DIET, HABITAT USE, AND REPRODUCTION CHARACTERISTICS IN AN OHIO POPULATION OF BLANDING'S TURTLE (*EMYDOIDEA BLANDINGII*) IN A LAKE ERIE COASTAL PLAINS MARSH

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ABSTRACT

There is a paucity of information reported for Blanding's Turtle (*Emydoidea blandingii*), a Species of Concern in Ohio, despite its precarious status in the state. This study aims to provide information of an autecological nature concerning aspects of the diet, habitat use, and reproduction in an Ohio population of this rare species for conservation management purposes. In 2006–2007, feeding activity of turtles in this population occurred from April through September, with peak feeding from May through July. Feeding appeared to be opportunistic and a size discrimination of items approximately ≥1 cm was observed. Diet was comprised of approximately 75% lymnaeid snails with decreasing contributions from insects, crayfish, leeches, and fish. Diets of males and females largely overlapped, but possible differences in food item preferences were observed. Dietary diversity and evenness varied among individuals with some individuals displaying a greater tendency toward specialization on lymnaeid snails. Habitat use varied seasonally, with palustrine emergent marsh (PEM) being the dominant habitat utilized in all seasons, but particularly during the active feeding period. Feeding habits were observed to vary according to month of the year and the microhabitat individuals were located in. The distribution of potential food items (≥1 cm) varied across wetland classes and PEM habitat was observed to hold the greatest number of potential food items. Although trapping of peripheral habitats was not targeted, current data suggests recruitment may be very low as no juveniles have been found since work with this population began in 2003. Nesting was observed to take approximately eight hours (from construction to completion) and nests were observed to be shallower than reported elsewhere for *E. blandingii*. Flooding and heavy soils were observed to have a negative effect on nest success and egg survivorship, and potential predator activity was observed around nearly every nest covered by protective screens. Of six protected nests, two were observed to successfully produce hatchlings. Radio telemetry revealed a wide dispersal pattern of hatchlings toward both aquatic and upland environments. Additionally, fall feeding by hatchling turtles was observed to have taken place prior to hibernation. The adult population was found to be significantly skewed toward males (3.7:1). This trend, along with characteristics of soil and land-use practices in upland nesting habitat, provide a potential explanation for the observed lack of juvenile recruitment.

Management plans aimed at conserving *Emydoidea blandingii* populations in Ohio should concentrate on maintaining diverse wetland habitats with an emphasis on emergent vegetation. Furthermore, suitable upland habitat must be maintained to ensure reproductive success for this species. The long life-span of *E. blandingii* is an adaptation that may have allowed the species to persist in degraded ecosystems; however, it may also mask the precarious position of this species throughout its range. Despite the ability of adult turtles to persist over time in marginally-suitable habitats, lack of sufficient recruitment could ultimately result in a slow, undetected dwindling of populations below sustainable levels. It is the opinion of the principle researcher that survey work is vitally needed for this species throughout its current and historical range in Ohio to more accurately determine the status of this species in the state.

INTRODUCTION

Blanding's Turtle (*Emydoidea blandingii*), currently resides as the lone representative of the genus *Emydoidea.* Although recent molecular data suggests *Emydoidea* may belong to and could be grouped in the genus *Emys* (Feldman and Parham, 2002), this study will defer to the conclusions of the Society for the Study of Amphibians and Reptiles (SSAR) in maintaining *Emydoidea* as a distinct genus (Crother et al., 2003). *Emydoidea blandingii* occurs in 15 states in the U.S. and in the provinces of Quebec, Ontario, and Nova Scotia in Canada (Fig. 1). Of those 15 U.S. states, the species has garnered state conservation status in 14 states. It is listed as Endangered in 4 states (Indiana, Maine, Missouri, and South Dakota), Threatened in 6 states (Iowa, Illinois, Massachusetts, Minnesota, New York, and Wisconsin), and a Species of Concern in 4 states (Michigan, New Hampshire, Ohio, and Pennsylvania) (Bandas and Higgins, 2004; www.state.in.us/dnr/fishwild; www.maine.gov/ifw/wildlife; http://mdc.mo.gov; www.iowadnr.com; www.dnr.state.il.us; www.mass.gov/dfwele/dfw; www.dnr.state.mn.us; www.dec.ny.gov; http://dnr.wi.gov; www.michigan.gov/dnr; www.wildlife.state.nh.us; www.dnr.ohio.gov; www.dcnr.state.pa.us). In Pennsylvania, where the early 19th century Philadelphia naturalist William Blanding first described the species, it has been proposed that *E. blandingii* be designated as extirpated from the state (www.dcnr.state.pa.us). The only U.S. state in which *E. blandingii* is currently considered Secure is Nebraska (www.ngpc.state.ne.us/wildlife). In Canada, the species is listed as Threatened in Quebec and Ontario, and is Endangered in its easternmost population of Nova Scotia (a disjunct population believed to be a relict group isolated during the last glacial period) (www.cosewic.gc.ca).

Accounts from the first third of the 20th century report that *Emydoidea blandingii* was once abundant in Ohio in the marshes along Lake Erie, especially in areas between Toledo and Sandusky (Conant, 1938). Although the species has been found in every county bordering Lake Erie in Ohio; that range has been drastically reduced such that the species is now almost entirely limited to the northwestern counties and is decidedly less common. Numbers have been reduced and whole populations have been extirpated largely as a result of habitat loss and over-collecting. Prior to 1850, an extensive coastal marsh and swamp system covered an area between Vermillion, Ohio and the mouth of the Detroit River extending up the Maumee Valley into Indiana (Fig. 2). This massive wetland complex blanketed most of the Lake Plains area in the northwest corner of Ohio, an area which encompassed the majority of this species' range in Ohio (Fig. 3). Presently, that area once called the Great Black Swamp has been drained from 4,000 km^2 to just 100 km^2 and much of these remaining wetlands are encompassed and managed behind dikes (Herdendorf, 1992). Such a drastic decline of the type of habitat vital to the survival of *E. blandingii* does not bode well for a slow-growing, late-maturing species such as this.

The Ohio Division of Wildlife defines a Species of Concern as *"A species or subspecies which might become threatened in Ohio under continued or increased stress. Also, a species or subspecies for which there is some concern but for which information is insufficient to permit an adequate status evaluation"* (www.dnr.ohio.gov). It is this scarcity of information that drives the urgency for studies of this type. Before any plans can be made to manage this species in the state of Ohio, a working knowledge of their ecology in this region should be established. This study focuses on aspects of diet, habitat selection, and reproductive ecology for a population of *Emydoidea blandingii* at Winous Point Marsh (WPM), a Lake Erie coastal plain marsh within northwest Ohio. The diet of turtles and the ability to reproduce successfully are two characteristics believed to be directly tied to the quality of the habitat, and thus, the overall sustainability of a population. The ultimate objective of this study is to provide an ecological foundation for conservation and potential restoration of *E. blandingii* in the marshes of the Lake Erie coastal plain and tributary watersheds of Ohio. Through research of an autecological nature, crucial information about the requirements necessary to sustain viable populations of this species may be gained.

BACKGROUND

Emydoidea blandingii, is a long-lived member of the Family Emydidae. The species is distinguished from all other species in its range by its bright yellow chin and throat. The carapace is a moderately high-domed, elongate shape with a variable pattern of lighter spots or streaks on a darker background. An adult carapace typically measures 15.2 to 27.4 centimeters. The plastron is yellowish with a large dark spot in the outer posterior corner of each scute and exhibits a hinge with variable amounts of flexibility among individuals. The neck is long and the rather square-shaped head is flat on top. The upper jaw is notched at the posterior angle of the mouth. Sexes are determined by the location of the cloaca relative to the posterior margin of the carapace (beyond the edge in males). In addition, males typically exhibit a concave plastron and more dark pigment on the lower jaw (Cahn, 1937; Conant, 1938; Ernst and Barbour, 1972; Ernst et al., 1994; Harding, 1997).

The habitat of *Emydoidea blandingii* is typically clean, shallow water habitats with abundant aquatic vegetation. The preferred substrate is characterized by some soft organics with a relatively firm base. These habitats include: lakes, ponds, marshes, bogs, swamps, creeks, wet prairies, and sloughs; usage of these habitats often varies according to the time of year (Conant, 1938; Ernst and Barbour, 1972; Ernst et al., 1994; Harding, 1997).

This paper will investigate three major ecological aspects in an Ohio population of *Emydoidea blandingii:* diet, habitat use, and reproduction. 1) The diet portion of this paper will consider variations in diet according to the time of year, sex of the turtles, individual preferences, and location within the available marsh habitat that turtles were collected in. 2) The habitat use portion of the paper will include seasonal patterns of movement observed, the seasonal use of available habitat, and patterns in individuals' movement and range. 3) The reproduction portion of this paper will encompass population structure, female nesting behaviors, nest site characteristics, incubation time and temperatures, outcome of nests, hatchling characteristics, post-emergence hatchling movements, and hatchling survivorship.

DIET:

Emydoidea blandingii is omnivorous; but while the inclusion of plant matter has been identified in all diet studies, the diet is reported as primarily carnivorous (Lagler, 1943; Bleakney, 1963; Kofron and Schreiber, 1985; Rowe, 1992a). The diet has been described as consisting predominately of crayfish (Lagler, 1943; Kofron and Schreiber, 1985), and may include other crustaceans, snails, clams, leeches, insects, fish (and eggs), amphibians, birds, and plant matter. Some debate has existed as to the possibility and frequency with which *E. blandingii* may feed out of water. Cahn (1937) reported that grasses, leaves, berries, other succulent vegetation, insect larvae, grubs, slugs, and earthworms were consumed on land. However, most recent data suggests the species is primarily aquatic. Lagler (1943), who dissected the stomachs and colons of 66 individuals collected in Michigan (from May–September), identified crayfish as making up 56.6% of the total volume in stomach contents while having been present in 74.5% of those samples (60.1% volume and 85.4% occurrence for colon samples). Penn (1950), in citing Lagler's results, noted the importance crayfish may hold as an available food item due to the enormous biomass they can hold in optimal habitats. The balance of the diet in Lagler's stomach content analysis was rounded out by insect (21.4%), bird (5.6%), fish (5%), "carrion" (4.7%), mollusk (2.6%), and vegetable debris (2.2%) for percent total volume. Kofron and Schreiber's (1985) contribution, the results of 15 turtles in Missouri, reported crayfish as the most important food item (according to frequency of occurrence) being present in 73.3% of the samples and making up 23.9% of the total food items identified. Insects made up 52.2% of the total items, and were identified in 6 of the 15 samples (40%). Fish, fish eggs, frogs, and plant matter were also identified in the 15 samples. Kofron and Schreiber's stomach contents were gathered from 3 April through 16 July, and then 15 August through 18 September; however, trapping ran continuously from mid-September 1980 through mid-November 1981 (excluding January through mid-March). Consequently, periods during this 14 month trapping duration, when stomach contents were successfully collected, were deemed to be periods of active feeding and was believed to be correlated to water temperature (beginning with sustained temperatures of 18°C in April, pausing in May when temperatures fell below 9°C, pausing again during high temperatures in mid-July, resuming in August when temperatures fell to 21°C, and finally ceasing in September when temperatures fell below 17°C). A similar biphasic feeding pattern was reported by Rowe (1987) for individuals in an Illinois population.

