions. Channel 11 was found with two females (BDKW and HKP) and a male (AJKX) (Figure 60).

Another hole, similar to the one which contained the four turtles, was observed nearby. Reaching approximately 13 cm into this damp, muddy hole, three turtles were collected, each on top of the other. All three Spotted Turtles were male (CDKV, FJKS, CDKVW). With the use of telemetry, Channel 2 (male ABCK) was found only one foot from the hole where the three males were found. With further investigation, female CKX was located nearby buried in mud, *Spaghnum* spp., and Sedge (Figure 60).

A week later, 2 October 2007, while attempting to locate Channel 11 (female KV), another possible hibernaculum was sighted. By locating Channel 11 using its radio telemetry frequency, a hole in the substrate was observed. Reaching into the hole, four turtles were collected; three females (HKP, CKX, KV Channel 11) and 1 male (AJKX). Turtles were found stacked on top of each other ranging from 13-33 cm downward. The hole contained both mud and water (Figure 61). AJKX, KV, and HKP had previously been located (25 September 2007) in a different hibernaculum locale.

On 12 October 2007, a possible hibernaculum was reinvestigated known to contain turtles a week prior. Standing over the entrance to the possible hibernaculum, no turtles were visible from the surface, but the small 7.62 cm hole was observed. Reaching down into the vertical hole, filled with water, mud and muck, a non-transmittered Spotted Turtle was located. Continuing to reach down into this hole another conspecific turtle, a little deeper horizontally to the first turtle was retrieved. Small tunnels, approximately three to six cm in size, were filled with water and were intertwined with roots of Sedge spp., *Typha* and other

hydrophytes. It is believed that these tunnels allowed easy movement for Spotted Turtles from surface predators. Within this hole three non-transmittered turtles were identified. The first turtle removed, a male (BCKV), was located approximately nine cm from the ground level and had a recorded carapace shell temperature of 11.8˚C. Reaching back into the hole, a second male turtle (IKP) was located just below the first turtle. The shell temperature was IKP was recorded at 12.3˚C. Reaching again into the hole, a third turtle, a female (KUW) was located slightly lower in the hole and horizontally to the right approximately 15 cm from the original vertical hole. The third turtle had a shell temperature of 13.3 ˚C (Figure 62).

On 16 October 2007, another possible hibernaculum was found in an area where Sandbar Willow was the main hydrophyte. While traversing through the site, a male Spotted Turtle (CDKV) was observed with only its carapace showing. Upon further observation, it was determined that the male turtle was located over a hole of possible hibernaculum. With further investigation, it was determined that three additional turtles were located stacked below the substrate in water and mud in a hole approximately 25 cm deep.

The carapace shell temperature for the turtle located on top of the substrate was 14.5˚C. Downward in the hole, a juvenile (KOQ) was collected with shell temperature of 14.5˚C. Beneath the juvenile, a juvenile (IKNP) was documented with a shell temperature of 15.5˚C. Lastly, another juvenile (AKP) was documented with a shell temperature of 16.7˚C (Figure 63).

As turtles were collected deeper in the possible hibernaculum, carapace shell temperatures increased. Although, Lewis and Ritzenthaler (1997) found no evidence that communal hibernaculae serve any thermal function, this study suggests the opposite. Evidence from this study implies that the deeper into the hibernaculum a turtle is found, the warmer the body temperature.

These possible hibernaculae, which were in lower elevation areas of the fen, were found with both single turtles and aggregations. Most hibernaculae ranged from eight to 35 cm in depth with some containing small tunnels that formed interconnected networks under the substrate. These tunnels were too small in size to be considered muskrat burrows. A possible explanation for the cause of these underwater passages may be the steady flow of groundwater throughout the root systems.

Another area of heavy Spotted Turtle concentration known as the "ditch" was to the south of the fen, running east and west. It handled overflow from the wetland and a nearby road. The ditch was generally filled with approximately 40-60 cm of water and hydrophytes which included *Typha*, Red-osier Dogwood, Sedge and Bulrush.

In spring of 2008, a heavy concentration of turtle emergence was observed from the ditch. On 3 April 2008, four turtles (CKW-juvenile, KLN-male, AKM-female, DKO- male) emerged and captured from the ditch and GPS coordinates were recorded. Three days later, 6 April 2008, four different individual turtles (KMW-female, KUV-male, KLM-male, and AK-male) were observed and documented close to this same location. Turtles were found

emerging periodically during the next several weeks in this same locale. These observations suggest the ditch was a heavily populated hibernaculum.

Spotted Turtles selected areas of the wetland for hibernation that are generally underwater or with the water table at ground level. Turtles preferred areas that had the deepest concentrations of water in the fen. Both possible hibernaculae were located within these areas.

In spring, when *C. guttata* emerged from hibernation in these two known hibernaculae, both sites were inundated with water from 40 to 60 cm deep. Shortly after emergence, turtles were observed moving from deep to shallow water. The deep water temperature ranged from 6.0˚C to 8.5˚C while the temperature in the shallow water ranged from 14.0˚C to 18.5˚C. The observation of Spotted Turtles migrating to shallower water confirms that *C. guttata*, being ectothermic, may be moving to a warmer habitat to raise metabolic rates.

In late summer and early fall of 2008 (September and October), with heavy amounts of rainfall, 2-40 cm of standing water covered the fen. Water levels in the first known hibernaculae (the area in the middle of the fen) were approximately 40 cm. Although tracking the transmittered turtles to these areas was no problem, locating holes and reaching into the substrate was a difficult undertaking. With deep water, locating turtle aggregations proved difficult.

When radio telemetry was conducted, and turtles located, these potential hibernaculae contained some of the same and new conspecifics than previously documented, including different combinations of males, females and juveniles.

This infers that turtles may be "staging" or trying to locate the most viable locations for future courtship which may yield genetic diversity.

On 12 January 2007, four Spotted Turtles were observed during a "January thaw" in the ditch. Two individual male turtles were observed, as well as a copulating pair (Lutz, 2008). This observation coincides with Ernst's (1970) suggestion that communal hibernaculae serve a purpose for turtles in their relationship to mating preference.

Males, females and juveniles were all found within the same hibernaculum, suggesting that hibernaculae are not sex biased. This evidence aligns with a previous study by Lewis and Ritzenthaler (1997).

Previous suggestions that the two main areas discussed (ditch and open middle area of fen) were hibernaculae areas for the Spotted Turtle were further supported by evidence shown using Arc View© and Arc Map©. Figure 56 (Kernel Home Range Analysis) also substantiates these findings. Not only were transmittered turtles found to hibernate in these two main regions, but also non-transmittered turtles were recorded to hibernate there, as well. This evidence further supports the findings that Spotted Turtles do communally hibernate.

Site fidelity of a hibernaculum was documented in 2007 and 2008 in the ditch and open middle area of fen. Eight of 23 (35%) transmittered turtles were documented having site fidelity. It should be noted that 29 turtles were originally equipped with transmitters, with two transmitters malfunctioning, and four turtles found dead. Further research is needed to determine whether the other 15 turtles show site fidelity.

With the telemetry equipment used in this study, hibernaculae temperatures were obtained (refer to Methods). A low winter hibernaculum temperature of 1.3°C was reported in the beginning of March 2008. In Ohio, Lewis and Ritzenthaler (1997) recorded low winter hibernaculae temperatures of 2.21 and 2.73°C. The findings of this study are in close proximity to the Ohio findings.

APPENDIX

Table 1. Specific habitat preferences documented throughout Spotted Turtle range.

Habitat Type	Location	Source
Forested Swamps	Maine	Joyal et al 2001
Boreal Fen	Ohio	Lovich 1989
Terrestrial Sites	Ontario	Haxton and Berrill 2001
	Florida	Berry 1978
Rock Outcrops	Ontario	Haxton and Berrill 2001
	Ontario	Litzgus et al 1999
Low Acidic Swamps	Ontario	Litzgus et al 1999
Small Bodies of Water	throughout range	Carr 1952
Salt Marshes/Brackish	Illinois	Cahn 1937
	Maryland	Nemuras 1966
Meandering Brooks	throughout range	Carr 1952
Little Bog Holes	throughout range	Carr 1952
Ditches	throughout range	Conant and Collins 1998
	Indiana	Minton 1972
Vernal Pools	Connecticut	Perillo 1997
	Massachusetts	Fowle 2001
	Maine	Joyal et al 2001
Early Successional Fields	Connecticut	Perillo 1997
Upland Fields	Connecticut	Perillo 1997
	Massachusetts	Fowle 2001
Older, more established woodlands	Connecticut	Perillo 1997
Cypress swamps	Florida	Barnwell et al 1997
Freshwater marshes	Florida	Barnwell et al 1997
	Pennsylvania	Ernst 1976
Mixed Hardwood Wetland	Florida	Barnwell et al 1997
Cypress Tupelo Ponds	South Carolina	Lovich 1990
	South Carolina	Litzgus and Mousseau 2004
Ephemeral Marshes	South Carolina	Lovich 1990
Upland Pine-Hardwood Forest	South Carolina	Lovich 1990
	South Carolina	Litzgus and Mousseau 2004
Flooded Mowed Fields	Maryland	Ward et al 1976
	Maine	Joyal et al 2001
	Indiana	Minton 1972
Woodland/Marsh Ecotones	Maryland	Ward et al 1976
Emergent Marshes	Massachusetts	Fowle 2001
Unpolluted Bodies of Water	Massachusetts	Graham 1995
	throughout range	Harding 1997

Table 2. Non-woody plants located in study site.

Common Name	Scientific Name
Small-flowered Gerardia	*Agalinis tenuifolia*
Bugle	*Ajuga reptans*
Common Burdock	*Arctium minus*
Mugwort	*Artemisia vulgaris*
Swamp Milkweed	*Asclepias incarnate*
Northern Bog Aster	*Aster borealis*
Bushy Aster	*Aster dumosus*
New England Aster	*Aster novae-angliae*
Frost Aster	*Aster pilosus*
Willow Aster	*Aster praealtus*
Tickseed Sunflower	*Bidens coronatus*
False Nettle	*Boehmeria cylindrical*
Downy Chess	*Bromus tectorum*
Marsh Bellflower	*Campanula aparinoides*
Chicory	*Cichorium intybus*
Canada Thistle	*Cirsium arvense*
Swamp Thistle	*Cirsium muticum*
Twig Rush	*Cladium mariscoides*
Queen Anne's Lace	*Daucus carota*
Water Willow	*Decodon verticillatus*
Common Wood Fern	*Dryopteris spinulosa*
Daisy Fleabane	*Erigeron annuus*
Spotted Joe Pye Weed	*Eupatorium maculatum*
Boneset	*Eupatorium perfoliatum*
Lesser Fringed Gentian	*Gentiana procera*
White Avens	*Geum canadense*
Ground Ivy	*Glechoma hederaceae*
Spotted Touch-me-not	*Impatiens capensis*
Blue Flag Iris	*Iris versicolor*
Canadian Rush	*Juncus Canadensis*
Torrey's Rush	*Juncus torreyi*
Rice Cutgrass	*Leersia oryzoides*
Marsh Blazing Star	*Liatris spicata*
Kalm's Lobelia	*Lobelia kalmii*
Northern water Horehound	*Lycopus uniflorus*
Tufted Loosestrife	*Lysimachia thrysiflora*
Purple Loosestrife	*Lythrum salicaria*
Sweet-scented Waterlily	*Nymphaea odorata*
Common Evening Primrose	*Oenothera biennis*
Cowbane	*Oxypolis rigidior*
Panic Grass	*Panicum flexile*
Switch Grass	*Panicum virgatum*
Swamp-Betony	*Pedicularis lanceolata*
Timothy	*Phleum pretense*
Water Smartweed	*Polygonum amphibium*

Table 2 (cont'd).

Common Name	Scientific Name
Water Pepper	*Polygonum hydropiper*
Meadow Spikemoss	*Selaginella apoda*
Canada Goldenrod	*Solidago Canadensis*
Ohio Goldenrod	*Solidago ohiensis*
Swamp Goldenrod	*Solidago patula*
Indian Grass	*Sorghastrum nutans*
Peat Moss	*Sphagnum spp.*
Marsh Fern	*Thelypteris palustris*
Marsh St. Johnswort	*Triadenum virginicum*
Cattail	*Typha angustifolia*
Cattail	*Typha latifolia*
Small Purple Bladderwort	*Utricularia resupinata*
Blue Vervain	*Verbena hastate*
Rattlesnake Root	*Prenanthes racemosa*
Black-eyed Susan	*Rudbeckia hirta*
Bouncing Bet	*Saponaria officinalis*
Hardstem Bulrush	*Scirpus acutus*
Common Threesquare	*Scirpus pungens*

Table 3. Woody plants located in study site.

Common Name	Scientific Name
Box Elder	*Acer negundo*
Red Maple	*Acer rubrum*
Sugar Maple	*Acer saccharum*
Shad spp.	*Amelanchier spp.*
Bog Birch	*Betula pumila*
Oriental Bittersweet	*Celastrus orbiculata*
Northern Swamp Dogwood	*Cornus racemosa*
Red-Osier Dogwood	*Cornus stolonifera*
White Ash	*Fraxinus Americana*
Winterberry	*Ilex verticillata*
Honeysuckle spp.	*Lonicera spp.*
Virginia Creeper	*Parthenocissus quinquefolia*
Cottonwood	*Populus deltoids*
Bigtooth Aspen	*Populus grandidentata*
Trembling Aspen	*Populus tremuloides*
Shrubby Cinquefoil	*Potentilla fruticosa*
Wild Black Cherry	*Prunus serotina*
Red Oak	*Quercus rubra*
Black Oak	*Quercus velutina*
Alder-leaf Buckthorn	*Rhamnus alnifolia*
Glossy Buckthorn	*Rhamnus frangula*
Black Locust	*Robinia pseudoacacia*
Carolina Rose	*Rosa Carolina*
Multiflora Rose	*Rosa multiflora*
Swamp Rose	*Rosa palustris*
Common Blackberry	*Rubus allegheniensis*
Black Raspberry	*Rubus occidentalis*
Dewberry	*Rubus spp.*
Blue-leaved Willow	*Salix myricoides*
Willow spp.	*Salix spp.*
Bittersweet Nightshade	*Solanum dulcamara*
Poison Ivy	*Toxicodendron radicans*
Poison Sumac	*Toxicodendron vernex*
Elm spp.	*Ulmus spp.*
Grape	*Vitis riparia*

Table 4. Wildlife documented in study site.