Rowe (1992a) reported that pulmonate snails, rather than crayfish, were the dominant food item in northeastern Illinois, making up 35% of the total volume for stomach contents flushed from 22 *Emydoidea blandingii* individuals (late March–November). Rowe also reported that crayfish (19.3%), earthworms (12.7%), insects (10.3%), and vertebrates (5.9%) made up the remainder of the total volume for stomach contents. The most frequent items reported in stomach contents were gastropods (45.4%), insects (45.4%), and vertebrates including: fish; anurans; and birds (31.8%). He identified plant matter in 56.1% of samples (always in association with animal matter), and it made up only 12.3% of the total volume. Additional analyses from fecal samples produced similar results with the exception that food items with more hard parts yielded higher values than softer bodied items. Rowe concluded that crayfishes' diminished role in the diet of this population may be a function of their abundance in the habitat. Observations of feeding activity were made at water temperatures as low as 14.1°C (Rowe, 1987). Quantitative dietary studies like these are also augmented by the sort of qualitative information gathered by Graham and Doyle (1977) who observed *E. blandingii* consuming Golden Shiners (*Notemigonous crysoleucas*), Brown Bullheads (*Ameiurus nebulosus*) and plant matter in Massachusetts. In Nova Scotia, where crayfish are not known to occur, their diet consists primarily of snails, insects, and fish (Bleakney, 1963).

The purpose of this study is to obtain quantitative data from a portion of this species' range (Ohio) which has yet to be reported in the literature and which may experience a difference in available food items. Furthermore, this study looks to elucidate seasonal trends in diet composition as well as detect any preferential feeding by habitat type. The information gathered may provide insight into seasonal movements between habitat types which could be driven by the seasonal dietary makeup of these turtles. As such, contents will be analyzed according to location of the individual within the available microhabitats (e.g., in varying vegetative cover types). Diet data will also be used to compare differences between individuals and the diets of males versus females. In addition, it should ascertain/confirm the diet of turtles in this Ohio population during times implied as inactive feeding periods.

HABITAT USE:

Studies that have monitored populations in Indiana, Michigan, Wisconsin, Missouri, Illinois, and Minnesota indicate that activity takes place roughly between emergence in late-March/early-April and hibernation in late-October/early-November (Evermann and Clark, 1916; Gibbons, 1968; Vogt, 1981; Kofron and Schreiber, 1985; Rowe, 1987; Ross and Anderson, 1990; Rowe and Moll, 1991; Pappas et al., 2000; Piepgras and Lang, 2000). Radio telemetry data from northeastern Illinois suggests that animals become active in late March when water temperatures are as low as 10°C (Rowe and Moll, 1991). In Wisconsin, Ross and Anderson (1990) observed turtles entering overwintering sites from late September to late October, and hibernation occurred when water temperatures ranged from 10–13°C. Additionally, it has been shown that activity may not completely shut down in winter and individuals may frequently change locations (Kofron and Schreiber, 1985). Individuals have even been observed moving under the ice during winter months (Conant, 1938). Nevertheless, little or no movement is observed at the coldest temperatures and water temperatures appear to play a large role in activity. Consequently, activity patterns probably vary slightly from year to year and from location to location (Sajwaj and Lang, 2000).

In Illinois, individuals predominately occupied cattail marsh habitat and used habitat types disproportionately to their availability. Males were also observed to utilize pond habitat more than females and juveniles (Banning, 2006). Similarly, in Wisconsin individuals were observed to utilize ponds more often than predicted by availability. These ponds were usually <60 centimeters deep and characterized by beds of aquatic vegetation. Individuals then traveled to “deep water ponds” for winter hibernacula, but water depths at overwintering sites were not significantly different from depths at summer activity centers (Ross and Anderson, 1990). In Minnesota, individuals were observed to hibernate underwater at a depth of 1–1.5 meters (Sajwaj and Lang, 2000). Although individuals in Maine were observed to use multiple wetlands throughout the year, there did not appear to be a seasonal pattern to habitat use in that population (Joyal et al., 2001). Sites reported to be used as hibernacula for overwintering include ponds, channels, and creeks (Cahn, 1937; Rowe, 1987; Ross and Anderson, 1990); as well as shallow areas of marshes (Kofron and Schreiber, 1985; Banning, 2006). However, terrestrial locations have also been recorded as hibernation sites (Rowe, 1987; Conant, 1938; Rowe and Moll, 1991; Banning, 2006), and typically involved burrowing into moist substrate and debris.

Individuals of *Emydoidea blandingii* are known to occupy well-defined activity centers within a homerange. A homerange is characterized as the total area occupied by an individual, and within that homerange areas of restricted movements make up activity centers which an individual utilizes over an extended period. Sizes of these activity centers and homeranges can vary among individuals, between populations, or both; and may be related to characteristics of the habitat available and density of the population (Rowe, 1987; Ross and Anderson, 1990; Rowe and Moll, 1991; Piepgras and Lang, 2000; Grgurovic and Sievert, 2005; Banning, 2006). Piepgras and Lang (2000) reported that the size of homeranges for males and females did not differ, but males tended to have more activity centers than females. Moreover, activity centers and homeranges of males and females, as well as same sexes have been observed to overlap (Rowe, 1987; Ross and Anderson, 1990; Piepgras and Lang, 2000). Individual turtles have also been observed to use the same areas from one season to the next (Rowe, 1987; Piepgras and Lang, 2000).

In many studies, juveniles are encountered infrequently, and may employ different behaviors and/or utilize separate habitats from adults (Gibbons, 1968; Graham and Doyle, 1977; Kofron and Schreiber, 1985; Ross, 1989; Congdon et al., 1993; Germano et al., 2000; Joyal et al., 2000). In Minnesota, juveniles primarily utilized habitats with emergent sedge, and Alder (*Alnus rugosa*) hummocks (Pappas and Brecke, 1992). McMaster and Herman (2000) found that juveniles and sub-adults occupied similar microhabitats to adults in Nova Scotia, but that their activity was concentrated in areas with moderate to highly dense *Sphagnum* dominated vegetation. Juveniles from western Nebraska were found to utilize the shallow waters and dense vegetation of small ponds and marshes, rather than lakes, proportionately more than adults (Bury and Germano, 2003). In Illinois, juveniles used few habitats and made shorter movements than adults (Banning, 2006).

Understanding the habitat requirements of a species is essential to efforts aimed at its conservation. Moreover, it is important to understand the range of habitats associated with different aspects of this species’ life history. In particular, this study is concerned with how habitat is used in relation to feeding activity and reproduction. Gathering information about habitat preferences, and potential seasonal movements between habitat types, will be important if we are to construct a successful management plan for the conservation of this species in Ohio.

REPRODUCTION:

The reproductive ecology of *Emydoidea blandingii* has been described for populations in Wisconsin, Michigan, Massachusetts, Minnesota, Maine, Illinois, Nebraska, Ontario, and Nova Scotia (Bleakney, 1963; Graham and Doyle, 1977; Graham and Doyle, 1979; Congdon et al., 1983; DePari et al., 1987; Rowe, 1987; MacCulloch and Weller, 1988; Linck, 1989; Ross and Anderson, 1990; Congdon and van Loben Sels, 1991; Rowe and Moll, 1991; Rowe, 1992b; Congdon et al., 1993; Congdon and van Loben Sels, 1993; Butler and Graham, 1995; Standing et al., 1997; Standing et al., 1999; Congdon et al., 2000; Joyal et al., 2000; Pappas et al., 2000; Standing et al., 2000; Banning, 2007). The longest running of these studies, with a population at southeast Michigan's E. S. George Reserve, has been ongoing since 1975. Maturation of females has been shown take 14–20 years or until carapace length reaches a measure of approximately 16.3 centimeters in Michigan (Congdon and van Loben Sels, 1993). This age and minimum size until maturation has been shown to vary from population to population (Graham and Doyle, 1977; Kofron and Shreiber, 1985; Ross, 1989). It appears that smaller maturation sizes and as many as 25 years may be required in more northerly regions. It is uncertain whether this is a product of the length of the growing season; but it seems likely it is tied to water temperature, food availability, or perhaps genetic control (Germano et al., 2000; COSEWIC, 2005).

Mating has been observed from March–November, but is most common from March–July (Ernst and Barbour, 1972; Graham and Doyle, 1979; Vogt, 1981). Females of related emydid species have been known to store sperm for more than two years (Gist et al., 2001) and individual clutches of *Emydoidea blandingii* are regularly sired by multiple males (Osentoski, 2001). Nesting generally takes place from late May–early July and may vary annually and geographically (Bleakney, 1963; Congdon et al., 1983; Rowe and Moll, 1991; Rowe, 1992b; Pappas et al., 2000). Ideal sites for nesting are in open, sunny spots with moist but well-drained loamy or sandy soil (Ernst and Barbour, 1972; Ross and Anderson, 1990; Harding, 1997; Congdon et al., 2000). However, nesting habits may be dictated by the character of the nesting habitat available. For example, in Nova Scotia *E. blandingii* typically nests on pebble beaches (Standing et al., 1999) and individuals in Maine were observed to nest in soil-filled cracks in the bedrock (Joyal et al., 2000).