Common Name	Scientific Name
Meadow Vole	*Microtus pennsylvanicus*
White-Tailed Deer	*Odocoileus virginianus*
Muskrat	*Ondatra zibethica*
Eastern Cottontail Rabbit	*Sylvilagus floridanus*
Coyote	*Canis latrans*
Red Fox	*Vulpes fulva*
Raccoon	*Procyon lotor*

Table 5. Amphibians and reptiles documented in study site.

Common Name	Scientific Name
Western Chorus Frog	*Pseudacris triseriata triseriata*
Spring Peeper	*Pseudacris crucifer*
Wood Frog	*Rana sylvatica*
Brown Snake	*Storeria dekayi*
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*
Northern Water Snake	*Nerodia sipedon sipedon*
Northern Ribbon Snake	*Thamnophis sauritus*
Midland Painted Turtle	*Chrysemys picta*
Queen Snake	*Regina septemvittata*
American Toad	*Bufo americanus*
Green Frog	*Rana clamitans*
Bullfrog	*Rana catesbeiana*
Common Snapping Turtle	*Chelydra serpentine*
Spiny Softshell	*Apalone spinifera*
Eastern Hog-nosed Snake	*Heterodon platirhinos*
Eastern Box Turtle	*Terrapene carolina carolina*
Eastern Grey Treefrog	*Hyla versicolor*
Common Musk Turtle	*Sternotherus odoratus*
Blanding's Turtle	*Emydoidea blandingii*
Spotted Turtle	*Clemmys guttata*
Eastern Massasauga Rattlesnake	*Sistrurus catenatus catenatus*

Table 6. Bird species present in study site.

Common Name	Scientific Name
Red-winged Blackbird	*Agelaius phoeniceus*
Swamp Sparrow	*Melospiza Georgiana*
Song Sparrow	*Melospiza melodia*
American Goldfinch	*Carduelis tristis*
America Robin	*Turdus migratorius*
Blue Jay	*Cyanocitta cristata*
Sandhill Crane	*Grus Canadensis*
Mute Swan	*Cygnus olor*
Canada Goose	*Branta Canadensis*
Common Snipe	*Capella gallinago*
Common Grackle	*Quiscalus quiscula*
American Crow	*Corvis brachyrhynchos*
Turkey Vulture	*Cathartes aura*
Eastern Phoebe	*Sayornis phoebe*
Wood Duck	*Aix sponsa*
Mallard Duck	*Anas platyrhynchos*
Mourning Dove	*Zenaida macroura*
Hairy Woodpecker	*Picoides villosus*
Downy Woodpecker	*Picoides pubescens*
Belted Kingfisher	*Megaceryle alcyon*
Tree Swallow	*Tachycineta bicolor*
American Woodcock	*Philohela minor*
Double-Crested Cormorant	*Phalacrocorax auritus*
Carolina Wren	*Thryothorus ludovicianus*
Tufted Titmouse	*Parus bicolor*
Black-capped Chickadee	*Parus atricapillus*
Northern Cardinal	*Cardinalis cardinalis*
Ring-billed Gull	*Larus delawarensis*
Yellow Warbler	*Dendroica petechia*
Common Yellowthroat Warbler	*Geothlypis trichas*
Yellow-rumped Warbler	*Dendroica coronata*
Palm Warbler	*Dendroica palmarum*
Willow Flycatcher	*Empidonax traillii*
Red-tailed Hawk	*Buteo jamaicensis*
Virginia Rail	*Rallus limicola*
Eastern Bluebird	*Sialia sialis*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Warbling Vireo	*Vireo gilvus*
Eastern Wood Pewee	*Contopus virens*
Baltimore Oriole	*Icterus galbula*
Eastern Kingbird	*Tyrannus tyrannus*
Cedar Waxwing	*Bombycilla cedrorum*
Rough-winged Swallow	*Stelgidopteryx ruficollis*
Spotted Sandpiper	*Actitis macularia*
Gray Catbird	*Dumetella carolinensis*
Black-billed Cuckoo	*Coccyzus erythropthalmus*
Green Heron	*Butorides striatus*

Table 6 (cont'd).

Common Name	Scientific Name
Yellow-throated Vireo	*Vireo flavifrons*
Great Crested Flycatcher	*Myiarchus crinitus*
White Throated Sparrow	*Zonotrichia albicollis*
Scarlet Tanager	*Piranga olivacea*
Brown-headed Cowbird	*Molothrus ater*
Ruby-throated Hummingbird	*Archilochus colubris*
Wood Thrush	*Hylocichla mustelina*
Cooper's Hawk	*Accipiter cooperii*
Great Blue Heron	*Ardea herodias*
Broad-winged Hawk	*Buteo playpterus*
Blue Gray Gnatcatcher	*Polioptila caerulea*
Eastern Meadowlark	*Sturnella magna*
Osprey	*Pandion haliaetus*
Northern Waterthrush	*Seiurus noveboracensis*
Veery	*Catharus fuscescens*

Table 7. Example of Microsoft Excel individual turtle data worksheet.

Turtle ID:	KV								
Sex (M/F):	F								
Age (yrs):	20								
Adult/Juvenile (A/J):	A								
Carapace Length (cm):	9.078 (3-22-07)	9.158 (9-25-07)		9.158 (3-26-08)					
Carapace Width (cm):	6.861 (3-22-07)	6.869 (9-25-07)		6.869 (3-26-08)					
Plastron Length (cm):	8.222 (3-22-07)	8.222 (9-25-07)		8.222 (3-26-08)					
Height (cm):	3.640 (5-29-07)	3.640 (9-25-07)		3.640 (3-26-08)					
Comments:	Previously marked V								
	Ch. 11; transmitter #123316; Freq. 164.339 (164.340) (2007)								
Date	**Time**	**Location**	**Weight (Kg)**	**Water Temp °C**	**Air Temp °C**	**Shell Temp °C**	**Comment**		
3/26/2008	5:10 PM		0.136	13	12.6		near maple w/ ABCKVW (M) attempting to mount it at surface of 15 cm water above a 25 cm tunnel with two entrances		
4/5/2008	--						found in hibernaculum with CKV (M)		
4/6/2008	2:05 PM		0.13	11	16.8		7.5 cm below water near maple between sedge & bulrush		
4/6/2008	2:05 PM		0.116				transmitter removed- new weight in deer trail with 15.24 cm of water		
4/22/2008	12:25 PM		0.12	19	23	20.39	just below surface		

Table 8. Example of the Microsoft Excel radio telemetry data sheet.

Radiotelemetry Data
Turtle: IKW (Channel 17); Male
Transmitter #:
Frequency: 164.65 MHz

Date	Location	Time	Weight (Kg)	Shell Temp. °C	Water Temp. °C	Air Temp. °C	Water Depth (cm)	Comments
6/1/08		2:00 PM	0.116		20.00	27.00		near lake edge buried in moss, mud mounds with sedge, rosebush & glossy buckthorn, mud temp rec.
6/1/08		2:00 PM						transmitter attached- new weight not recorded
6/3/08		11:15 AM			22.00	20.00		did not find, at lake edge, buried under moss, mud, water, sedge glossy buckthorn & rosebush
6/4/08								at lake edge in muskrat hole
6/5/08		3:30 PM		27.28	25.50	30.60		found 50' from lake edge buried in wet moss, sedge, potentilla, & red twig dogwood, moss & mud temp rec.
6/6/08								moving in water in brush west of big trail to lake
6/9/08		2:10 PM	0.126		26.00	26.30	5.08	in deer trail in water with BKW (F)
6/10/08		2:45 PM			27.00	26.80		did not find, buried in water, moss mounds, potentilla, sedge, fern, tall glossy buckthorn & willow
6/12/08		12:55 PM			23.00	30.30	12.70	found in deer trail in water
6/14/08								under sphagnum hummock in hole below brush roots

Table 9. Compilation of 2007 and 2008 data for the 187 turtles of southwestern Michigan fen.

Turtle	Age (yrs)	Male/ Female	Adult/ Juvenile	Carapace Length (cm)	Width (cm)	Plastron Length (cm)	Height (cm)	Weight (kg)
A (2006)	1		J	3.020	2.707	2.599		
ABCK	13	M	A	9.264	6.556	7.595	3.331	0.118
ABCKVW	12	M	A	10.930	6.918	8.223	3.434	0.130
ABCKW	12	F	A	9.580	6.765	8.383	3.954	0.134
ABDK	11	F	A	9.368	6.350	8.432	3.852	0.114
ABKW	14	F	A	8.848	6.245	7.699	3.748	0.110
ABKWX	15	M	A	10.305	7.180	8.640	3.538	0.158
ACDK		F	A	9.388	6.391	8.352		
ACIK	11	F	A	8.536	6.380	7.596	3.434	0.102
ACK	7		J	7.807	5.830	6.765	3.020	
ACKVWX	7	M	A	7.983	5.954	6.970		
ACKW	8	F	A	9.054	6.867	8.014	3.744	0.114
ADKO	12	F	A	9.262	6.454	8.010	3.851	0.140
ADKV	11	F	A	8.341	6.245	7.702	3.332	0.088
AHK	6		J	4.944	4.061	4.164	2.078	0.024
AJK	11	M	A	9.073	6.525	7.742		
AJKX	11	M	A	9.678	6.868	8.119	3.437	0.120
AK	15	M	A	9.056	6.462	7.598	3.320	0.110
AKLMP	8		J	7.710	6.620	6.665	2.813	0.072
AKM	12	F	A	8.811	6.347	7.705	3.747	0.112
AKN	7	M	A	8.488	6.047	7.285	3.333	0.092
AKO	12	F	A	8.540	6.140	7.495	3.750	0.106
AKOQ	7		J	7.810	6.040	6.868	2.811	0.080
AKP	7	F	J	7.708	5.620	6.766	3.018	0.066
AKU			J	6.640	5.420	5.839		
AKW	13	M	A	9.570	6.574	8.223	3.740	0.116
AKWX	13	M	A	8.354	5.944	7.282	3.021	0.084
AKX	15	F	A	8.848	6.350	7.810	3.645	0.135
B (2006)	2		J	3.123	2.706	2.602		0.004
BCEKL	2		J	6.240	5.100	5.520	2.500	0.042
BCK		F	A	9.471	6.661	8.329		0.132
BCKV	12	M	A	9.368	7.705	7.911	3.436	0.120
BCKW		M	A					
BDK	10	F	A	8.745	6.455	7.914	3.746	0.110
BDKV	10	M	A	9.580	6.870	8.010	3.430	0.120
BDKW	10	F	A	8.950	6.660	8.118	3.850	0.135
BDKX	14	M	A	9.570	6.660	7.910	3.644	0.112
BHK	12	F	A	8.535	6.557	7.705	3.850	0.126
BIK			J	7.708	5.517	6.454		
BIKX	8	M	A	8.015	6.039	7.787	3.226	0.084
BJK	8	F	A	8.120	6.038	7.390	3.123	0.084
BJKW	13	M	A	9.246	6.507	7.809	3.435	0.114
BK (Juv.)			J	5.622	4.889	4.993		

Table 9 (cont'd).

Turtle	Age (yrs)	Male/ Female	Adult/ Juvenile	Carapace Length (cm)	Width (cm)	Plastron Length (cm)	Height (cm)	Weight (kg)
BK		F	A	8.435	6.455	7.704	3.852	0.112
BKM	9		J	6.663	5.210	5.832	2.500	0.050
BKN	6		J	6.670	5.204	5.932	2.602	0.050
BKOV			J	5.414	4.475	4.788		
BKP			J	6.208	5.103	5.512		
BKU	13	F	A	8.920	6.294	7.772	3.748	0.112
BKV		F	A	9.055	6.589	8.123		
BKW	12	F	A	9.471	6.768	8.329	3.642	0.144
BKX	7	M	A	8.534	6.063	7.078	3.029	0.090
C	2		J	3.021	2.707	2.599		0.004
CDK		F	A	8.325	6.141	7.492		
CDKV	12	M	A	9.387	6.453	7.724	3.434	0.102
CDKVW	11	M	A	9.992	7.280	8.235	3.540	0.130
CHJKLVW	11	F	A	9.473	6.558	8.225	3.851	0.152
CHK	13	M	A	8.848	6.039	7.596		
CHKW			J	5.623	4.788	5.099		
CHKZ	10		J	6.038	4.889	5.312	2.495	0.036
CIJKP	6	M	A	6.560	5.120	5.730	2.600	0.052
CJK	11	F	A	8.328	6.139	7.699		
CK	7		J	7.181	5.417	6.247	2.915	0.062
CKM			J	6.973	5.413	6.038		
CKN	7	F	J	6.454	5.100	5.728	2.610	
CKO			J	7.153	5.893	6.223		
CKP	5		J	4.995	4.372	4.265	1.978	0.022
CKU		F	A	9.161	6.765	8.326	3.748	0.138
CKW	6		J	7.491	5.829	6.558	2.913	
CKX	17	F	A	9.163	6.520	8.118	3.643	0.116
CRV		M	A	10.635				
DHK	11	M	A	8.950	6.455	7.720	3.640	0.112
DIK		F	A	9.301	6.541	8.131		
DJK		M	A	8.816	6.264	7.549		
DKL		F	A	8.758	6.586	7.691		
DKLM	8	M	A	6.450	5.410	5.720	2.603	0.048
DKM	16	F	A	9.368	6.555	7.912	3.539	0.106
DKN	9	M	A	8.432	6.556	7.285	3.021	0.098
DKO	8	M	A	7.705	6.036	6.869	3.123	0.070
DKP	13	F	A	8.750	6.554	7.720	3.540	0.122
DKU		M	A	8.593	6.245	7.288	3.333	0.102
DKVWX	12	F	A	8.750	6.770	7.846	3.440	0.112
DKX	11	F	A	9.050	6.770	8.174	3.640	0.114
FGK	14	F	A	8.265	6.185	7.325	3.440	
FIKS	6		J	5.839	4.892	5.000	2.495	0.038
FJKS	10	M	A	9.060	6.350	7.500	3.230	0.112

Table 9 (cont'd).

Turtle	Age (yrs)	Male/ Female	Adult/ Juvenile	Carapace Length (cm)	Width (cm)	Plastron Length (cm)	Height (cm)	Weight (kg)
FKS	13	M	A	9.160	6.680	7.601	3.539	0.122
GK	7		J	5.932	4.287	5.102	2.498	0.036
GKX	10	M	A	8.535	6.036	7.077	3.125	0.096
H	2		J	4.265	3.750	3.643	1.665	0.012
HIK	12	M	A	9.264	6.661	7.808	3.124	0.112
HJK	12	F	A	9.158	6.560	8.222	3.954	0.136
HJKV	12	F	A	8.640	6.870	7.705	3.539	0.136
HK	2		J					
HKL			J	6.245	5.205	5.517	2.705	0.046
HKLQ	12	F	A	9.158	6.868	8.223	3.332	0.114
HKM	22	F	A	10.306	7.600	9.056	4.579	0.198
HKN			J	6.558	5.412	5.727		
HKNQV	11	M	A	8.744	6.452	7.363	3.124	0.098
HKO	6	M	A	7.388	5.620	6.452	2.709	0.056
HKP	13	F	A	9.368	7.283	8.535	3.850	0.136
HKQ		M	A	8.580	5.987	7.328		
HKQW	6		J	6.868	5.312	6.141	2.708	0.054
HKQX			J	6.807	5.438	6.162		
HKU	11	F	A	9.265	7.077	8.324	3.850	0.134
HKV	18	F	A	9.471	6.973	8.535	4.059	0.160
HKW (F)	5		J	5.933	4.890	5.207	2.394	
HKW (M)		M	A	9.368	6.453	7.704	3.537	0.132
HR	1		J	3.850	3.230	3.540	3.230	0.010
I	5		J	6.247	4.892	5.623	2.707	0.044
IF			J	5.525	4.717	4.770		
IJK		M	A	8.575	6.030	7.135		
IK (2006)	2		J	3.995	3.230	3.228	1.460	0.008
IK (5 yr.)	5		J	4.893	4.164	4.268	1.870	
IKL	11	M	A	9.413	6.599	7.705	3.332	0.118
IKM	10	M	A	9.262	6.452	7.596	3.332	0.110
IKNP	8		J	7.821	5.932	7.389	3.226	0.084
IKNX	14	M	A	9.252	6.140	7.390	3.225	0.096
IKO	5		J	5.519	4.682	4.994	2.287	0.030
IKOPQ	11	M	A	8.326	6.140	7.290	3.124	0.092
IKP	10	M	A	9.159	6.558	8.016	3.125	0.108
IKW	11	M	A	9.327	6.765	7.869	3.644	0.124
IMX		M	A	8.966	6.203	7.356		
J	1		J	3.227	2.813	2.707	1.249	0.006
JKL	12	M	A	8.745	6.245	6.973	3.435	0.098
JKOP	7	M	A	7.079	5.519	5.935	2.708	0.060
JKP	4		J	6.245	4.787	5.518	2.500	0.038
JKW	10	M	A	9.991	6.454	8.225	3.540	0.138

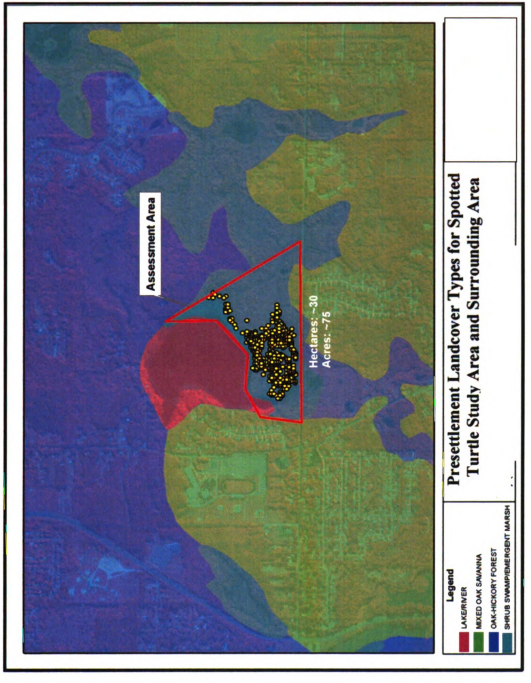
Table 9 (cont'd).

Turtle	Age (yrs)	Male/ Female	Adult/ Juvenile	Carapace Length (cm)	Width (cm)	Plastron Length (cm)	Height (cm)	Weight (kg)
JKX	7		J	5.725	4.786	4.788		
K	6		J	6.765	5.204	6.038	2.710	0.048
KL	4		J	4.371	3.645	3.539		
KLM	12	M	A	9.369	6.348	7.705	3.333	0.132
KLN	8	M	A	9.053	6.244	7.390	3.227	0.102
KLO		M	A	9.522	6.789	7.887		
KLP	6		J	6.035	5.205	5.205	2.598	0.034
KLQ	17	F	A	9.367	6.455	8.265	3.745	0.126
KLU	9	F	A	8.744	6.557	7.808	3.539	0.118
KLW	19	F	A	8.898	6.650	7.717	3.740	
KLX		F	A	9.091	6.746	8.120	3.540	0.122
KMN	12	F	A	9.056	6.558	7.808	3.953	0.128
KMOQ	19	F	A	9.159	6.558	8.118	3.850	0.126
KMP			J	6.868	5.208	6.037	2.599	0.048
KMU	8		J	5.830	4.890	5.206	2.602	0.032
KMW (JUV)	11		J	7.600	5.934	6.675	2.915	0.070
KMW	13	F	A	9.886	7.825	8.536	4.059	0.168
KMX	9	F	A	8.750	5.921	7.500	3.021	0.096
KN	4		J	4.370	3.540	3.542	1.665	0.014
KNO	9	M	A	9.262	6.143	7.597	3.226	0.100
KNP	6		J	6.660	5.210	5.930	2.810	0.052
KNU	14	M	A	8.534	5.934	7.285	2.910	0.084
KNV	5		J	5.392	4.890	5.100	2.290	0.036
KNW	15	M	A	9.161	6.452	8.385	3.331	0.104
KNX	12	M	A	9.885	6.952	8.285	3.022	0.120
KO	3		J	4.268	3.747	3.332	1.660	0.014
KOP	5		J	6.558	5.206	6.038	2.604	0.048
KOPR	6		J	7.285	5.820	6.246	2.813	0.062
KOQ	6	M	A	6.767	5.204	5.934	2.602	0.052
KOU	13	M	A	9.158	6.555	7.910	3.339	0.110
KOV	7		J	7.390	5.516	6.351	2.917	0.064
KOW			J	7.503	5.875	6.485		
KOX			J	7.226	5.517	6.383		
KP	7		J	5.375	4.465	4.737	2.189	0.026
KPQ	8	F	A	9.160	6.453	8.120	3.850	0.128
KPU	5		J	5.830	4.990	5.100	2.390	0.036
KPV	7	M	A	7.492	5.729	6.659	2.708	0.068
KPW	6		J	6.145	5.205	5.518	2.705	0.044
KPX	9	F	A	8.140	6.765	7.206	3.245	0.110
KQ (2006)	2		J	3.123	2.707	2.602	1.146	0.006
KQU			J	7.071	5.453	6.200		
KU		M	A					

Table 9 (cont'd).

Turtle	Age (yrs)	Male/ Female	Adult/ Juvenile	Carapace Length (cm)	Width (cm)	Plastron Length (cm)	Height (cm)	Weight (kg)
KU	14	F	A	9.158	6.763	8.224		
KUV	12	M	A	8.950	6.570	7.590	3.330	0.134
KUVX	9		J	6.878	5.271	6.140	2.708	
KUW	8	F	A	8.014	5.934	7.078	3.230	0.084
KV	21	F	A	9.158	6.869	8.293	3.641	0.136
KVW	9	M	A	9.055	6.455	7.390	3.125	0.110
KVWX			J	6.713	5.177	6.033		
KVX	14	F	A	8.952	6.765	8.013	3.750	0.128
KW		F	A	9.083	6.871	8.202		
KWX	4		J	5.208	4.578	4.580	2.291	
KX (2006)	2		J	3.227	2.812	2.605	1.145	0.006
LMN		M	A	10.066				
O	2		J	4.058	3.437	3.332	1.560	0.010
P	1		J	3.228	2.915	2.603	1.147	0.006
R	1		J	3.330	3.020	2.610	1.350	0.008
V	3		J	4.060	3.538	3.228	1.562	0.012
W	1		J	3.123	2.810	2.501	1.145	0.004

Figure 1. Presettlement land cover of southwestern Michigan fen.



Hectares:~30; Acres:~75

Figure 2. Outlying regions of study site.

Figure 3. Open wetland in middle of fen.

Figure 4. Thick growth of *Chara* spp. in study site *Chara* pond.

Figure 5. Large transmitter attached to turtle carapace.

Figure 6. Alphabetical turtle marking system diagram.

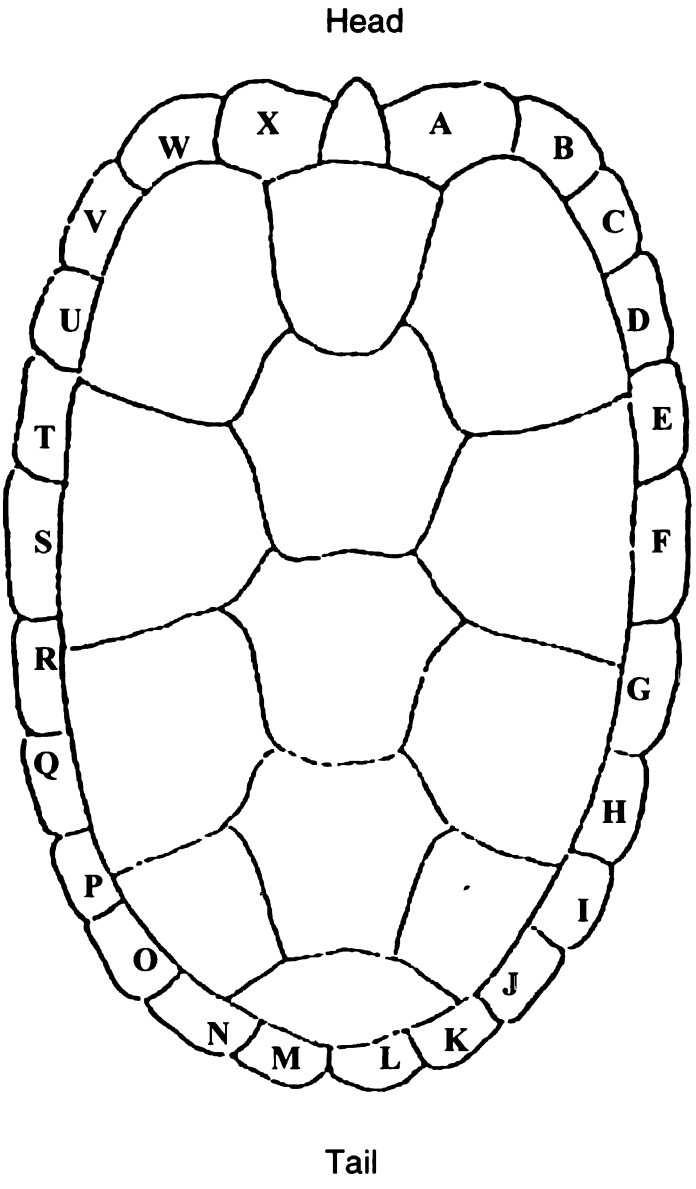


Figure 7. Diagram of sample markings for turtle ABX.

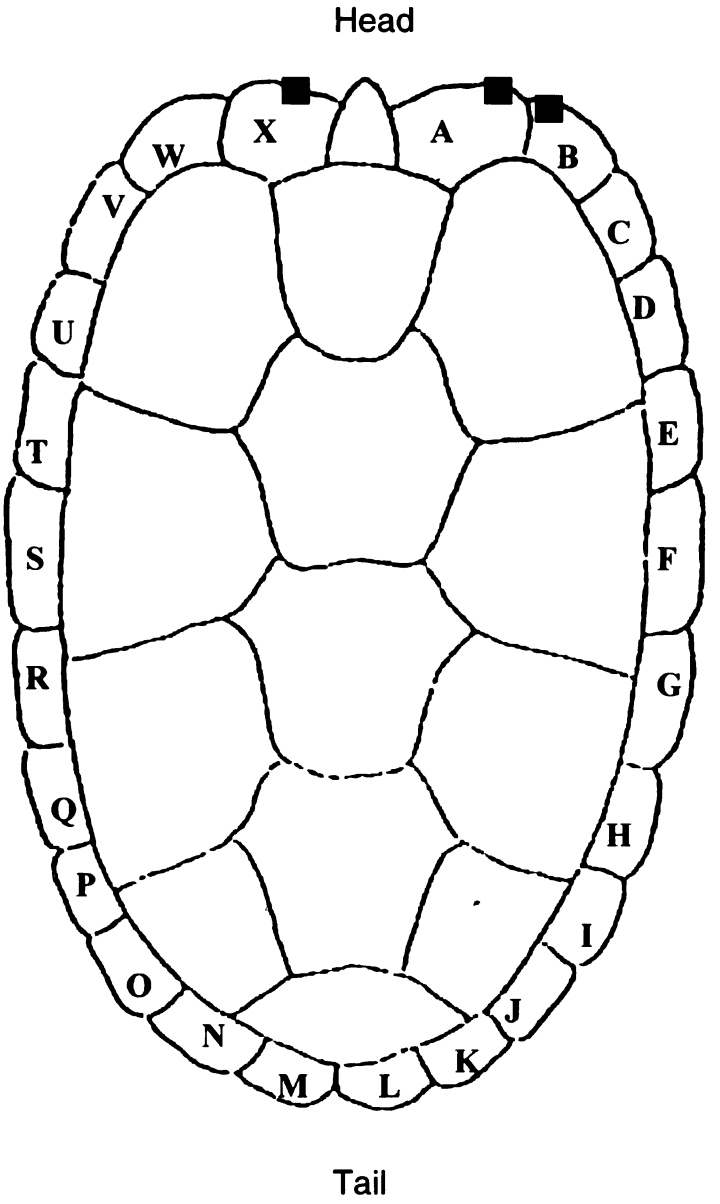
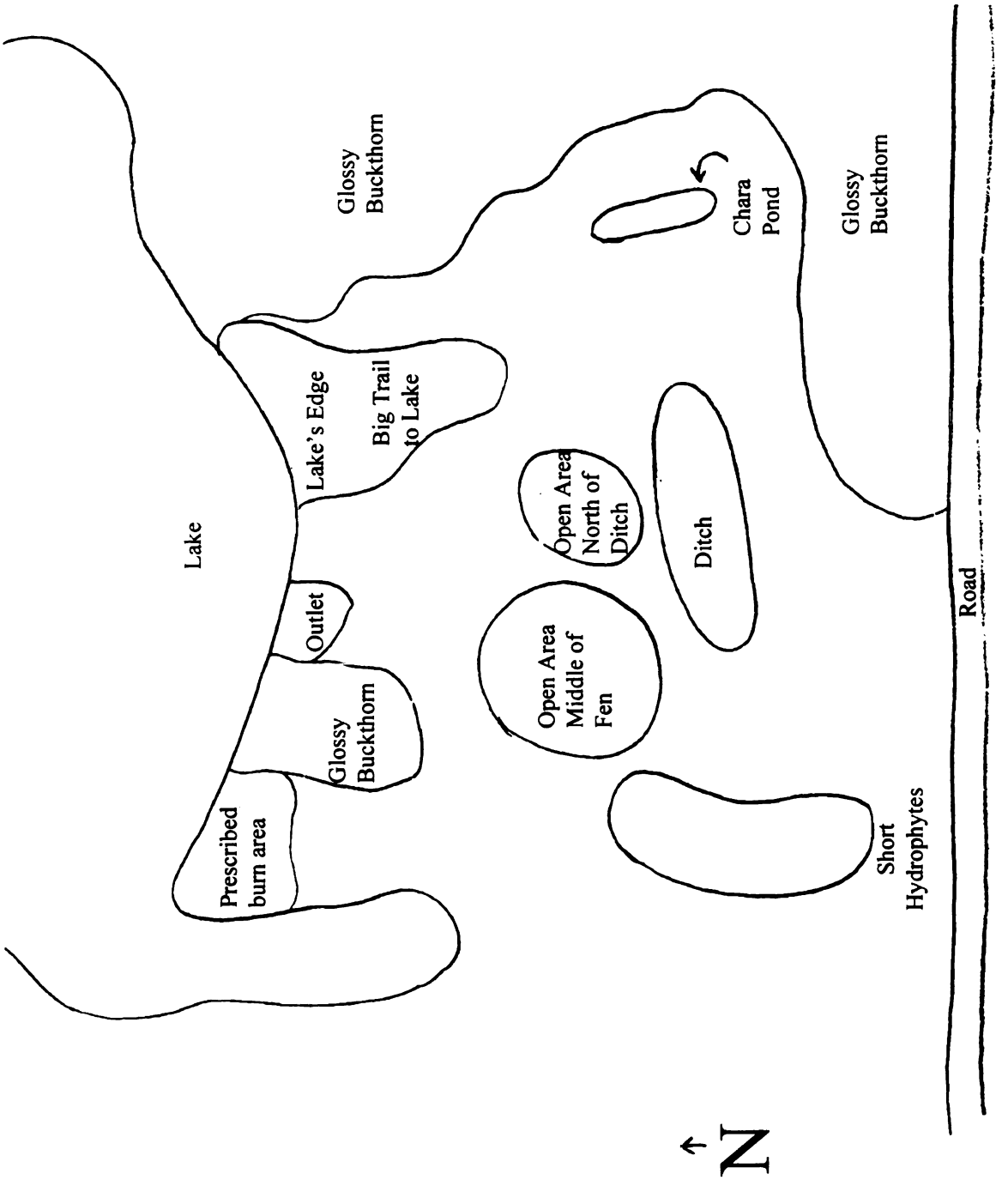