Nesting activity has been shown to take place predominately in the evening hours and is usually completed by midnight (Congdon et al., 1983; Linck et al., 1989; Power, 1989; Standing et al., 1999; Congdon et al., 2000; Banning, 2007). Nesting females often make long treks over land when selecting nest sites, and individuals typically seek out dense vegetative cover during daytime hours. Females in Michigan may remain on land for 2–7 days to complete nesting (Congdon et al., 1983), and 5–17 days was observed in Illinois (Rowe, 1987; Rowe and Moll, 1991). During this time incomplete nest excavations are often attempted (Rowe, 1987; Standing et al., 1999; Joyal et al., 2000; Banning, 2007). Completed nests are flask-shaped and about 18 centimeters deep by 18 centimeters wide with a narrowed 7.5–10 centimeter opening

(Ernst et al., 1994). In Nova Scotia where nesting occurred on pebble beaches nests were reported to be approximately 12 centimeters deep (Standing et al., 1999). Nest site fidelity has been shown for *Emydoidea blandingii* in Michigan, Nova Scotia, and Maine (Congdon, 1983; Power, 1989; Standing et al., 1999; Joyal et al., 2000). Females typically lay one clutch per year, although Refsnider and Schlick (2006) recently reported an individual depositing two clutches in one season. Additionally, while some females nest annually, less than annual reproduction has been reported for a portion of the females in a number of populations (Congdon, 1983; Pappas et al., 2000; Congdon and Keinath, 2006; Banning, 2007). This trend likely varies from one population to another as the frequency of nesting has been shown to be significantly higher among older individuals in a population (Congdon et al., 2001). Clutch size averages 10–15 eggs but can vary from 3–22 eggs (Congdon et al., 1983; DePari et al., 1987; MacCulloch and Weller, 1988; Congdon and van Loben Sels, 1991; Rowe, 1992b; Congdon and van Loben Sels, 1993; Butler and Graham, 1995; Standing et al., 1999; Pappas et al., 2000; Banning, 2007). Common nest predators include raccoons (*Procyon lotor*), foxes (*Urocyon* and *Vulpes sp*.), skunks (*Mephitis mephitis*), opossums (*Didelphis virginiana*), shrews, and ants. Other nests may be destroyed by droughts, flooding, and root intrusion (Congdon et al., 1983; Standing et al., 1999; Congdon et al., 2000). Incubation times range from just 47.4 days at a constant temperature above 30°C in the laboratory (Ewert, 1979) to 128 days in a natural nest in Nova Scotia (Standing et al., 1999). Hatchlings emerged from natural nests in Michigan from the middle of August to early October after 65–110 days (n = 59; mean = 85) of incubation (Congdon et al., 2000). Emergence generally takes place between

10:00 and 15:00 and may be either synchronous or asynchronous over several days. Congdon et al. (1983) observed that an average of 2.2 eggs per nest failed to hatch in Michigan. Measurements of hatchlings reported for Michigan between 1975 and 2001 averaged 35.0 millimeters carapace length (min = 26.0 mm; max = 39.0 mm), 31.2 millimeters plastron length (min = 25.0 mm; max = 33.9 mm), and 9.1 grams (min = 5.0 g; max = 13.0 g) in body wet mass (Congdon and van Loben Sels, 1991; Congdon and Keinath, 2006). Reported measurements of hatchlings (from both natural nest and laboratory incubation) from populations in Nova Scotia, Massachusetts, Nebraska, Ontario, Maine, Minnesota, and Illinois are comparable to those reported for Michigan (Bleakney, 1963; Graham and Doyle, 1979; Gutzke and Packard, 1987; Power, 1989; Butler and Graham, 1995; Standing et al., 1997; Packard et al., 1999; Joyal et al., 2000; Packard et al., 2000; Pappas et al., 2000; Dinkelacker et al., 2004; Banning, 2007).

Emydoidea blandingii exhibits Temperature Sex Determination (TSD), meaning that the incubation temperature within the nest determines the sex of the hatchling opposed to genetic control over sex determination (GSD). TSD is exhibited in two basic patterns: Pattern I (in which species display a single threshold temperature) and Pattern II (in which species display an upper and a lower threshold temperature). At the threshold temperature a sex ratio of 1:1 is produced and there is generally an abrupt change in the sex ratio in a narrow range above or below this temperature (Vogt and Bull, 1982). Thus, this threshold temperature is a pivotal temperature at which one sex is produced above and the other is produced below. Within Pattern I there are two expressions: Ia and Ib. Pattern Ia species produce females above the threshold temperature, whereas Pattern Ib species produce males. *Emydoidea blandingii* is a Pattern Ia species. Specifically, the female sex for *E. blandingii* is produced at a constant incubation temperature of 30°C and higher, whereas males are produced at 100% frequency when incubated at a constant temperature of 22.5°C. At temperatures between 25°C and 30°C, the sex ratio is split with increasing proportions of females produced as the temperature approaches 30°C (Gutzke and Packard, 1987; Ewert and Nelson, 1991). The critical developmental period for which sex is determined by temperature is referred to as the thermosensitive period (TSP), which Pieau and Dorizzi (1981) reported as stages 16–21 (the middle third of development) for the European Pond Turtle (*Emys orbicularis*), a closely related species. Additionally, Bull and Vogt (1981) determined that stages 16–22 for two turtle species (*Chrysemys picta* and *Graptemys ouachitensis*) also in Family Emydidae, correspond to the TSP. However, to complicate this matter, incubation temperatures found in the wild are never held constant, but rather follow a diel pattern with temperatures rising sharply during the day and falling by night. The sex ratio of natural turtle nests has been associated with both: 1) hours per day above the pivotal temperature and 2) the mean and variance of nest temperature; during the TSP (Bull, 1985). Factors that have been shown to strongly influence nest temperatures, embryonic development, and sex ratio include shading and depth of the nest (Valenzuela, 2001). Additionally, precipitation and characteristics of the soil may also play a role. As a result, the environment has the ability to greatly influence developmental temperature, and thus the sex ratio found in a population. In addition to the role incubation temperature plays in TSD species, incubation temperature has also been shown to influence other phenotypic characteristics. By studying species of turtle which exhibit GSD, a number of studies have linked traits such as hatchling morphology, locomotor performance, and growth with incubation temperature independently of any effect on sex determination (Rhen and Lang, 2004). Furthermore, it has been shown that extremes in incubation temperatures may lead to decreased fitness of hatchling turtles (Ewert and Nelson, 1991; Standing et al., 2000). Standing et al. (2000) recorded developmental abnormalities in *E. blandingii* hatchlings from natural nests incubated at cooler temperatures in Nova Scotia. Abnormalities were also observed by Graham and Doyle (1979) in Massachusetts when eggs were incubated at room temperature. When incubated at a constant temperature below 22°C, embryos of *E. blandingii* did not complete development (Gutzke and Packard, 1987). Consequently, the future reproductive success of a population is closely tied to the environmental conditions of available nesting habitat. Because temperature has the ability to play such a vital role, and because conditions found within available nesting habitat can vary widely, incubation temperature of natural nests deserves closer inspection. For this reason, this study also monitors the temperature at which natural nests of *E. blandingii* were incubated at in an Ohio population. The quality of nesting habitat is certain to vary across this species' range and may be crucial to future survival of populations in some areas. By tracking females in Ohio, we may begin to determine whether nesting behaviors are congruent with those of populations studied in other states and ascertain the quality of nesting habitat available to turtles in this region.

Turtles which successfully hatch must find suitable habitat in which to survive imminent cold weather and the first precarious years of life. The post-emergence behavior of hatchling turtles can be difficult to study. The water-seeking behavior of hatchling sea turtles is well documented, but few studies have actually tracked hatchling freshwater turtles. It has generally been assumed that hatchling freshwater turtles, like their marine relatives, head for water after emergence from the nest (Ehrenfeld, 1979). The information available on the post-emergence behavior of *Emydoidea blandingii* is limited and much speculation remains. Sixty-three hatchlings in Massachusetts were dusted with fluorescent powder and tracked for up to 24 days from 25 August to 6 October (Butler and Graham, 1995); of those, most were tracked to just their first form (shallow burrows in the available vegetation, leaf litter, or other substrate), but nine individuals from seven nests were tracked from nest to water over 12 hours to 9 days. Mean distance traveled per day by these nine hatchlings was 71.2 meters. Hatchlings were observed to enter wetlands distinct from known adult and sub-adult activity centers and overlapping between trails of siblings and unrelated neonates was suggested to be linked to olfactory clues. While Butler and Graham (1995) maintain that hatchlings sought out standing water prior to hibernation, they do not rule out the possibility that some individuals may remain in terrestrial environments. Standing et al. (1997) tracked 78 hatchling *E. blandingii* using fluorescent powder in Nova Scotia under the assumption that late emergence patterns in more northerly populations should show strong selection for water-seeking behavior to avoid freezing. Hatchlings were tracked for a maximum of 11 days and were not observed to orient themselves with respect to slope, vegetation, or nest-mates; and paths did not follow consistent compass bearings among days. Results suggested that hatchlings in this population may overwinter in both terrestrial and aquatic habitats.

The question was then revisited under a controlled setting to determine how the proximity to water and shrub cover influenced movements (McNeil et al., 2000). The likelihood of entering water was not found to be affected by the proximity of water to the release location; but the likelihood of entering shrubs was significantly increased by the proximity of shrubs to the release location. These results again supported the possibility that *E. blandingii* hatchlings may over-winter in terrestrial habitats. Captures of hatchlings on land in the spring offer additional evidence for terrestrial hibernation (Congdon et al., 2000; Pappas et al., 2000).

If hatchling *Emydoidea blandingii* do in fact overwinter in terrestrial environments, another question begs further investigation. Unlike some other turtle species (*Chrysemys picta* and *Chelydra serpentina*), which are common throughout the range of *E. blandingii,* overwintering in the nest by *E. blandingii* seldom takes place. This is believed to be due to the limited freeze tolerance of this species. So why then would hatchlings emerge in the fall and attempt to hibernate in terrestrial sites? Neonates from Minnesota were observed to possess an equilibrium freezing point for body fluids around -0.7°C (Packard et al., 2000). Under dry conditions they were capable of supercooling to -6°C before spontaneously freezing, but -4°C was the approximate limit for survival and recovery. Additionally, hatchlings were shown to survive freezing at -2°C for at least 48 hours (Packard et al., 1999). Consequently, Packard et al. (2000) determined that contact with ice crystals would result in fatal freezing only slightly below the equilibrium freezing point, and that this might explain why *E. blandingii* neonates do not overwinter in the nest. Somewhat contrary to Packard et al. (1999, 2000), Dinkelacker et al. (2004) found neonate *E. blandingii* were capable of surviving 72 days at -3.5°C, indicating that hibernation in terrestrial habitats may indeed be possible. Rather than supercooling, as contact with ice crystals yielded similar results to Packard et al. (1999, 2000), they were believed to survive by increasing plasma concentrations of lactate and glucose. Furthermore, Dinkelacker et al. (2005) tested neonates of *E. blandingii,* in comparison with neonates of *C. serpentina* and *Apalone spinifera* (another turtle species common in the range of *E. blandingii*), for survival and physiological responses to submergence in normoxic and hypoxic water conditions (at 4°C). They found that *E. blandingii* were not particularly well suited to hibernation in normoxic or hypoxic aquatic habitats. In order for hatchlings to hibernate in aquatic habitats they suggest that they would utilize highly oxygenated microhabitats such as the edges of ponds where they could gain access to air during intermittent thaws (Dinkelacker et al., 2005). Alternately, hatchlings hibernating on land would be expected to seek out moist, friable soils beneath vegetation or cover objects where they could avoid dehydration and severe cold (Dinkelacker et al., 2004). Presumably, this microhabitat is not suitably achieved by overwintering in the nest chamber. The survival of hatchling turtles subsequent to emergence from the nest is at the heart of conservation for this species. The scarcity of information currently available in the literature presents a major gap in our understanding of the life history of *E. blandingii.* By tracking the early movements of hatchling turtles in this population, some light may be shed on those early and rarely observed behaviors.