Figure 8. Spotted Turtle with notched markings.

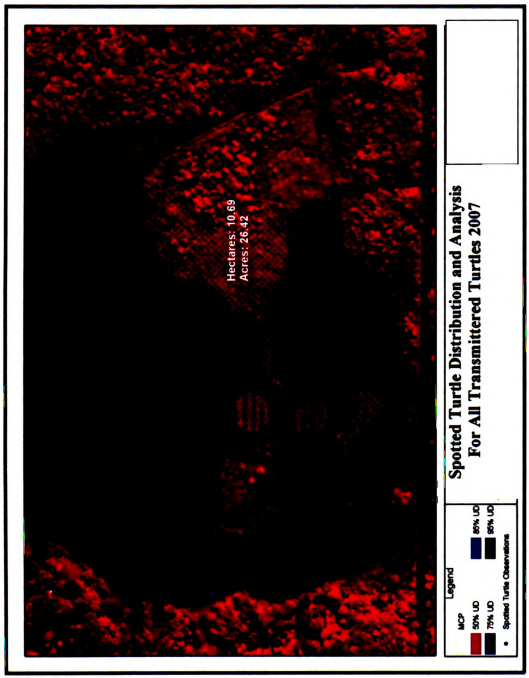
Figure 9. Small transmitter attached to turtle carapace.

Figure 10. Labeled diagram of study site.



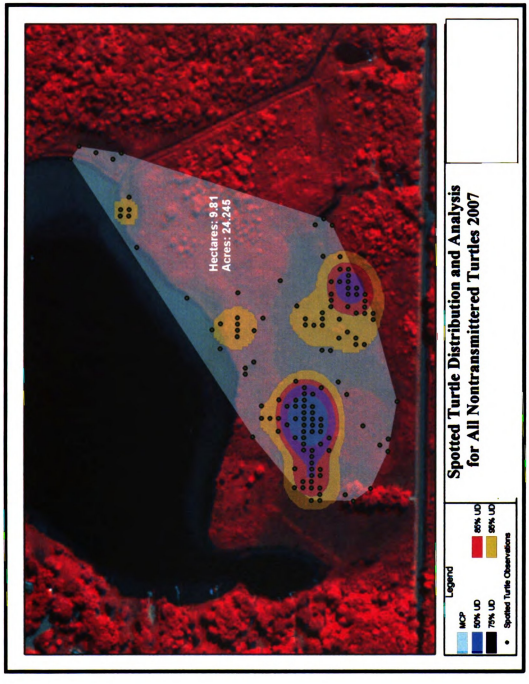
*Hand-drawn diagram by Diana Lutz.

Figure 11. Compilation of habitat utilization for transmittered turtles 2007.



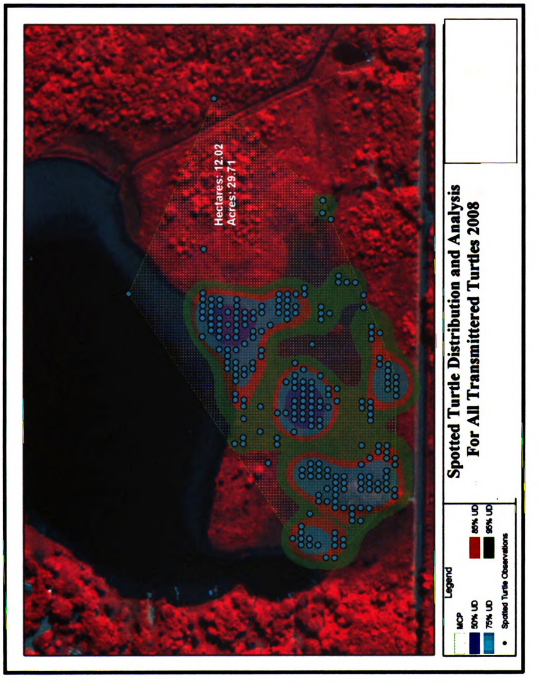
*Hectares:10.69; Acres: 26.42

Figure 12. Compilation of habitat utilizations for turtles without transmitters in 2007.



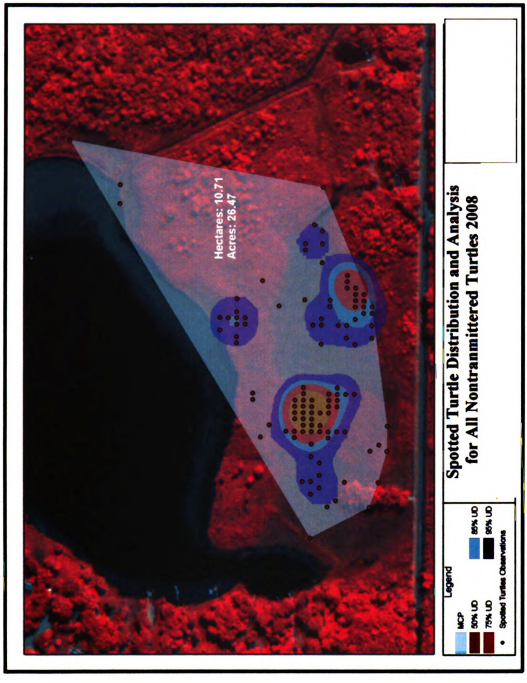
*Hectares: 9.81; Acres: 24.245

Figure 13. Compilation of habitat utilizations for transmittered turtles in 2008.



*Hectares: 12.02; Acres: 29.71

Figure 14. Compilation of habitat utilizations for turtles without transmitters in 2008.

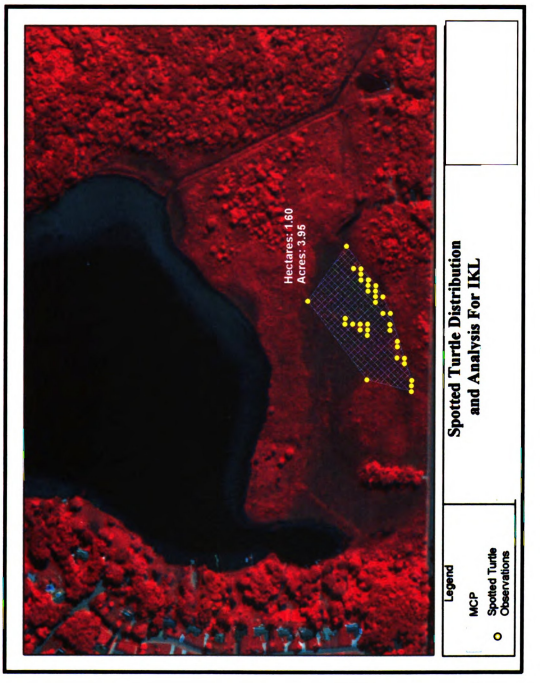


*Hectares: 10.71; Acres: 26.47

Figure 15. Predated Nesting Site.

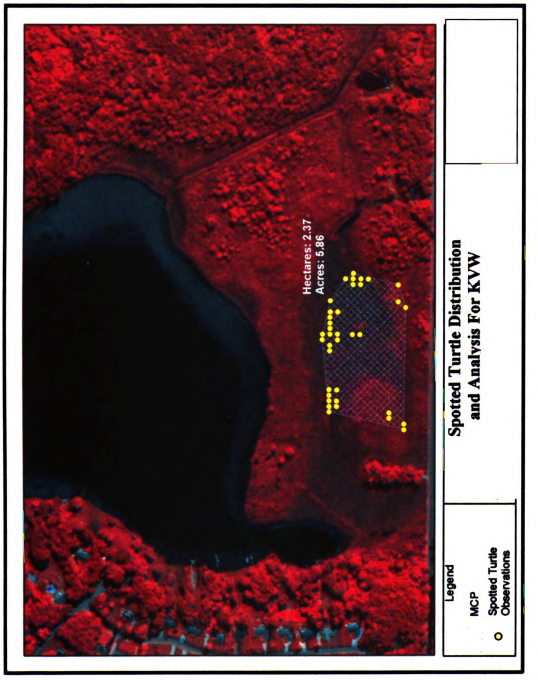
Figure 16. Hatchling found in successful nesting location.

Figure 17. Channel 0 male IKL habitat utilization in 2007.



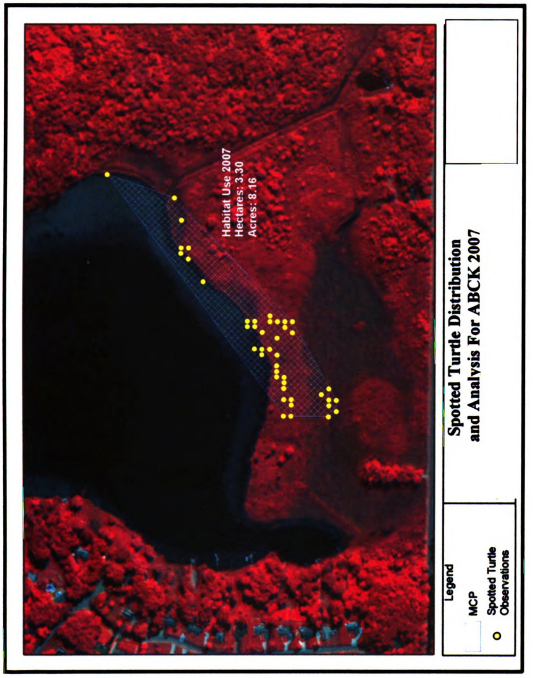
*Hectares: 1.60; Acres: 3.95

Figure 18. Channel 1 male KVW habitat utilization in 2007.



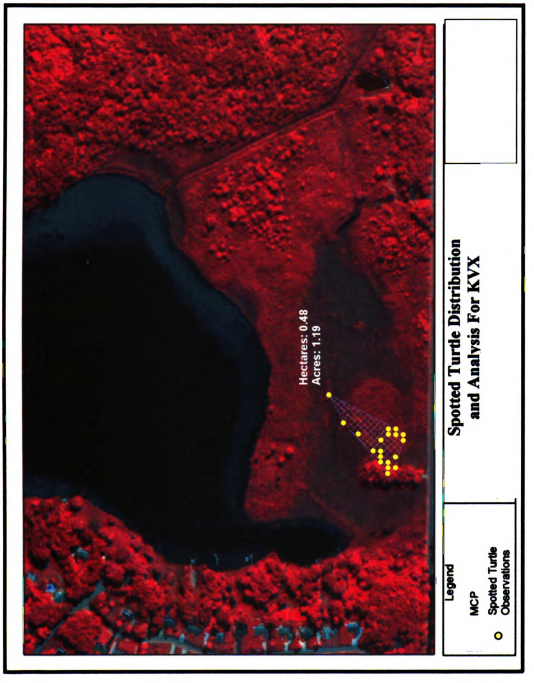
*Hectares: 2.37; Acres: 5.86

Figure 19. Channel 2 male ABCK habitat utilization in 2007.



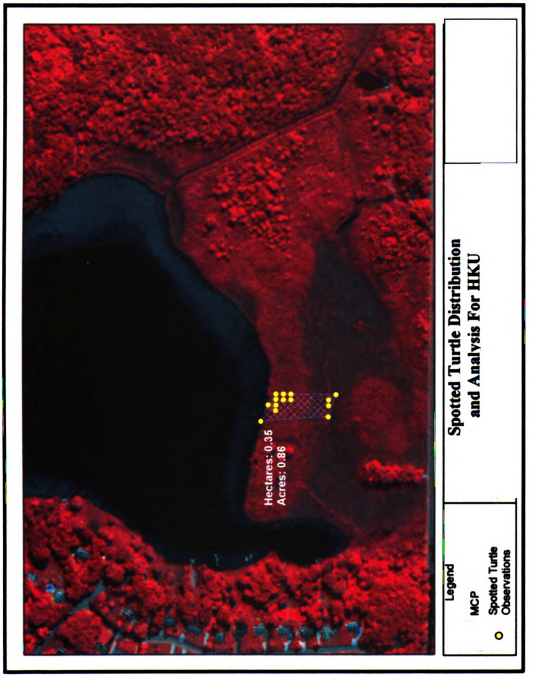
*Hectares: 3.30; Acres: 8.16

Figure 20. Channel 3 female KVX habitat utilization in 2007.



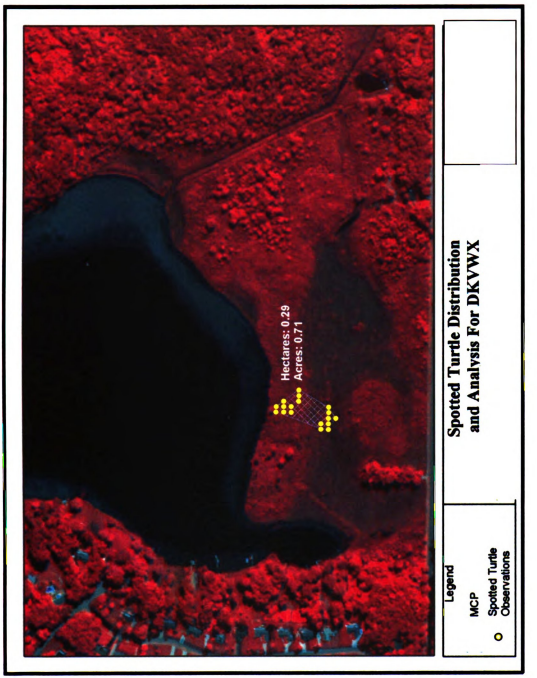
*Hectares: 0.48; Acres: 1.19

Figure 21. Channel 4 female HKU habitat utilization in 2007.



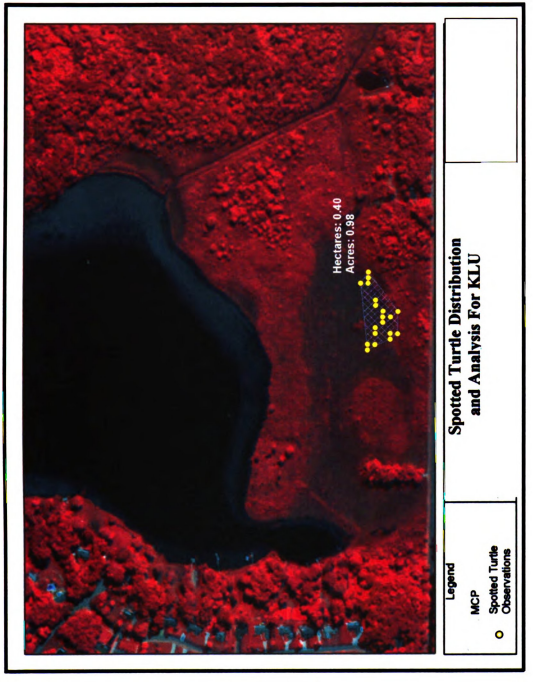
*Hectares: 0.35; Acres: 0.86

Figure 22. Channel 6 female DKVWX habitat utilization in 2007.



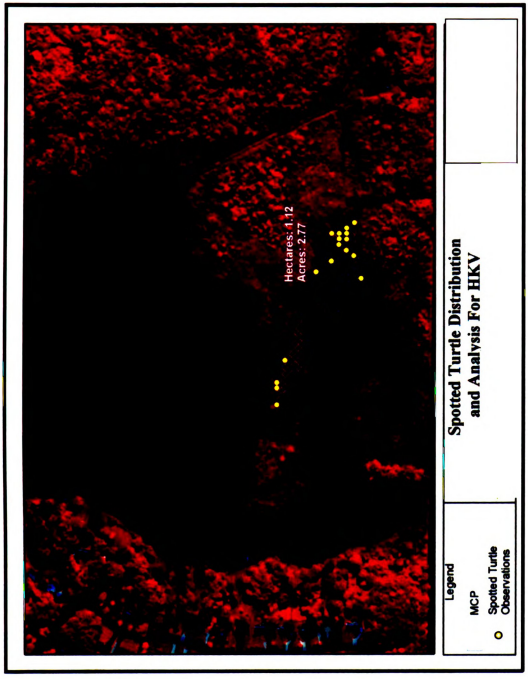
*Hectares: 0.29; Acres: 0.71

Figure 23. Channel 7 female KLU habitat utilization in 2007.



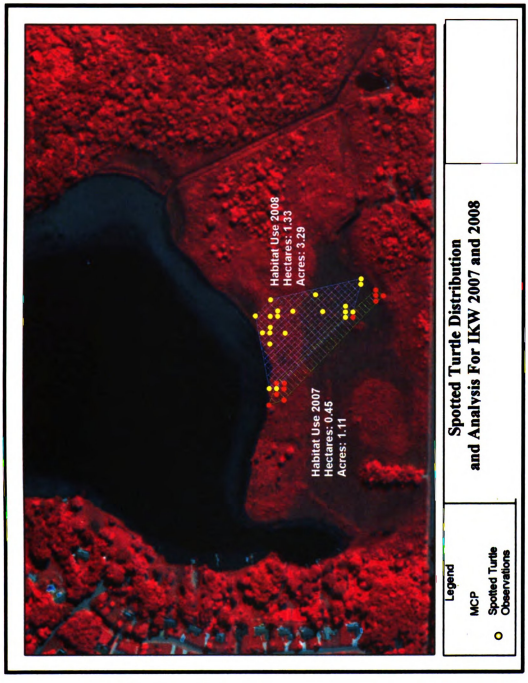
*Hectares: 0.40; Acres: 0.98

Figure 24. Channel 8 female HKV habitat utilization in 2007.



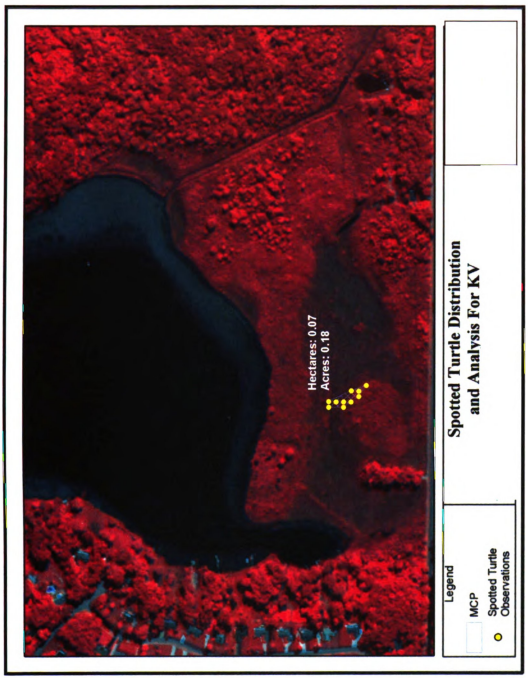
*Hectares: 1.12; Acres: 2.77

Figure 25. Channel 10 male IKW habitat utilization in 2007.



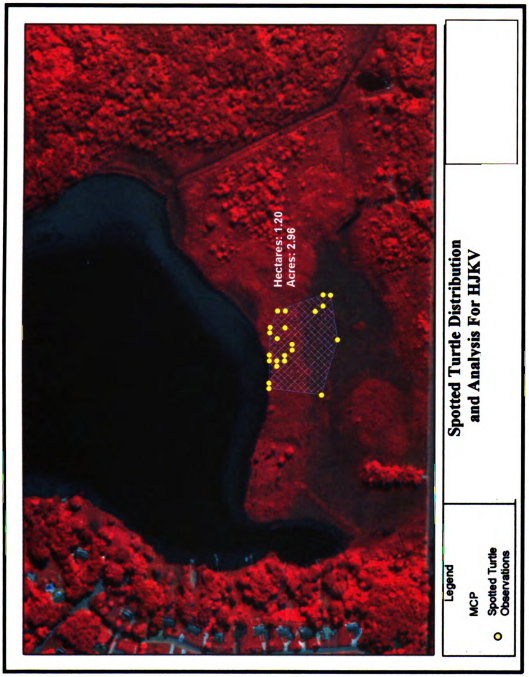
*Hectares: 0.45; Acres: 1.11

Figure 26. Channel 11 female KV habitat utilization in 2007.



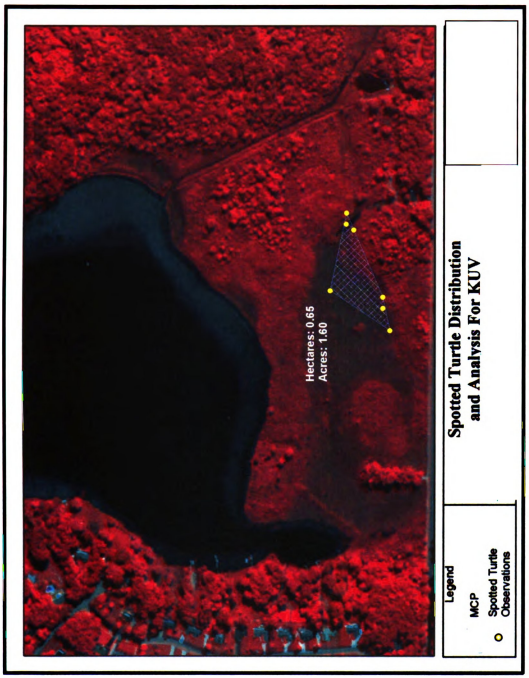
*Hectares: 0.07; Acres: 0.18

Figure 27. Channel 1 female HJKV habitat utilization in 2008.



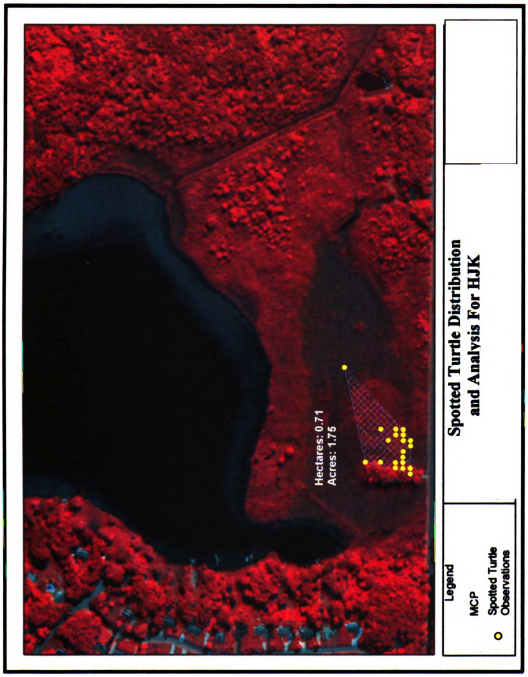
*Hectares: 1.20; Acres: 2.96

Figure 28. Channel 2 male KUV habitat utilization in 2008.



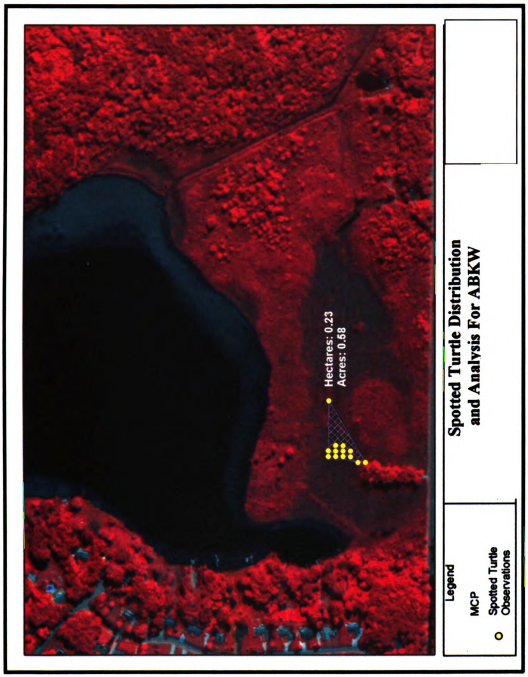
*Hectares: 0.66; Acres: 1.60

Figure 29. Channel 3 female HJK habitat utilization in 2008.



*Hectares: 0.71; Acres: 1.75

Figure 30. Channel 4 female ABKW habitat utilization in 2008.

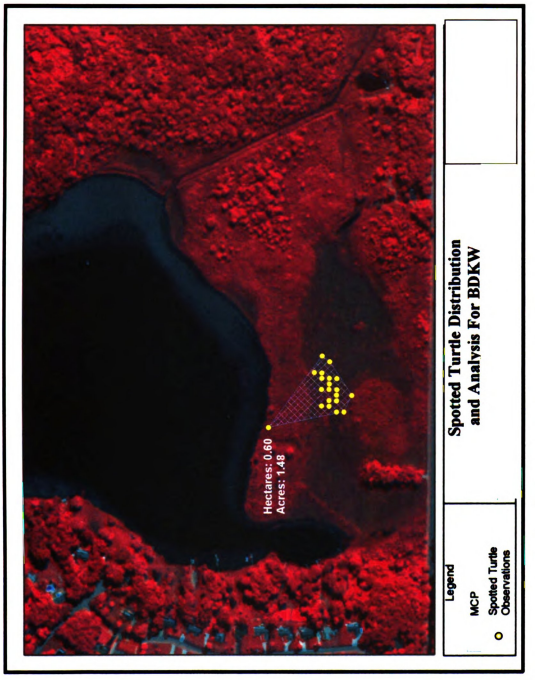


*Hectares: 0.23; Acres: 0.58

Figure 31. Channel 5 female CHJKLVW habitat utilization in 2008.

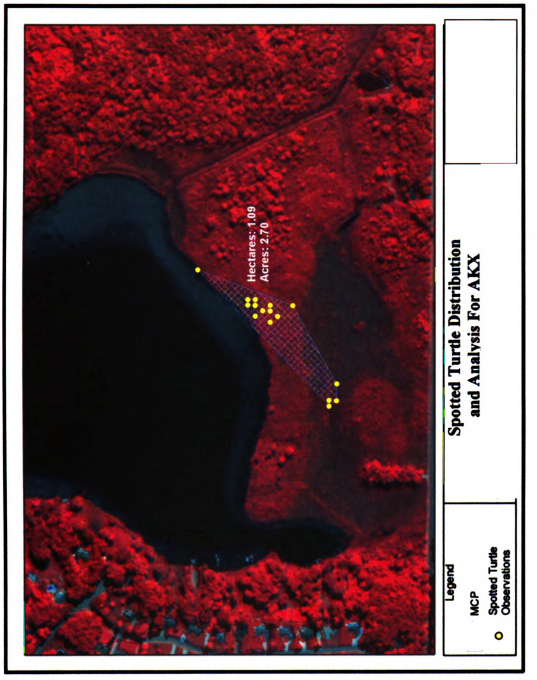
*Hectares: 0.22; Acres: 0.55

Figure 32. Channel 6 female BDKW habitat utilization in 2008.