MATERIALS AND METHODS

The study took place at the private wetland complex of the Winous Point Marsh Conservancy, a 2,000 hectare marsh system surrounding Muddy Creek Bay along the southern shore of Lake Erie in Ottawa County, Ohio (Fig. 4). Winous Point Marsh (WPM) is part of the Maumee Lake Plains located within the greater Huron-Erie Lake Plains physiographic region of Ohio. The region is characterized by clay, silt, and wave-planed clayey till from the Pleistocene epoch. Part of an ice-aged lake bed, it is a region of very low relief which was formerly part of the Great Black Swamp (Brockman, 1998). From Ohio Endangered Bald Eagle (*Haliaeetus leucocephalus*) and Northern Harrier (*Circus cyaneus*), to Threatened Pondhorn Mussel (*Unimerus tetralasmus*) and Black-crowned night-heron (*Nycticorax nycticorax*), the high quality habitat of WPM supports populations of a number of species considered rare elsewhere in the state. It is also home to other rare reptiles listed as Species of Concern in Ohio, including the Eastern Fox Snake (*Pantherophis gloydi*) and melanistic Eastern Garter Snake (*Thamnophis sirtalis*). The marshes are made up of a system of dikes on the bay, and are managed year-round for waterfowl. The dikes shield the marsh from the effects of wave action in the open bay and serve to protect wetland vegetation, and promote water clarity and improved detrital habitat (Kroll et al., 1997). Severe storms, intense wave action, and rapid water level changes experienced in Lake Erie likely would have eroded away much of the wetland vegetation in this area if it were not for the system of dikes in place (Herdendorf, 1992). Water levels behind the dikes are controlled by a series of gates and may be raised or lowered for both wildlife and invasive species management. The site is characterized by emergent vegetation including: Narrow-leaved Cattail (*Typha angustifolia*); Giant Burreed (*Sparganium eurycarpum*); Soft-stem Bulrush (*Scirpus validus*); Swamp Rose Mallow (*Hibiscus moscheutos*); Phragmites (*Phragmites australis*); Reed Canary Grass (*Phalaris arundinacea*); Flowering Rush (*Butomus umbellatus*); Pickerelweed (*Pontedaria cordata*); Arrowhead (*Saggitaria latifolia*); and Smartweed (*Polygonum sp.*). Aquatic plants abundant in the marsh include: American Lotus (*Nelumbo lutea*); Fragrant Water-lily (*Nymphaea odorata*); Common Bladderwort (*Utricularia vulgaris*); Coontail (*Ceratophyllum demersum*); Duckweed (*Lemna sp.*); Watermeal (*Wolffia sp.*); Greater Duckweed (*Spirodella polyrrhiza*); Mosquito Fern (*Azolla sp.*); Eurasian Water-milfoil (*Myriophyllum spicatum*); and Curly-leaf Pondweed (*Potamogeton crispus*). Trees and shrubs common along the dikes and margins of the marsh are Eastern Cottonwood (*Populus deltoids*), Willows (*Salix sp.*), Buttonbush (*Cephalanthus occidentalis*), and Silky Dogwood (*Cornus ammomum*). The marsh substrate is predominately clay, silt, and organics ranging from relatively firm (2–3 cm) in some areas to very soft in others (and extremely soft, >30 cm, in areas like the canals and deep marsh-channels along dikes). Most of WPM is bordered to the north by agricultural lands with crops ranging from soybean and wheat, to feed corn raised for hunting local wildlife and sale. The mats of vegetation created as lodges and feeding platforms by an abundant Muskrat (*Ondatra zibethicus*) population provides much of the basking sites available to turtles. Additionally, *O.*

zibethicus actively creates openings and paths through dense stands of *T. angustifolia*.

Cleveland Metroparks began research at WPM with limited turtle trapping in 2003 in order to gain information about habitat use as part of an *Emydoidea blandingii* restoration project in the Ohio & Erie Canal Reservation (OEC) of the Cleveland Metroparks. In 1999, a total of four adult *E. blandingii* individuals were found at OEC, and in June of 2000 one of these individuals was observed nesting. The nest was covered with a protective screen and when ten hatchling turtles successfully emerged, six of them were collected and an *E. blandingii* headstarting program began. Subsequent eggs were later harvested from individuals in a population at Sheldon Marsh State Nature Preserve. When the time came to release these headstarted juvenile turtles, it was decided that supplemental research into the habitat requirements and behavior of this species could best be obtained by observing individuals in a more stable population in Ohio. This would ultimately help shape the management plans for a potential restoration of the newly found Cleveland population. Extensive trapping efforts were carried out at WPM in 2004 and 2005. In 2005 the trapping effort was designed to systematically assess habitat use by surveying for *E. blandingii* in all major habitat types present in the north shore region of WPM (Figure 4). Individuals captured at WPM were equipped with radio transmitters and telemetry was used to track movements and habitat preferences in this population. Additionally, an effort to estimate the total availability of different habitat types was undertaken at WPM in 2005. The first tracking and observations of female reproductive behavior also began in 2005. The scope of this paper deals specifically with diet, habitat use, and reproduction in the WPM population and the observations reported here took place primarily in the years of 2006 and 2007. The **diet** portion of this paper will consist of an analysis of stomach contents according to the time of year they were collected, the sex of the turtles, the preferences of individuals, and the location within the available marsh habitat that turtles were collected in. It will also incorporate an assessment of the availability of potential food items at WPM. The **habitat use** portion of the paper will include tracking of individuals to elucidate seasonal patterns of movement, the seasonal use of available habitat, and patterns in individuals' movement and range. The **reproduction** portion of this paper will encompass population structure (pooling all data collected since 2003), female nesting behaviors, nest site characteristics, incubation time and temperatures, outcome of nests, hatchling characteristics, post-emergence hatchling movements, and hatchling survivorship.

Hoop net turtle traps (18) were set throughout the marsh on the west side of WPM north of Muddy Creek Bay (Lattimore, Lily Pond, North Lily Pond, Durban's Bay, and Darr) in May of 2006 (Fig. 5). Utilizing 2004–2005 data (Cleveland Metroparks, unpublished) on habitat use in WPM, trapping sites were chosen to include all the Cowardin wetland cover type classes that *Emydoidea blandingii* were observed to utilize: Palustrine Aquatic Bed (PAB), Palustrine Unconsolidated Bottom (PUB), Palustrine Emergent Marsh (PEM), and Palustrine Forest (PFO) (Cowardin et al., 1979). PAB habitat was characterized by aquatic plants floating at the surface (e.g., *Lemna* and *Nymphaea*) and submersed plants (e.g., *Utricularia* and *Ceratophyllum*). PUB habitat was characterized by open water. PEM habitat was characterized by emergent wetland plants (e.g., *Typha* and *Pontedaria*). PFO habitat is characterized by trees growing in and along the margins of the marsh. Because vegetation in some cover types does not remain constant throughout the growing season (PUB and PAB) and because availability of cover types varied and was often limited to small patches or corridors, hoop-net traps were ultimately placed within the following categories: three traps in canals (typically PUB); three traps in deep marsh-channels (typically PAB); three traps in shallow marsh (typically PEM); three traps in intermediate marsh (typically PEM); three traps in deep marsh (typically PAB); and three traps in forested wetlands (PFO). Deep marsh-channel habitat at WPM generally consisted of a deep channel around the perimeter of the marshes resulting from excavations in dike building (Fig. 6). Traps sites were ultimately selected to maximize the chances of capturing the greatest number of study individuals. Additionally, three solar turtle traps were set to capture basking turtles in areas of the marsh were turtles had been previously observed to bask. Hoop-net turtle traps were equipped with crayfish traps baited with Rainbow Smelt (*Osmerus mordax*). The use of crayfish traps with the hoop-nets (a trap within a trap) was done for a threefold purpose: 1) to assess crayfish populations (a presumed major dietary component); 2) to ensure that consumption of bait did not impact stomach content data for the turtles; and 3) to trap and hold resident fauna that could potentially serve as additional or superior bait for *E. blandingii.* Crayfish traps had a 6.4 millimeter (¼ in) mesh and were modified from Gee Minnow Traps (model G40M) by enlarging the entrances to allow larger crayfish to enter. Hoop-net traps were used in three sizes: 50 centimeter (20 in) hoop-net catfish traps (the entrance enlarged to allow larger turtles to enter); 76 centimeter (2.5 ft) hoop-net turtle traps; and 91 centimeter (3 ft) hoop-net turtle traps depending on the depth of the water in the location being trapped. The mesh size on these traps varied between 2.6 and 3.9 centimeters (1 and 1.5 in). Trapping was conducted from 22 May through 21 August of 2006. Hoop-net traps were set Mondays through Fridays and were checked approximately every 24 hours for a total trapping effort of 19,689.25 hours. Solar traps were set on 28 June and ran continuously until 21 August for a total trapping effort of 3874.25 hours.

All *Emydoidea blandingii* individuals captured in traps and by hand were identified and marked by permanent notch codes filed into the marginal scutes of the carapace according to Mitchell's (1988) method (Fig. 7). Individuals were sexed and measurements of mass, carapace length, plastron length, and head/jaw width were recorded. The observed sex ratio was compared to an expected ratio of 1:1 using Chi-Square Goodness of Fit analysis. Radio transmitters (Model R2020 and R1695) produced by Advanced Telemetry Systems (ATS) were affixed to carapace with epoxy and turtles were released back to the location of capture (Boarman et al., 1998). Transmitters were set to frequencies 149.001–149.999 and were tracked with an ATS radio receiver (Model R4000). It has been shown that the permanent marking and handling of turtles does not appear to affect their likelihood of recapture indicating that handling does not notably impact behavior (Pike et al., 2004).