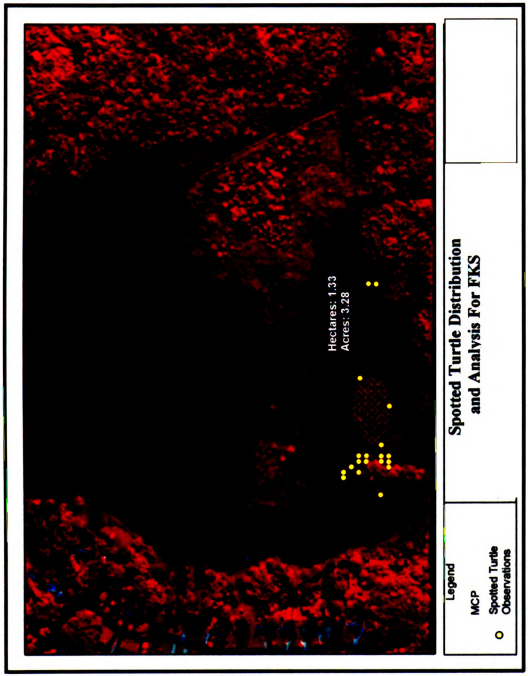
*Hectares: 0.60; Acres: 1.48

Figure 33. Channel 7 female AKX habitat utilization in 2008.



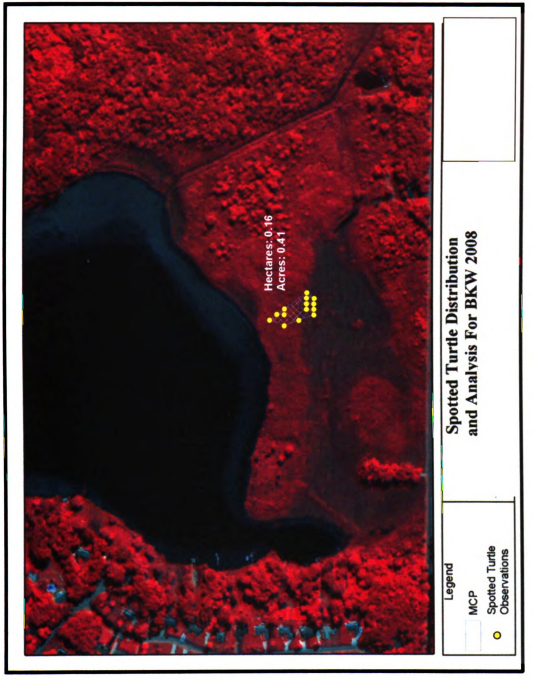
*Hectares: 1.09; Acres: 2.70

Figure 34. Channel 8 female FKS habitat utilization in 2008.



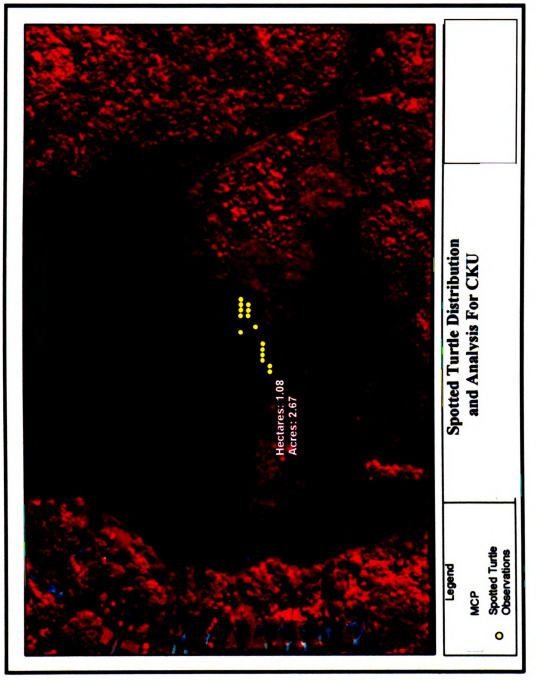
*Hectares: 1.33; Acres: 3.28

Figure 35. Channel 9 female BKW habitat utilization in 2008.



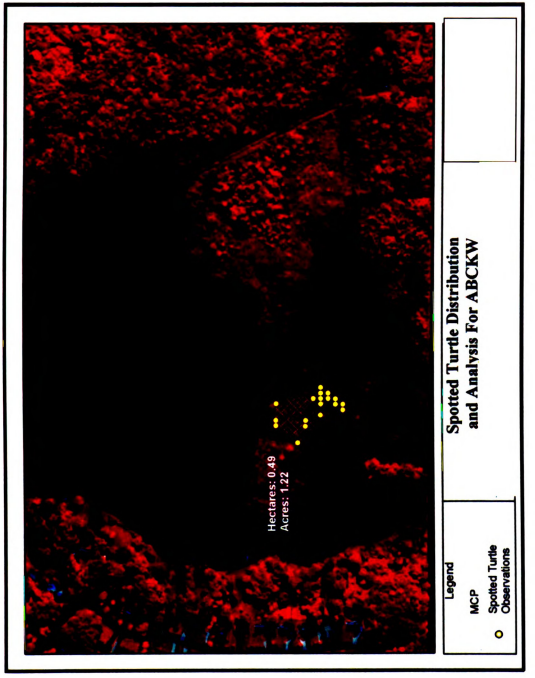
*Hectares: 0.16; Acres: 0.41

Figure 36. Channel 11 female CKU habitat utilization in 2008



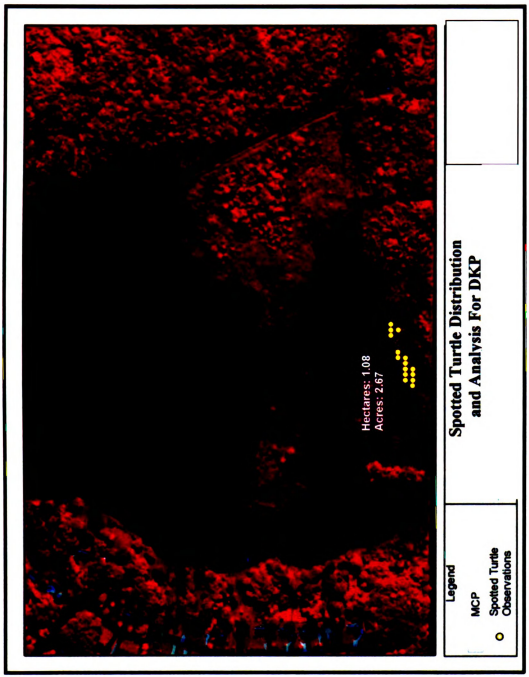
*Hectares: 1.08; Acres: 2.67

Figure 37. Channel 12 female ABCKW habitat utilization in 2008.



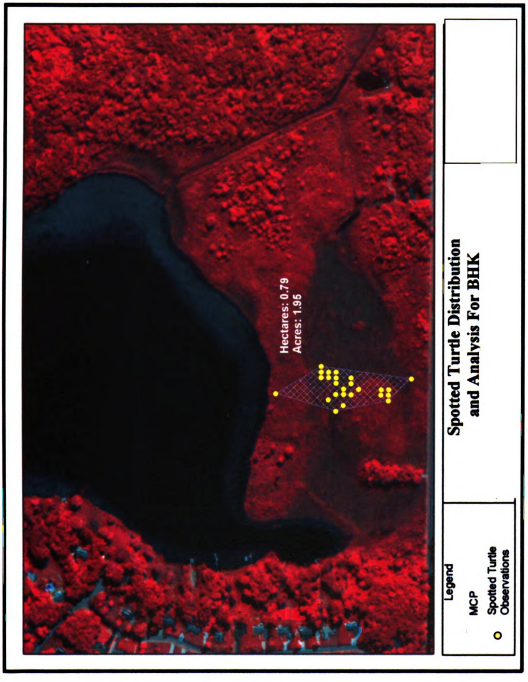
*Hectares: 0.49; Acres: 1.22

Figure 38. Channel 13 female DKP habitat utilization in 2008.



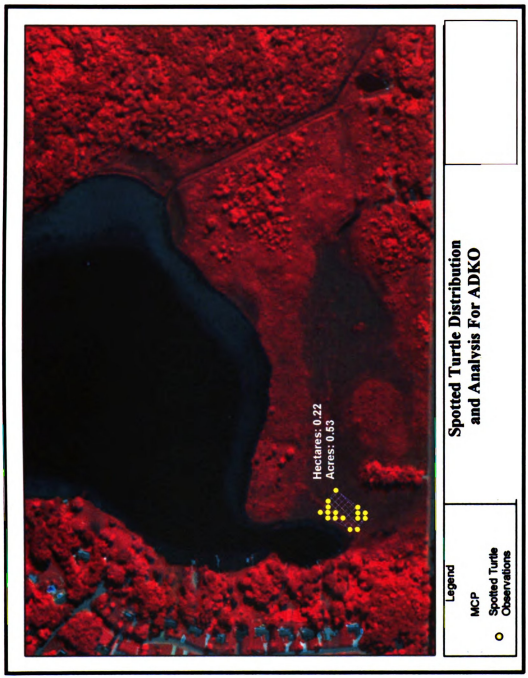
*Hectares: 1.08; Acres: 2.67

Figure 39. Channel 14 female BHK habitat utilization in 2008.



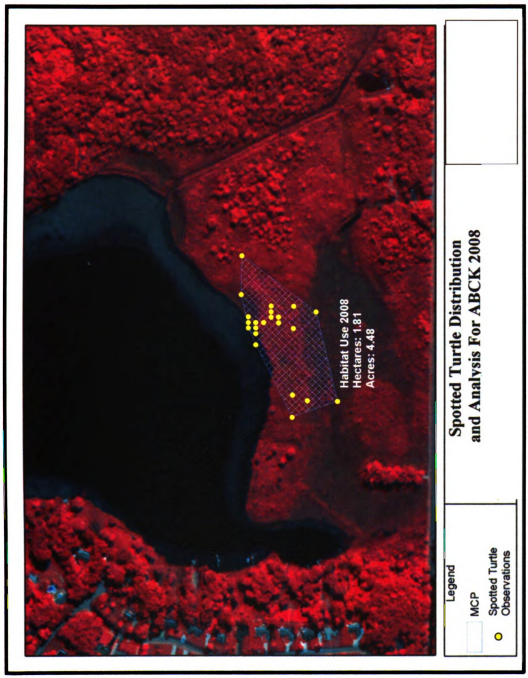
*Hectares: 0.79; Acres: 1.95

Figure 40. Channel 15 female ADKO habitat utilization in 2008.



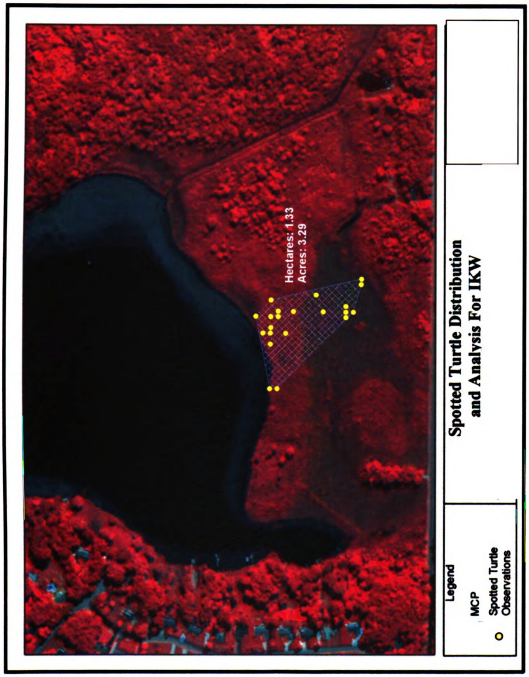
*Hectares: 0.22; Acres: 0.53

Figure 41. Channel 16 male ABCK habitat utilization in 2008.



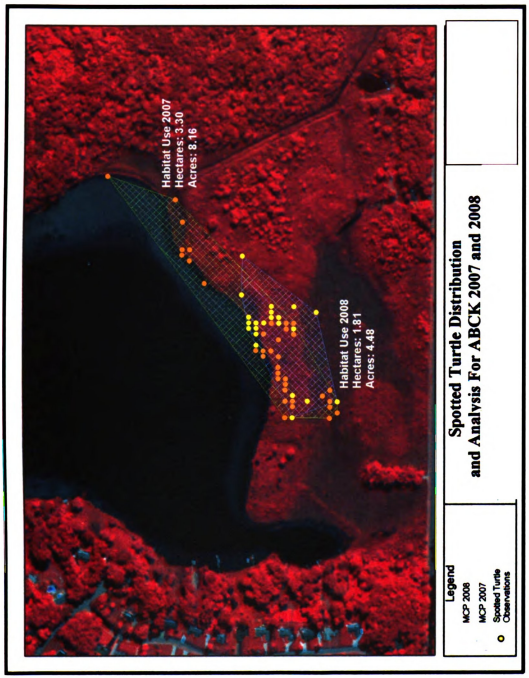
*Hectares: 1.81; Acres: 4.48

Figure 42. Channel 17 male IKW habitat utilization in 2008.



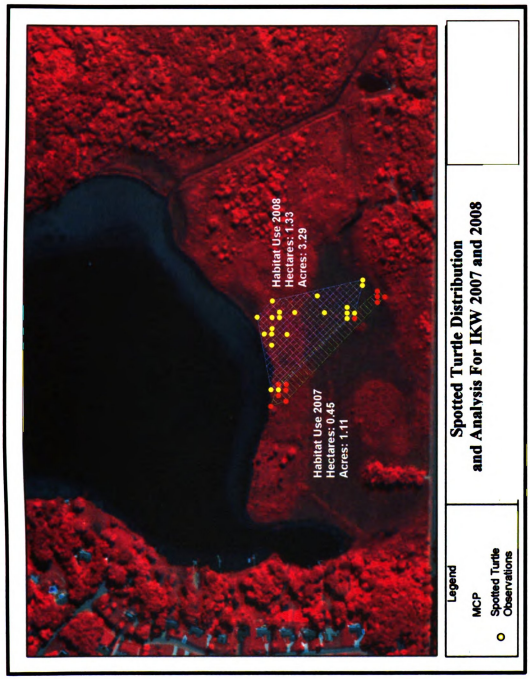
*Hectares: 1.33; Acres: 3.29

Figure 43. Habitat utilization for male ABCK in 2007 and 2008.



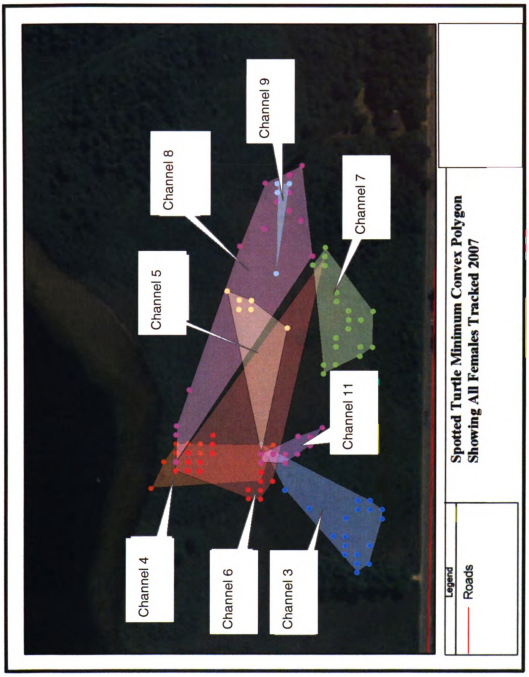
*2007 Hectares: 3.30; Acres: 8.16
*2008 Hectares: 1.81; Acres: 4.48

Figure 44. Habitat utilization for male IKW in 2007 and 2008.



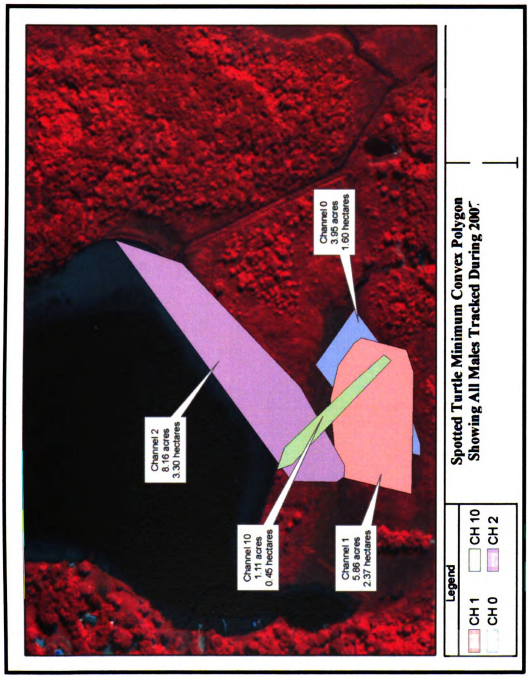
*2007 Hectares: 0.45; Acres: 1.11
*2008 Hectares: 1.33; Acres: 3.29

Figure 45. Overlapping areas of all females tracked in 2007.



Ch. 3: Hectares: 0.48; Acres: 1.19
Ch. 4: Hectares: 0.35; Acres: 0.86
Ch. 5: Hectares: 0.37; Acres: 0.92
Ch. 6: Hectares: 1.08; Acres: 2.67
Ch. 7: Hectares: 0.40; Acres: 0.98
Ch. 8: Hectares: 1.12; Acres: 2.77
Ch. 9: Hectares: 0.05; Acres: 0.11
Ch. 11: Hectares: 0.07; Acres: 0.18

Figure 46. Overlapping areas of all males tracked in 2007.



Ch. 0: Hectares: 1.60; Acres: 3.95
Ch. 2: Hectares: 3.30; Acres: 8.16
Ch. 1: Hectares: 2.37; Acres: 5.86
Ch. 10: Hectares: 0.45; Acres: 1.11

Figure 47. Channel 1 overlapping with all transmittered females during 2007.

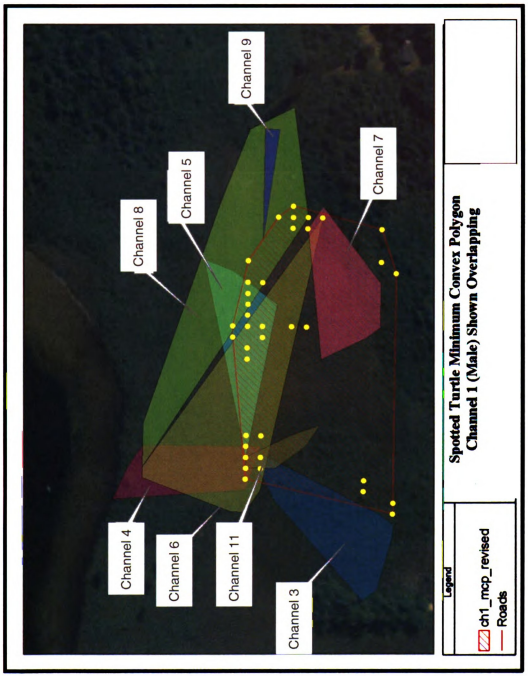
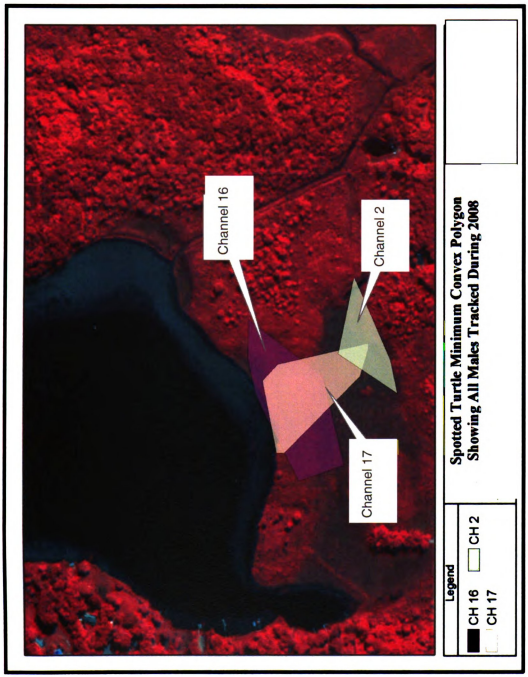
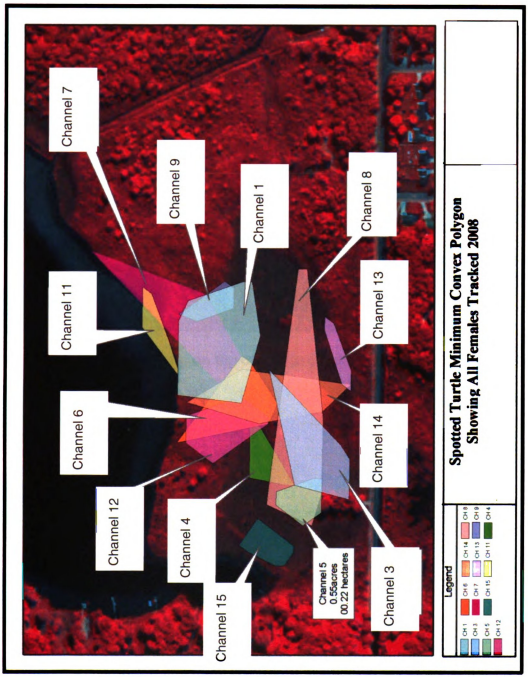


Figure 48. Male overlapping home ranges in 2008.



Ch. 2: Hectares: 0.65; Acres: 1.60
Ch. 16: Hectares: 1.81; Acres: 4.48
Ch. 17: Hectares: 1.33; Acres: 3.29

Figure 49. Female overlapping home ranges in 2008.

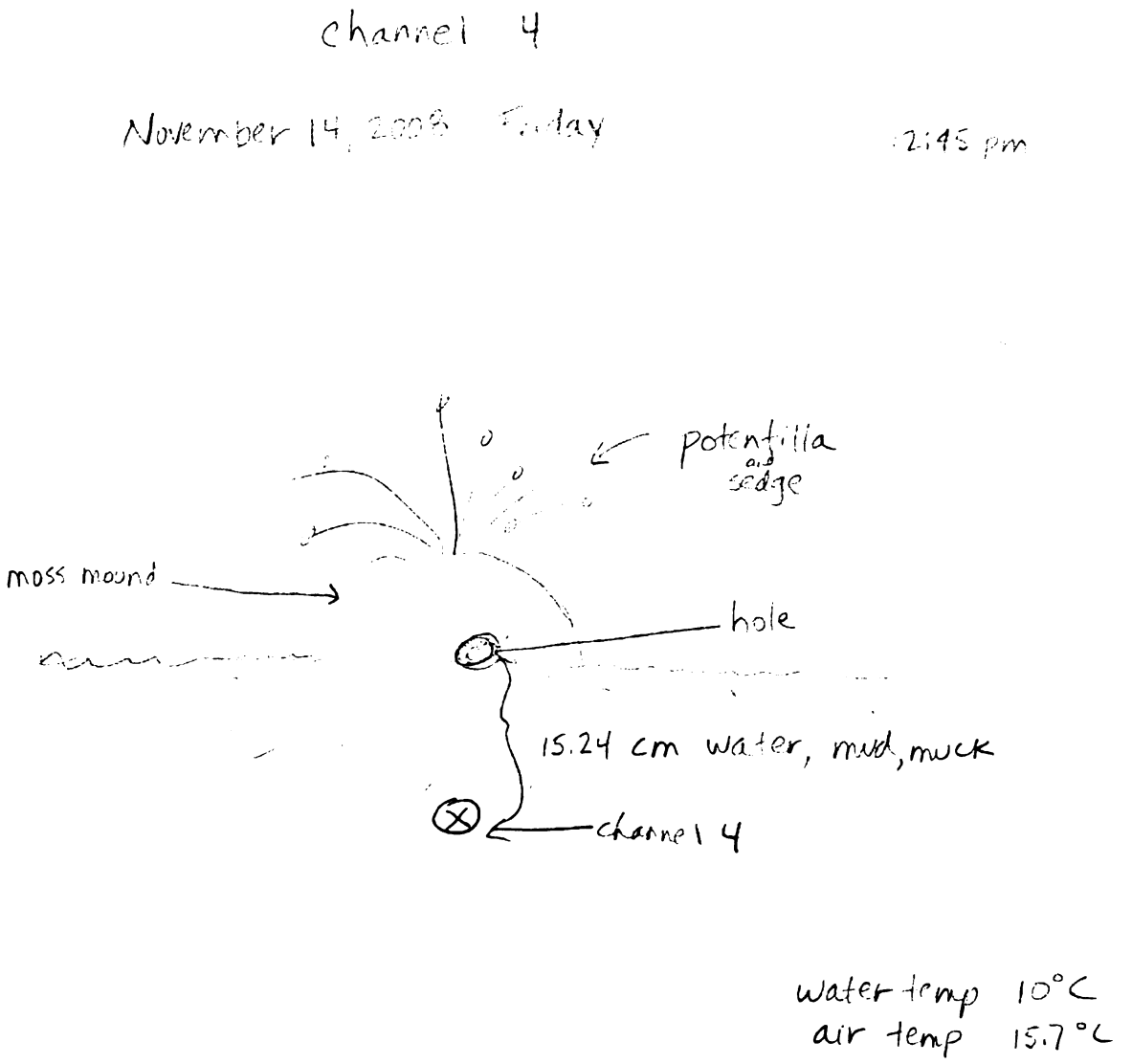


Ch. 1: Hectares: 1.20; Acres: 2.97
Ch. 3: Hectares: 0.71; Acres: 1.75
Ch. 4: Hectares: 0.23; Acres: 0.58
Ch. 5: Hectares: 0.22; Acres: 0.55
Ch. 6: Hectares: 0.60; Acres: 1.48
Ch. 7: Hectares: 1.09; Acres: 2.70
Ch. 8: Hectares: 1.33; Acres: 3.28
Ch. 9: Hectares: 0.17; Acres: 0.41
Ch. 11: Hectares: 0.17; Acres: 0.42
Ch. 12: Hectares: 0.50 Acres: 1.22
Ch. 13: Hectares: 0.12; Acres: 0.29
Ch. 14: Hectares: 0.79; Acres: 1.95
Ch. 15: Hectares: 0.22; Acres: 0.53

Figure 50. *Sphagnum* spp. moss mounds.

Figure 51. *C. guttata* basking on top of sedge on *Sphagnum* spp. moss mounds.

Figure 52. Channel 4 aestivation and hibernation locale.



*Hand-drawn diagram by Diana Lutz.

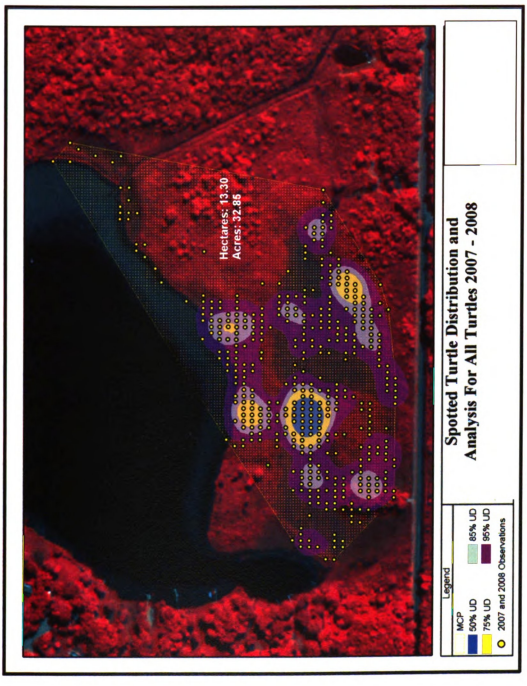
Figure 53. Fallen Shrubby Cinquefoil petals with comparison Spotted Turtle.

Figure 54. Fallen Shrubby Cinquefoil petals.

Fig

Figure 55. Deer trail in study site.

Figure 56. Total utilization area for all turtles in 2007 and 2008.



*Hectares: 13.30; Acres: 32.85

Figure 57. 2007 and 2008 Spotted Turtle sex distribution.