DIET:

Turtles were tracked and recaptured by hand approximately every two weeks from April–October of 2006 and 2007. Upon capture, turtles were taken back to shore where mass was recorded and stomach contents were obtained through the Legler Method of stomach flushing (1977). The Legler Method involves the insertion of a tube down the esophagus and into the stomach. A water-delivery apparatus was designed using a 3.8 liter (1 gal) canister sprayer with a syringe and rubber feeding tube (14 or 18 French) attached to the tip. The insertion of the tube was eased with a small amount of a water-based lubricant (K-Y Jelly). The turtle was inverted with the neck held outstretched, and a gentle stream of water was administered to induce flushing of the stomach of recently-consumed food items. The volume of water required to retrieve contents varied and greatest success was met using approximately 1,400 milliliters (not including water retained by the turtle). All regurgitated stomach contents were separated from flushed fluids in a wire sieve (fine mesh cooking strainer) and preserved in 70% ethanol. This method allowed stomach contents to be extracted and preserved from wild turtles without euthanizing any turtles, and it provided stomach contents that could be identified to a lower taxonomic category than other methods like fecal analysis. Additionally, soft-bodies items may be recovered from the stomach during flushing where they would otherwise be under-represented in a diet inferred from fecal samples (Rowe, 1987; Bjorndal, 1997). All individuals were then examined to confirm they were in a healthy condition and were released at or near the site of capture. Used feeding tubes were sanitized in a solution of Chlorhexidine and recycled for future use.

Analyses of diet data included a comprehensive identification of invertebrate food items to a minimum level of Order and most items were identified to the level of Family or further. Vertebrate items were identified as far as the state of the partial digestion allowed. Food items were analyzed according to: 1) percent total items; 2) percent total volume; 3) frequency of occurrence; and 4) “index of relative importance” (IRI). Percent total items (%N) was calculated as the count of a particular food item in all samples divided by the total count of all items in all samples. Volume for items was estimated by removing excess moisture and by measuring the displacement of water in a graduated cylinder to the nearest 0.1 milliliter (Hart, 1983). Percent total volume (%V) was calculated as the total volume of a particular food item in all samples divided by the total volume of all food items in all samples. Frequency of occurrence (%F) was calculated as the number of samples which contained a particular food item expressed as a percentage of the total number of samples. IRI incorporates percent total items, percent total volume, and frequency of occurrence into one, more reliable, measure for ranking the importance of dietary categories (Hyslop, 1980; Bjorndal et al., 1997; Chen and Lue, 1999). IRI was calculated as: $\text{IRI} = (\%N + \%V) \times \%F$; and measures may range from 0 to an upper limit of 20,000. Analyses of diet by one measure alone may result in misleading interpretations of the relative importance of diet categories. Stomach samples were pooled for 2006 and 2007; and diet was analyzed according to categories for time of year, sex, individuals, and location within the available marsh habitat. Diet categories were also compared using Shannon’s diversity index and Shannon’s equitability (Chen and Lue, 1999).

Shannon's diversity index provides a measure that takes into account both species richness (the number of species) and the abundances of those species. For dietary purposes, higher values should represent generalist behavior and lower values should represent more specialized feeding behavior. Shannon's equitability provides a measure for the distribution of species in a community. Equitability measures range from 0.0–1.0, with complete evenness across species at 1.0. In dietary terms, values closer to 0 represent greater specialist behavior, such that a limited number of the total species consumed comprises the bulk of the diet. Diversity and evenness were calculated using %N. Overlap between the sexes was determined using Horn's method (Horn, 1966; Bjorndal et al., 1997; Chen and Lue, 1999). Horn's overlap index ranges from 0.0–1.0, with a value of 0 representing no overlap and a value of 1 indicating complete dietary overlap.

In addition to stomach flushing, two Blanding's turtles found dead on the road also provided stomach contents by dissection for analysis (intestinal contents were not included in analyses). Fecal samples were salvaged for analysis whenever provided. Analysis of fecal samples was held separate from calculations of frequency of occurrence for stomach contents. Due to the digested state of the contents, the volume and number of items could not be accurately measured; consequently, fecal samples were excluded from all calculations of IRI.

Feeding behavior and diet composition of turtles has been shown to vary according to habitat and food availability (Parmenter, 1980). In order to assess available food items within the habitat, dip net sampling at or near the hoop-net trap sites took place on a monthly basis throughout the field season. An approximate one-meter swipe was taken with a triangular dip net measuring 30×30×30 centimeters, and invertebrate samples were preserved in 70% ethanol for later identification to furthest possible taxonomic level. Swipes taken in deeper water columns included a surface swipe followed by a backswipe approximately 30 centimeters below the surface. Due to extreme counts for items less than one centimeter (mean count for items <1 cm per sample = 534, max per sample = 2,580, total items <1 cm = 28,845) and time constraints, sub-samples (½ or ¼) of each dip net sample were used to count items <1 cm. Total counts per sample were then extrapolated from sub-sample counts. The %N identified in dip net samples and the %F was calculated for each of item. Items were then compared according to the trap location category, Cowardin wetland cover type, and the time of year. A Detrended Correspondence Analysis (DCA) was used to look for trends in food item taxa assemblages across habitat types (trap sites) and time of year. DCA analysis was run on MultiVariate Statistical Package (MVSP) software. Items one centimeter and larger were considered to be potential food items as this appeared to be the general size minimum identified in stomach samples. The abundance of items ≥1 cm available across wetland classes was analyzed using ANOVA, and was run on the statistical program R, software version 2.2.1. Shannon's diversity index and Shannon's equitability were used to compare the availability of food items in the marsh according to time of year and habitat type, with the diversity and evenness of items identified in the diet of turtles for these categories. In order to make direct comparisons between stomach and dip net samples, all measures of diversity and evenness were calculated using %N instead of IRI. Identification of all invertebrates was aided by Voshell's (2002) guide to the common freshwater invertebrates of North America and Peckarsky et al.'s (1990) taxonomic keys to freshwater macroinvertebrates of northeastern North America.

HABITAT USE:

Characteristics of habitat used by *Emydoidea blandingii* were systematically collected at trap sites and when radio-tagged turtles were relocated. Turtles were re-located by radio telemetry approximately every two weeks when stomach flushing took place. During the winter turtles were located as often as once per week and in the interest of their health stomach flushing was not performed. Information about water depth, water temperature, water clarity, subaqueous substrate characteristics, basking sites, bank and shoreline characteristics, subaerial cover (vegetation type and percent cover), Cowardin wetland type within 10 meters of traps, disturbance types within 100 meters of traps and turtle, and turtles captured was collected. The geographic coordinates of traps and turtles were determined by Global Positioning System (GPS) hand-held units (Garmin) with a typical accuracy of 5–10 meters. The positions of turtles were mapped on DeLorme Topo USA 5.0 software using coordinates gathered with the hand-held unit. Straight lines were then used to connect these points and form a perimeter which outlined the general homerange and activity centers for all individuals tracked.

REPRODUCTION:

In addition to trapping, dikes and fields were surveyed during afternoon and evening hours from late May–June for any females moving over land toward nesting sites. Female Blanding's turtles were palpated regularly during May and June to determine whether they were carrying eggs. They were tracked by radio transmitter and closely monitored at this time for any indications of nesting movements into upland habitat. Nesting females located on land were additionally equipped with a spool-and-line apparatus to track their movements across suitable nesting habitat and to aid in locating nests (Heyer, 1994; Dodd, 2001). Confirmed nests in 2006 were carefully excavated to allow the insertion of a small probe amongst the eggs to record thermal data, and the depth to the top of the first egg was recorded. Nests were then carefully covered back up and protected from predators with a screening of hardware cloth. Information on clutch size and nest depth in 2006 was recorded after hatchling emergence had occurred or nests were deemed to no longer be viable. Conversely, after nests were laid in 2007, all eggs were removed to ascertain the dimensions of the nest cavity and the number of eggs present. Nests were then reassembled with thermal probes inserted in the same manner as 2006 and covered with a protective screen. The screens were constructed as open boxes inverted and buried approximately 10 cm deep, and acted as a cage around the perimeter of the nest. When and wherever nest screens were unable to be buried they were instead firmly fixed to the ground using large fence staples. During 2006, nests were monitored daily for predation attempts during the month of June. Predation attempts were identified as digging around the protective screen and/or thermal data logger. Subsequently, they were checked weekly when thermal data was being uploaded to a handheld PDA. In 2007, nests were monitored approximately every other day in June and thereafter once every three to four weeks to upload thermal data. “Mock nests” were also set up in 2006 to gather information about potential nest site temperature regimes. Mock nests were set up just as true nests and were placed in areas known to be used for nesting but where the exact location of nests had not been identified. Nests were monitored daily in 2006 and every 2–3 days in 2007 prior to the expected onset of hatchling emergence (~70 days). This was done to determine the date of emergence from the nest, to determine whether hatchlings emerged synchronously or asynchronously, and to ensure that hatchlings did not endure prolonged exposure under the nest screen.

Thermal profiles of each nest were recorded through an external probe on a 1.8 meter (6 ft) lead to an RH/TEMP/2X External H8 HOBO thermal recording device and uploaded onto a Palm V PDA equipped with HandCar software compatible with the BoxCar Pro 4.3 program. H8 HOBO thermal recording devices were sealed in watertight 7.6 centimeter (3 in) PVC capsules buried near the nests. Thermal recording devices were set to record temperature every minute in 2006, and data was uploaded weekly to the handheld PDA. In 2007, thermal recording devices were set to record temperature every five or six minutes and data was uploaded once a month. Paired t-tests for 2006 data, and an ANOVA with a conservative Tukey Test for 2007 data, was used to reveal any significant differences which might be present between mean temperatures during the month of July for each nest site in the given year. Tests were run with the statistical program R version 2.2.1. The month of July was chosen for analysis because it should roughly correspond to the middle third of incubation for nests and can generally be considered the period of TSD (Pieau and Dorizzi, 1981; Bull and Vogt, 1981). Temperatures during this period have the ability to direct the sex of the embryos developing in the nest and may ultimately direct sex ratios operating in the population.

Nest temperature is influenced by a number of factors in addition to ambient air temperature; consequently, multiple variables related to the nest site were recorded. These variables included: location of the nest (sun or shade); depth of the nest; and visible characteristics of the soil's condition. Samples of the surrounding soil were also collected for analyses of composition at the surface of each nest site in September of 2006. In addition to three nest sites, soil samples were collected near a mock nest site (in an area known to have been used by a nesting female) and on a dry hummock within the marsh. Samples were air dried and two sub-samples were measured out of the sample from each site. Sub-samples were pretreated with a 30% H_2O_2 solution to remove organic matter. A solution of 10% sodium hexametaphosphate was added to aid dispersion of small aggregate silt and clay particles. The mixture was agitated in a conventional shaker mixer, and the percentage of clay present was determined by particle-size analysis using the Bouyoucos Hydrometer Method. The mixture was then run through a 53 μm mesh sieve to separate out sand. After drying the recovered sand at 105°C overnight the percentage sand was calculated for each sub-sample. The percentage of silt present in each sub-sample was calculated by subtraction. The average of calculations for sub-samples was used for the final determination of the percentage of clay, silt, and sand present in each soil sample (Gee and Bauder, 1986).

All hatchlings produced were removed from the nest, rinsed clean, measured, and fitted with 0.5 gram radio transmitters set at 15 ms with 24 ppm (Model R1615). The use of fluorescent powders limits the ability and duration with which individuals can be tracked, particularly in wet conditions, and requires that researchers track in darkness with a UV light. Though this method provides an aspect of the sinuosity in the path traveled (which is not generally observable with radio telemetry) it was ultimately deemed impractical for this study. Hatchlings were not notched and individuals were instead identified by their unique transmitter frequencies (e.g., Hatchling .311). Hatchlings were tracked daily and GPS points were taken when locations were visually verified for individuals every one or two days. Measurement of distances traveled were made using straight-line distances between location coordinates as mapped on DeLorme Topo USA 5.0 software; or by direct straight-line measurements for shorter movements observed in the field. Measurements taken from hatchlings included carapace length, carapace width, plastron length, head width, tail length (cloaca to tip), shell height, and mass. Hatchlings salvaged after predation or other causes of death were dissected to determine sex and to examine digestive tracts for possible feeding activity.

Painted turtles (*Chrysemys picta*) trapped in 2006 were also measured, sexed, and notched to compare population status and sex ratios with that of *Emydoidea blandingii*. Because previous observations of sex ratios for *E. blandingii* in WPM appear to be strongly skewed toward males (unpublished data) and *C. picta* follows a similar temperature pattern of TSD as that of *E. blandingii* (Ewert and

Nelson, 1991), it was suspected that nesting conditions which may have elicited this ratio in *E. blandingii* could also be acting on the *C. picta* population.

Copies of data sheets and field notes recorded throughout this study are located with the Natural Resources Division of the Cleveland Metroparks in Cleveland, Ohio. All stomach contents, dip net items, and specimen salvaged during this study were deposited at the Cleveland Museum of Natural History under Scientific Collection Permits #362 (2006) and #177 (2007), filed with the Ohio Department of Natural Resources' Division of Wildlife. Protocols used in this study were approved by John Carroll University's Institutional Animal Care and Use Committee (IACUC #606).

RESULTS

From 2003–2007, a total of 61 individual turtles were captured at WPM and marked with unique notch codes. However, the bulk of the diet, movements, and reproductive data presented here were collected from 22 individuals captured in 2006 and 2007. A total of 12 *Emydoidea blandingii* were captured over the 2006 field season and an additional 10 individuals were captured in 2007. Of the 12 turtles captured in 2006 (6 male and 6 female) only 1 of those (Male #59) was an individual tracked the previous year that was recaptured using radio telemetry. Of 19 turtles equipped with radio transmitters during 2005, this was the only individual still sending a signal in the spring of 2006. Eight turtles were captured in baited traps while the rest were captured by hand in 2006. Solar traps (set in late June) did not capture any *E. blandingii* individuals. The 10 turtles captured in 2007 included 9 males and 1 female, and give a total sample size of 22 adult turtles (15 males and 7 females) for this study (Table 1). No traps were set in 2007, thus all but 2 of the 10 new individuals were captured by hand (2 were incidentally trapped by WPM staff). Mean carapace length for these 22 adult turtles was 21.5 cm, mean plastron length was 20.1 cm, mean head/jaw width was 33.0 mm, and the average of the mean masses for individuals was 1480 g (Table 1). In addition to these 22 turtles, 3 females tracked during nesting in 2005 are included in the reproduction results and 2 females found dead on the road in 2006 are included in dietary results. Radio signals were lost for individuals throughout this study, and thus, a number of the individuals captured and tracked during 2006 could not be carried over into 2007 (Individuals: #59; #72; #73; #109; #112; #113; #115; and #116).

DIET:

Stomach contents were successfully collected from all but two turtles using the Legler Method for flushing stomachs. One female captured in June of 2006 was only flushed once before the signal from her radio transmitter was lost. Similarly, one male turtle was only flushed once in 2007 before his signal was also lost. Fecal samples were collected from six individuals including the male that stomach contents were never successfully flushed from. Individuals included in the dietary study are listed in Table 2.

From May 2006 to October 2007, flushing was attempted a total of 182 times. Stomach flushing was attempted on each of the 22 individuals an average of 8 times, and contents were retrieved from 35.7% of the attempts. Contents were retrieved from each sex at an equal rate. A total of 65 diet samples were collect by stomach flushing (45 from males and 20 from females). In addition, stomach contents were salvaged from 2 adult females found dead on the road, and eight fecal samples were collected from 6 individuals (four from 2 females and four from 4 males). Individual stomach content volumes ranged from <0.1 ml to 12.5 ml (mean = 1.6 ml) and combined samples totaled 109.4 ml. Number of items identified in a given stomach sample ranged from 1–164 (mean = 14) and combined samples totaled approximately 949 items. Items found in stomach contents had a general size minimum of 1 cm. A total of 25 distinct items were identified and recognized in diet samples (including stomach and fecal samples). Four families of snails were identified within Class Gastropoda. Within Class Insecta, five orders of insects were identified. Most insects, with the exception of those in Order Odonata, were further identified to the level of family. Eleven families in the orders: Hemiptera; Coleoptera; Megaloptera; and Diptera were identified. Three orders of Crustacea were identified: Decapoda; Cladocera; and Amphipoda. Leeches were identified representing Family Hirudinidae. Additionally, three groups of vertebrates were identified and grouped as either fish, anuran, or avian. Another group was designated for all egg masses of unknown origin. Finally, a single group was designated for all plant matter identified in diet samples.

Table 3 shows the results of 67 stomach samples (including 2 collected from D.O.R. individuals). Gastropods were the most common food item found in stomach contents, making up 75.6% of the total volume and 82.0% of the total items retrieved. They were identified in 67.2% of the samples. Of the four families of gastropods identified, lymnaeid snails, specifically *Stagnicola elodes,* made up the overwhelming bulk of this group. The most common food item after Gastropoda was Insecta, with Anisoptera nymphs being the most common insect group consumed. Plants were identified in 37.3% of the samples; however, they made up just 1.4% of the volume and 3.3% of the total items. Plant matter consumed was typically *Lemna sp.* and filamentous algae. The top six dietary groups overall, as highlighted in Table 3, were rounded out by Hirudinidae, fish, and Decapoda.

The fluctuation in the diet of turtles over the season is visible in Table 4. The IRI for gastropods during the month of June was 5,527.8, whereas the IRI for gastropods in May, July, and August was over 11,000 in each month. Conversely, the month of June showed a surge in the IRI for crayfish at 659.4. The IRI for insects was highest in the months of June and July (at 871.1 and 1,272.5 respectively). Shannon's diversity index (H) showed the diet to be most diverse during the months of June and July (H = 1.71 and H = 1.33) when years 2006 and 2007 were pooled; however, measures for diversity and evenness (E_H) were much lower across the board in 2006 than in 2007. Considering 2007 data alone, diet was least diverse (H = 0.58) and evenness was lowest ($E_H = 0.24$) during the month of May (Table 5). In addition to diet analysis, Figure 8 shows the variable retrieval rate for contents from stomach flushing over two seasons with the highest retrieval rate occurring in the months of May through July. The earliest stomach flushing took place during the month of April (2007) and 15 attempts produced 1 stomach sample. During the month of September (2006 and 2007) stomach flushing was attempted 21 times, but produced just 1 sample. Five attempts in the month of October produced no stomach samples. The greatest mean volume and mean number of items for stomach contents flushed, was collected during the month of May (Fig. 9). The mass recorded prior to flushing displayed similar peaks and valleys over the course of the seasons. Figure 10 shows the seasonal fluctuation in mass recorded over the seasons for four individuals tracked over an extended period in 2006 and/or 2007.

Diets of males versus females are compared in Table 6. The IRI for crayfish was higher for female stomach samples than for male (249.7 versus 3.6), whereas the IRI for insects and leeches were higher for male stomach samples (829.3 and 182.0 versus 135.9 and 13.0). Evenness was just 0.42 for both male and female stomach samples, and diversity was slightly higher for male stomach samples (Table 5). Dietary overlap between the sexes was 0.88 according to Horn's overlap index. The diets of individuals are compared in Table 7 and Table 8. The number of stomach samples collected from individuals also varied, and measures of diversity and evenness from individuals with multiple samples are of greater interest. Measures of diversity and evenness varied greatly from one individual to another. For example, the diversity and evenness in the diet of Male #92 ($H = 0.45$ and $E_H = 0.20$) was much lower than that in the diet of Male #114 ($H = 1.91$ and $E_H = 0.92$). The lymnaeid snail, *Stagnicola elodes,* was the most important food item (by IRI) in 14 of 22 (64%) individuals. Physid snails were the most important food item for one individual (Male #95), but the item occurred in only one of its four stomach samples. Another individual (Male #117) held plant matter as its most important food item, but in only one instance (of five stomach samples) was ingestion of plant matter apparently anything other than incidental. Insects and fish were the most important food item in the diets of two individuals each, but the importance of fish was biased heavily by its conspicuous presence in just one of two samples for each individual. In addition, only one stomach sample was available for one of the individuals (Male #120) exhibiting insects as the most important food item. Table 9 provides results for the stomach samples analyzed according to the microhabitat individuals were collected in. The majority of these samples (50 of 65) came from individuals picked up in PEM habitat, where the primary food item according to the IRI was *S. elodes* (10,808.8). A comparison between PEM and PAB habitat (which had the next highest number of samples at n = 9) showed the diet to be generally similar apart from fewer fish being consumed by animals in PEM habitat (IRI = 9.8 versus 392.2). Additionally, diversity and evenness in stomach samples was lowest ($H = 0.92$ and $E_H = 0.31$) for samples from PEM habitat (Table 10).

Figure 11 shows the results for eight fecal samples collected. Remains identified in fecal samples were only analyzed for presence of taxa. Volume and number of items was not able to be accurately measured. However, remains of *Stagnicola elodes* were identified from shell fragments and were found in seven of eight samples. Remains of *Procambarus sp.* were identified in five of six samples from June; however, remains were not found in either sample from the month of July. Insect remains of various taxa were found in all fecal samples and were largely represented by legs, wings, and other chitinous parts. Remains of larval Corydalidae were the only taxa identified in fecal samples which were not also identified in stomach samples.

From 23 May to 18 August, 2006, crayfish traps captured a total of 490 crayfish. All crayfish captured belonged to the genus *Procambarus.* Those individuals large enough to positively identify to species in the field were found to be the invasive species *P. clarkii.* Crayfish were most abundant in traps during May and June with 71.4% of individuals having been trapped during this time. Figure 12 shows the frequency for crayfish trapped during this time plotted against the average water temperature for all trap sites. A regression of crayfish trapped into average water temperature at a 20 cm depth showed a weak but significant correlation between the two variables (p=.0006842; correlation coefficient = 0.48).