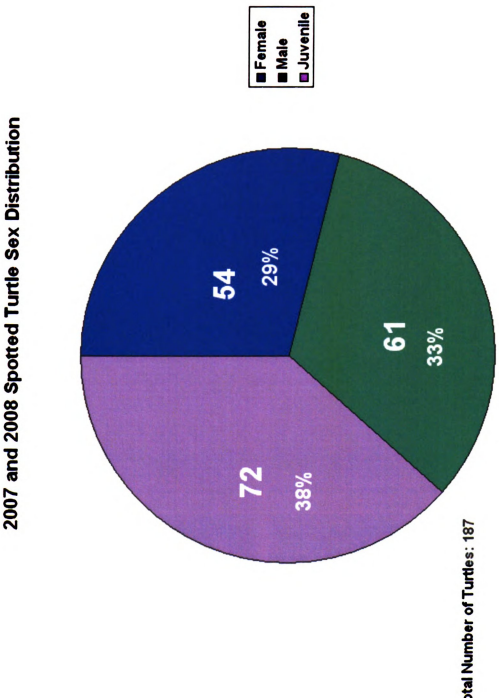
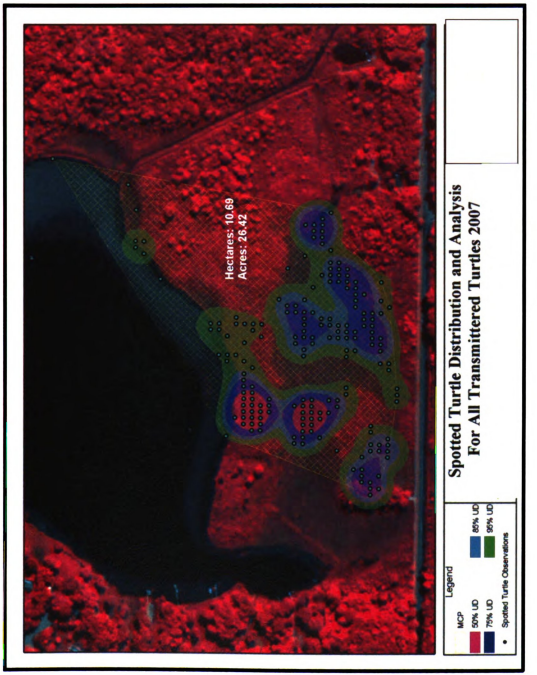
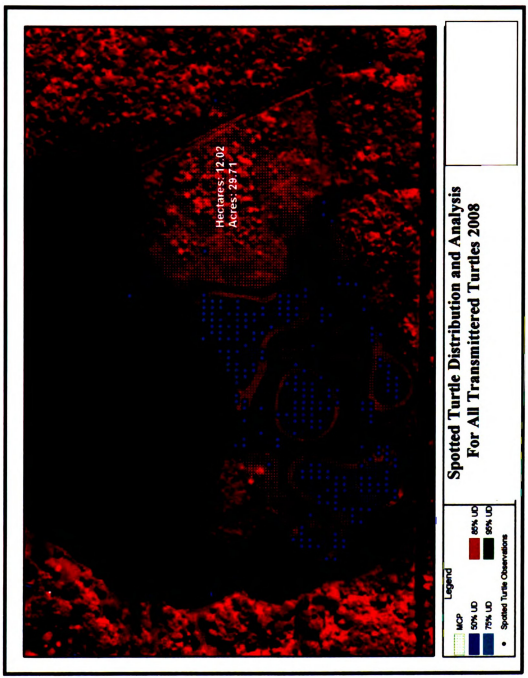


Figure 58. Main aggregations of Spotted Turtles during 2007.



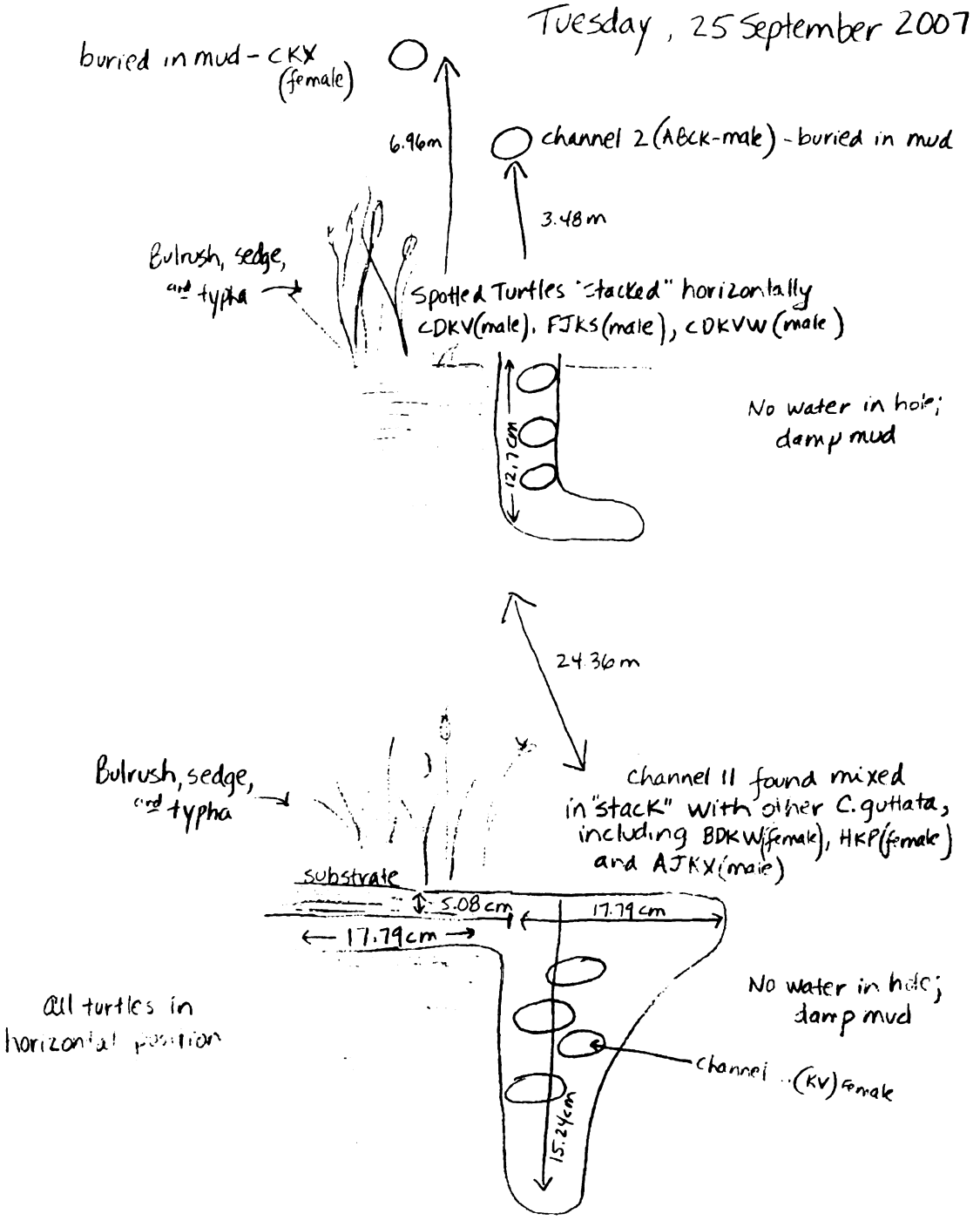
*Hectares: 10.69; Acres: 26.42

Figure 59. Main aggregations of Spotted Turtles during 2008.



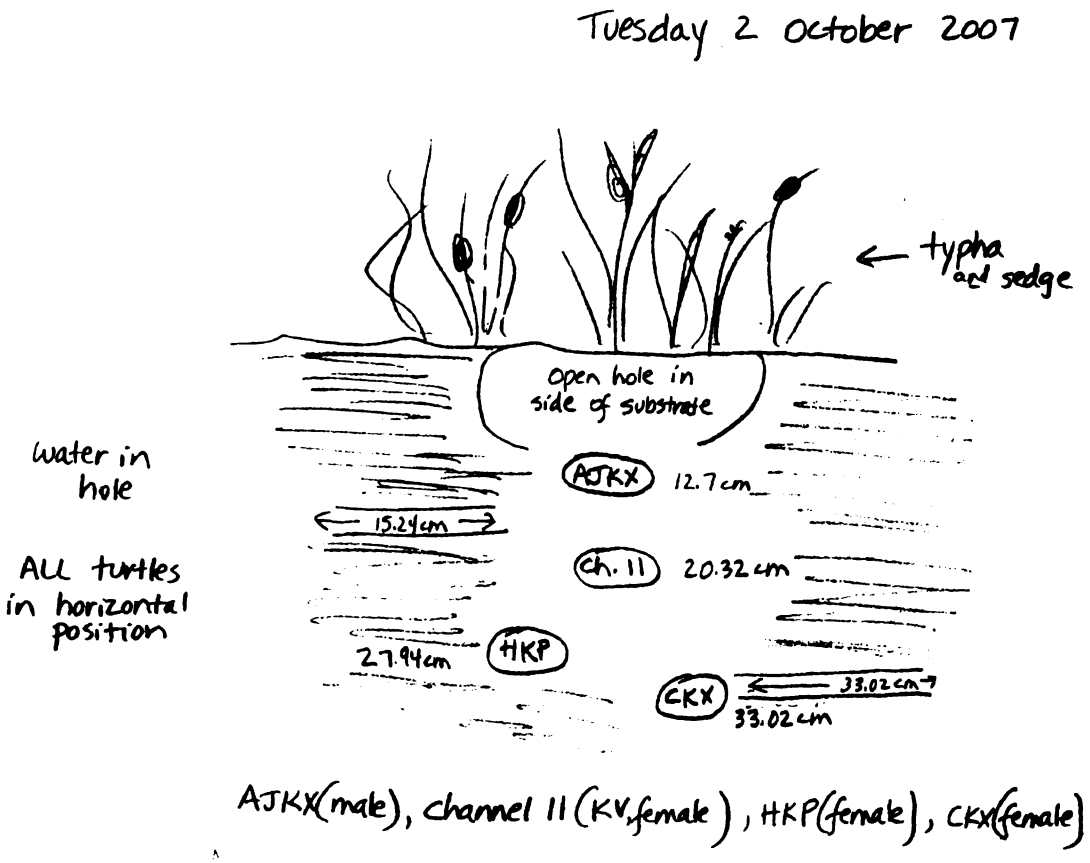
*Hectares: 12.02; Acres: 29.71

Figure 60. 25 September 2007 possible hibernaculum.



*Hand-drawn diagram by Diana Lutz.

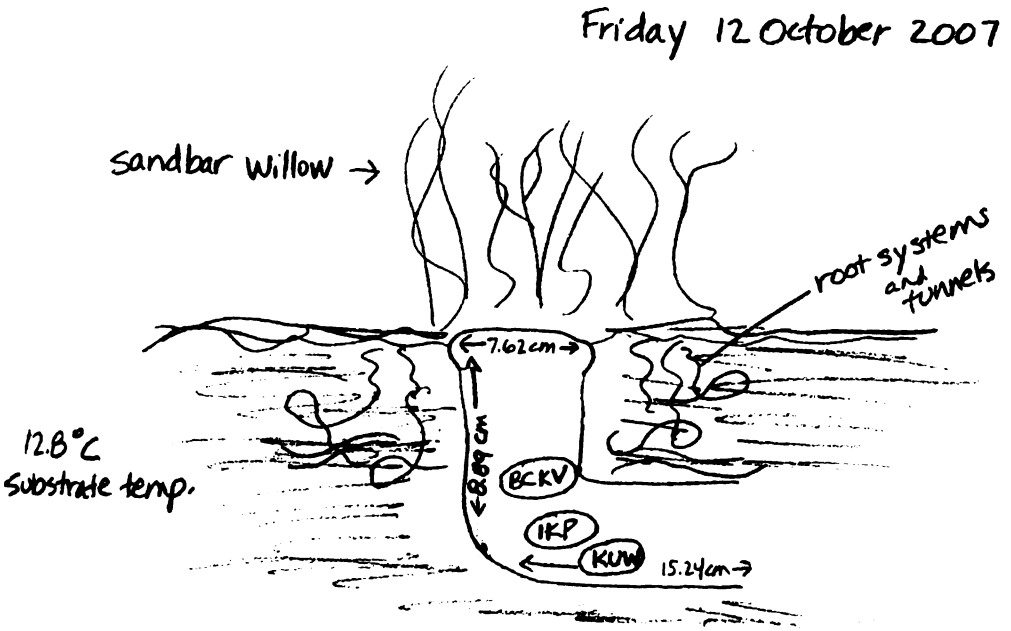
Figure 61. 2 October 2007 possible hibernaculum.



Note: On 25 September 2007, AJKX, channel 11, and HKP were located in a different hole, 2.88 m from present location. A fourth turtle, BDKW (female) was observed with the 3 turtles. BDKW was unable to be located today. CKX (female) that was observed today was observed on 25 September 2007 approximately 31.32 m from AJKX, channel 11, and HKP.

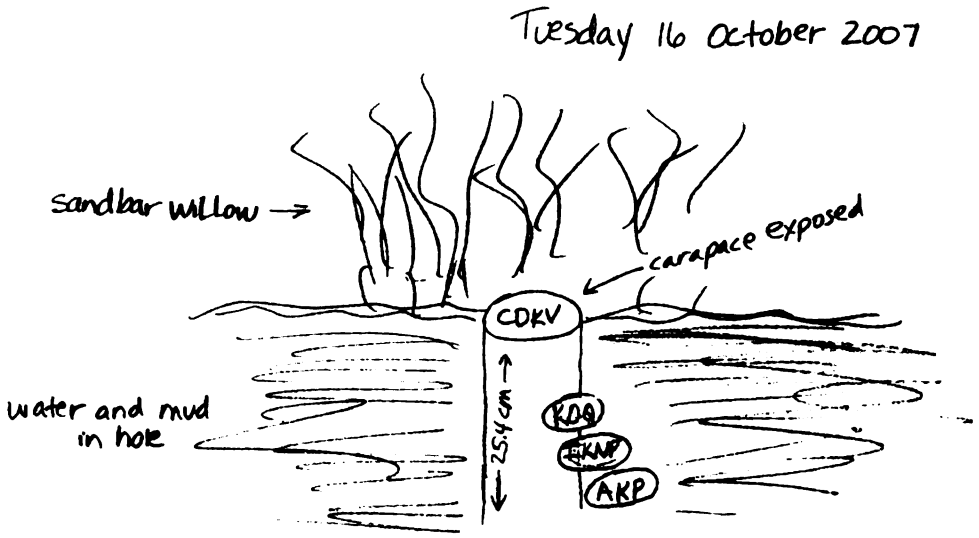
*Hand-drawn diagram by Diana Lutz.

Figure 62. 12 October 2007 possible hibernaculum.



*Hand-drawn diagram by Diana Lutz.

Figure 63. 16 October 2007 possible hibernaculum.



Note: change in shell temps as turtles get deeper into substrate.

CDKV (male) 14.5°C shell temp.
KOQ (Juv) 14.5°C shell temp.
IKNP (female/Juv) 15.5°C shell temp.
AKP (female/Juv) 16.7°C shell temp.

*Hand-drawn diagram by Diana Lutz.

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