Figure 13 shows the regression analysis between these two variables with points weakly grouped along the line of best fit. A total of 1,076 fish were captured (and potentially recaptured) in the combination turtle and crayfish traps. Fish captures encompassed several species including species in families: Cyprinidae; Centrarchidae; Ictaluridae; Amiidae; Umbridae; and Clupeidae. The most abundant fish captured in traps were from Genus *Lepomis,* with a total of 449 captures (including potential recaptures). The majority of these were in the juvenile size range and were captured in the crayfish traps. Green Sunfish (*Lepomis cyanellus*) was the most abundant species making up 30.9% of all fish species, and the second most abundant species was the invasive *Cyprinus carpio* (Carp) which comprised 29.7% of all fish. A total of 371 tadpoles representing the species *Lithobates catesbeianus, L. clamitans,* and *L. pipiens* were captured in the crayfish traps. The 6.4 mm mesh of these traps was of a size that only the largest invertebrates were retained, and thus, these traps did not effectively sample all potential food items (items ≥1 cm in length).

A total of 72 dip net samples were analyzed representing the 18 turtle trap sites during the months of May, June, July, and August, 2006. These samples contained a combined 29,530 items (extrapolated from sub-samples for items <1 cm). Items <1 cm were counted for samples from the months of June, July, and August and analysis showed the most abundant taxa in dip net samples from this time period to be under 1 cm in length, such that only 2.3% of all items identified were ≥1 cm. However, the frequency of occurrence for items ≥1 cm in dip net samples from this period was 93.1%. Insects were the most abundant and frequent item in dip net samples, making up 71.9% of items ≥1 cm in dip net samples, but insect taxa identified in stomach contents was only 20.0% (Table 11). Second to insects, gastropods were the next most abundant and frequent item ≥1 cm in dip net samples. While planorbid and physid snails made up the majority of gastropods <1 cm, lymnaeid snails were the most abundant gastropod at 13.3% of the total for items ≥1 cm collected in dip net samples and was found in 22.2% of dip net samples. Seasonal fluctuations in the availability of food items are seen in Table 12. Gastropods ≥1 cm were most abundant during June making up 27.6% of the total items identified in dip net samples at this time. Insects ≥1 cm as a whole were least abundant during the month of June at 58.5% of all items; however, insect taxa that were identified in the diet of turtles were most abundant at 25.2% during this time. Further analysis of dip net samples revealed that the diversity and evenness of taxa ≥1 cm available in WPM ($H = 2.25$ and $E_H = 0.63$) was greater than that expressed in the diet of *Emydoidea blandingii* ($H = 1.38$ and $E_H = 0.43$). Moreover, diversity and evenness in dip net samples was greater than in stomach samples during all months and in both years. Despite this, both dip net and diet samples were most diverse in the months of June and July (Table 5).

Table 13 provides the results of dip net sampling, according to microhabitat type at hoop-net trap sites, for items ≥1 cm during the months of May, June, July, and August of 2006. The Detrended Correspondence Analysis (DCA) for dietary items found in dip net samples indicated a potential similarity between taxa assemblages in shallow marsh and wet woods habitat (Fig. 14). Additionally, a general grouping of taxa assemblages in deep water habitats appeared. A fairly tight grouping of the intermediate marsh taxa overlaps with that of a part of the deep water taxa assemblages. Grouping was not readily apparent for taxa according to the month of the year. The scatterplot of weights for individual taxa showed that the primary food item, *Stagnicola elodes,* fell out in the area characterized by shallow marsh and wet woods habitat (Fig. 15). Table 14 shows the distribution of potential food items in dip net samples across wetland classes. The greatest percentage of *S. elodes* items and the most frequent occurrence in dip net samples came from PFO habitat; however, percent items and presence of this species was relatively stable across wetland classes. Similarly, the percentage of insect taxa items included in the diet was relatively stable across habitat types with the exception of canal habitats (typically PUB) where insects were generally less common and where only 5% of all items were netted. Across wetland classes, PEM habitat had the greatest mean number of items per dip net sample and PUB had the lowest (Table 15). ANOVA was unable to detect a significant difference between any of the means for the number of items per dip net sample found in each wetland class ($p = 0.164$). Diversity was greatest at shallow marsh habitats ($H = 2.20$) and wetland class PEM ($H = 2.18$). Evenness was strongest across wet woods and PFO ($E_H = 0.79$) (Table 10).

HABITAT USE:

Between May 2006 and October 2007, 21 individuals of *Emydoidea blandingii* were equipped with radio transmitters (Table 2). Of 12 individuals tracked during 2006, 1 (Female #113) was never successfully relocated following its original capture and release. Radio signals from two other individuals (Females #109 and

#115) were subsequently lost in the fall of 2006. Nine individuals were tracked during the winter of 2006–2007 (until 31 January). The following spring, five more radio signals (from the remaining nine) were lost (Individuals: #59; #72; #73; #112; and #116), and nine new individuals were subsequently encountered and equipped with radio transmitters in 2007. Activity and movement varied among individuals, but movements toward apparent winter hibernacula and/or cessation of wide ranging movements generally occurred during the month of October during 2006. Figure 16 shows the general homeranges for the active seasons of 2006 and 2007, and the interceding winter range for the six males tracked over 2006 to 2007. Figure 17 shows the same data for the three females tracked over 2006 to 2007. Movement was observed for all individuals throughout the winter, but the amount varied greatly between individuals. For example, Male #59 showed very little movement from its location under the overhanging bank of a pond, whereas Female #110 was observed to move over 180 meters from 18–27 December (water temps were 9°C and 4°C respectively) and was seen actively moving under the ice on 24 January (water temp was 3°C). Sites observed to be used as hibernacula included the marsh itself, often under thick mats of vegetation including cattail and muskrat dens, and beneath the overhanging banks of ponds and canals. Previous Cleveland Metroparks tracking data for Male #59 (unpublished data) shows that a specific pond, distinct from its active homerange, was used as an overwintering site in 2004–2005. This same individual then returned to the same pond for the winter of 2006–2007 (Fig. 18). On the other hand, Male #63 did not appear to utilize any distinct region of WPM for overwintering during 2004–2005 (Fig. 19). At least six of the nine turtles tracked over the winter of 2006–2007 were observed to overwinter within their active homerange. The large variation in the seasonal movement patterns observed among individuals is particularly evident in the behavior of Female #73. Figure 20 shows that while Female #73 did not seem to utilize a separate and distinct region of the marsh during the winter of 2004–2005, she was observed to occupy a winter region distinct from her active homerange in 2006–2007. The mean water depth at winter locations for all individuals was 0.43 meters, and was not different from the mean active season depth.

The return to active movement patterns was observed to begin as early as April in 2007; however, measurements of body mass taken in early April (Fig. 10) and previous Cleveland Metroparks tracking data (unpublished) indicate that activity of at least some individuals begins as early as March. Turtles captured between April and September in 2006 and 2007 were found in shallow marsh 66.3% of the time during stomach flushing. Other microhabitat types utilized include intermediate marsh (14.1%), deep marsh-channel (8.5%), canal (6.5%), and wet woods (4.5%) (turtles were not captured in “deep marsh”). Similarly, the same locations were classified according to Cowardin wetland cover types. According to Cowardin wetland classification, turtles were captured in PEM habitat 71.9% of the time. The next most frequent wetland class was PAB (13.1%), followed by PUB (10.1%), PFO (4.5%), and finally PSS (.5%). Figure 21 shows the similarity between the two methods used in characterization of habitat when the microhabitat types are grouped as “shallow marsh with intermediate marsh” and “deep marsh with deep marsh-channel." Reasoning for this grouping can be found in Figure 6. Although palustrine emergent was the dominant wetland class turtles were captured in, the majority of capture sites (~80%) were accompanied by thick beds (>30% coverage) of floating and/or submersed aquatic vegetation (e.g., *Lemna* and *Utricularia*). While utilization of microhabitat types was similar between the sexes, females were observed to utilize PUB and PFO habitat more than males (14.9% and 6.8% versus 7.4% and 3.0%). Males were located in PEM and PAB habitat more than females (74.1% and 14.8% versus 70.3% and 8.1%) (Fig. 22). Utilization of microhabitat type between the active season (April–September) and winter (October–January) is compared in Figure 23. Turtles utilized PEM and PAB habitats proportionately more during the active season than in winter (71.9% and 13.1% versus 59.6% and 1.1%) , and PUB habitat was utilized more in winter than during the active season (35.1% versus 10.1%). The mean water depth for all active season captures was 0.44 meters.

In 2005, Cleveland Metroparks estimated the percentages of available habitat in the WPM using a series of random points generated by a random coordinates generator extension for Arcview 3.2 (ESRI, Redlands, California). Points were ground checked when necessary and points were classified according to Cowardin wetland cover type. Available habitat types reached relatively stable levels after 100 points had been assessed; however, the habitat type at 177 random points was verified before an accurate assessment of available habitat was deemed to have been satisfactorily achieved. Of those 177 points, 147 were physically assessed on the ground while there remainder were determined by aerial photographs. Figure

24 depicts the random points generated for this purpose. A comparison of available habitat at WPM in 2005, versus the habitat turtles were located in during the active season (April–September) based on flushing retrieval rate (Fig. 8), is found in Figure 25. Turtles were located in PUB habitat proportionately more than its availability at WPM.

Figure 26 shows the general homerange of males tracked during the active season of 2006, and Figure 27 shows the general homerange of males tracked during the active season of 2007. Overlap between the homeranges of individual males was observed in both years. Figures 28–30 show that the homeranges of individual females overlapped with each other in 2005, 2006, and 2007, respectively. Moreover, the homeranges were observed to overlap between individual males and females in 2006 (Fig.31) and 2007 (Fig. 32). In addition to the delineation of a general homerange for individuals, the presence of specific activity centers was evident for a number of individuals. For example, Males #95 and #114 were observed to move between distinct and widely separated regions of WPM (Fig. 33). Male #114 was located in the same northerly activity center in the spring of 2006 and 2007; Male #95 was observed to move from a northerly activity center to a more southerly region, and then back to the same general northerly region. Incidentally, both of these males were also captured in isolated locations while pursing Female #73. The general homerange for each individual was also observed to deviate from year to year. This trend is best observed in Figure 16 and Figure 17 where active season homeranges can be viewed side by side for years 2006 and 2007.

REPRODUCTION:

Of the 61 *Emydoidea blandingii* captured and marked at WPM since work began there, all of these individuals have been adults. Of those, 48 (78.7%) were males and 13 (21.3%) were female, producing a sex ratio skewed 3.7:1 (male:female). Chi-Square analysis showed this sex ratio to be significantly different from a ratio of 1:1 ($p<.001$; $X^2 = 20.08$). Of the 13 females tracked since work began at WPM in 2003, nesting behaviors were observed for 8 individuals (Table 16). During the 2006 season, 95 adult *Chrysemys picta* individuals were captured by hand or in traps and permanently marked. Five of those individuals were recaptured, and one of those was a female captured twice on land (possibly laying a second clutch of eggs). Of those 95 *C. picta,* 50 were male and 45 were female. Of those 45 females, 15 were captured on land, during assumed nesting movements (no males were captured on land). Males comprised 53% of all *C. picta* captured, but 63% of all *C. picta* captured in traps. The overall ratio of males to females for *C. picta* ($p>.05$; $X^2 = 0.26$) was not significantly different from 1:1, but the ratio of individuals caught in traps ($p<.05$; $X^2 = 5.0$) was.

Potential mating/courtship behavior of *Emydoidea blandingii* was observed on several occasions during the months of April, May, June, October, and November since work began at WPM in 2003. These observations generally occurred when marked turtles were being tracked and were found in the immediate presence of another turtle. The first female captured (Female #73) was picked up (in the immediate vicinity) while “muddling” (searching through murky water by hand) for two marked males (transmitter-equipped Males #63 and #61) that were located within two meters of each other on 28 October, 2004. A second unmarked female (Female #74) was captured along with an unmarked male (Male #75) on 3 November, 2004 while muddling for a transmitter-equipped male (Male #63). A third female (Female #77) was captured under an overhanging bank on 10 November, 2004 while muddling near a transmitter-equipped male. On 8 April and 18 April, 2005, Female #74 was found mating with a different unmarked male on each occasion (Males #82 and #86, respectively). Additionally on 18 April, 2005, Female #77 was found mating with a marked male (Male #76). On 8 June, 2005, Female #94 was found mating with an unmarked male (Male #98). Female #111 was first capture in a hoop-net trap with an unmarked male (Male #112) on 7 June, 2006. On 15 June, 2006, an unmarked male (Male #114) was captured while muddling for Female #73 with radio telemetry. Male #95 was recaptured by hand in the immediate vicinity of transmitter-equipped Female #73 on 13 April, 2007. Male #63 was recaptured (with non-functioning transmitter still attached) on 11 May, 2007, while muddling for transmitter-equipped Female #111.

Nesting:

2005: In 2005, four females nested during the evening hours in the month of June. Females #73 and #94 were observed nesting in a soybean field on 9 June around 19:30 and 21:00, respectively. The field had been freshly tilled and planted; consequently, the soil was bare, loose, and relatively moist at the time of nesting. The final site of nest excavation observed for Female #73 was at the south end of the field in a location that had not been freshly tilled. The soil at this location was more compacted than areas north where she had previously wandered, but was still relatively bare. In the days prior to nesting, Female #73 spent the daytime hours on land in the tall grass and shrubs at the western border of the field. Female #77 was believed to have nested in a wheat field on 13 June. The wheat in this field was already mature and growing very densely. Female #74 was observed nesting in a recently tilled and planted cornfield at 22:00 on 20 June. Prior to nesting, Female #74 spent several days at the north end of a flooded ditch which ran the perimeter of the agricultural fields. She often exited this ditch in the evening for brief forays into the freshly tilled soils of the surrounding cornfields before returning to the ditch for the night. Observations of nesting females were made until approximately 22:00, when nest sites were believed to have been confirmed. Females were tracked the following day to confirm that they had indeed nested the previous night. However, none of the locations where females were observed to be excavating nests turned out to be completed nest sites. Females were assumed to have abandoned these sites for more suitable locations nearby. Locations of nesting attempts and female ranges are shown in Figure 28.

2006: Of the six females captured during 2006, only one (Female #73) was from the previous season. Two females were hand captured on land during June 2006 nesting movements (Females #73 and #110). Four of the six females captured in 2006 were found to be gravid and three of those were successfully tracked and observed during nesting. Nesting movements were first observed on 31 May and the last nest laid was observed on 16 June. Female #73 was captured on land during the evening of 31 May and was released to the same location the following morning. The next evening she was found wandering the same field she had used for nesting in 2005 (Fig. 29). A resident of the Lattimore region of WPM, she had returned to nest in the same distant field she had traveled to and nested in during the previous spring. This field was again recently planted with soybean and was generally bare at this time, but it remained untilled in 2006. Female #73 spent the next two nights on land hidden in a clump of *Phragmites* near a shallow wet ditch at the northern border of this field (directly adjacent to highway SR53). On 3 June, she reentered the field around 17:30 and wandered until she was observed nesting around 21:20. The nesting process continued throughout the night and was completed (with Female #73 moving off the location) at 05:30. The air temperature was recorded at 15.5°C at 02:00. The soil in the field was relatively moist and it began to rain shortly after she moved away from the nest.

Female #110 was captured (in the same general vicinity as Female #73) on a dike during the evening of 2 June. She was released to the same location the following morning. Female #110 was then tracked (by radio telemetry) moving north in a flooded ditch along the perimeter of the agricultural fields. She exited the ditch around 19:30 on 4 June and briefly wandered in a cornfield south of the ditch. She reentered the ditch by 20:00, and continued this same routine the next night crossing over the dike and moving north into the adjacent buckwheat field around 19:45 before reentering the ditch by 20:00. On 6 June, she again entered the buckwheat field to the north around 19:45 and began nesting sometime between 22:30 and midnight. The air temperature shortly after midnight was around 17°C and fell to around 15°C overnight. Female #110 completed nesting and moved off the site at 06:45. The buckwheat field had just recently been planted and was relatively bare, but the field had not been tilled this year.

On 3 June, Female #109 was tracked by radio telemetry to the canal north of the Darr region of WPM. She was located in this canal and the flooded ditch north of the canal until the evening of 5 June when she was observed digging in the soil of a freshly tilled and planted cornfield at 20:45. The soil was made up of very loose, large clumps and the corn had not yet sprouted. This nesting attempt was abandoned by 22:40 and Female #109 spent the remainder of the night in the cover of a stand of tall grass at the southern border of the field. This incomplete nesting behavior occurred nightly for the next three nights. On the evening of 9 June, Female #109 was located back in the flooded agricultural ditch south of the cornfield. She spent the next two nights in the ditch before reentering the field around 20:45 on the evening of 12 June. Again the female failed to nest and returned to the tall grass at the edge of the field. The same routine was repeated the following two nights with wandering in the field around 20:00 and returning to the tall grass at the edge of the field for the remainder of the night. These evening wanderings often included incomplete nesting excavations that sometimes continued well after dark. On 15 June, Female #109 was found wandering around the southeast corner just behind the cornfield at 19:45. At 21:00 she was observed making back and forth nesting movements near a pile of burned automobile tires. The location was characterized by dusty black soot and ash with tangled metal hoops and small bits of rusty wire (remains of steel belts in the tires) mixed into the pile of wheel rims. The untilled soil surrounding this pile was now dry, hard, and cracked from lack of moisture. The air temperature at 21:45 was 15°C and had fallen to 10°C by 05:50. She was observed still digging (very slowly) at 06:20, and at 09:45 she was observed dropping her last egg into the nest. By 08:00 the air temperature had risen to around 21°C and her movements had noticeably quickened. Her efforts to backfill the nest were hampered by the surrounding hoops of wire which often caught her back legs during movements. Female #109 completed nesting and moved off the site at 10:30 in the morning. At this time, the spool-and-line apparatus that was used to aid tracking of nesting movements had to be cut free of the wire hoops around the nest site.

In contrast, Female #111 was not observed nesting and her nest site was not located. This female apparently nested atypically during the morning hours while hoop net traps were being checked. She was found coming out of a cornfield at 14:45 on 9 June with her plastron caked in mud. She was palpated, and it was determined that she was no longer gravid. The corn in this field was what 30–60 centimeters high at this point and the tilled soil was moist and loose. Her tracks were visible in the soil and although they could be followed a good distance into the field, there was no evident sign of the actual nest location.

Nests 1, 2, and 3 were laid in a soybean field, buckwheat field, and adjacent to a cornfield (in a pile of burned automobile tires) by Females #73, #110, and #109 on 4, 7, and 16 June, 2006, respectively (Table 16). Nest 4 was designed as a “mock nest” set in a cornfield at the approximate location Female #111 was believed to have nested in 2006. Nest 5 was also a mock nest set in a cornfield at the same time as Mock Nest 4 (near where Female #74 had attempted nesting in

2005), but this field had been planted later in the season. Figure 29 shows the location of 2006 nest sites with ranges for females. The top egg in all three 2006 nests was barely below the surface of the soil (1.5 cm or less). The top two eggs of Nest 1 were inadvertently destroyed during nest excavation to insert the thermal probe. Interestingly, one egg from Nest 1 was also found outside the nest and was covered by some dry thatch. This egg was placed inside the nest to replace the two destroyed during excavation. The total clutch size was 17 eggs (including those destroyed). The nest chamber extended to a depth of 11 cm and measured 9–10 cm wide (measured after eggs failed to hatch and nest was exhumed in October). The total clutch size for Nest 2 was 13 eggs and the nest chamber measured approximately 10 cm deep and 9 cm wide (measured after hatchlings emerged). The clutch size for Nest 3 was 17 eggs and the nest chamber measured 12 cm deep and 9–11 cm wide (measured after eggs failed to hatch and nest was exhumed in October).

Soil samples were taken at all three nests in 2006, from Mock Nest 4, and from a dry hummock in the marsh—the latter site was isolated from agricultural impact. Soil composition was largely silt and clay and samples taken from Nests 1, 2, 3, and Mock Nest 4 was notably more compacted than the soil collected from the marsh hummock. During analysis, the sample from the marsh hummock contained greater quantities of organic matter. The organic matter lent a friable character to the soil whereas samples from the other sites were densely compacted and difficult to break apart. The results of soil analyses can be seen in Table 17.

Extremely large sample sizes were recorded for nest temperatures (approximately 30,000 temperature observations per month), thus paired t-tests were performed among all five 2006 nests for the month of July. T-tests showed a significant difference between mean temperatures for all nests (df = 29,277; $p = 2.2\times10^{-16}$). Furthermore, one-tailed paired t-tests showed the mean temperature for Mock Nest 4 to be significantly cooler than the mean temperature for all other nests in 2006 (df = 29,277; $p = 2.2\times10^{-16}$). Mock Nests 4 and 5 were both located in cornfields, but the corn around Mock Nest 4 was planted much earlier and was considerably higher than the corn around Mock Nest 5 during July (Fig. 34). Nest temperatures for 2006 can be seen in Table 18.

2007: In the spring of 2007 three females were tracked and monitored for nesting movements. Females were palpated beginning in early May until onset of the nesting season. Nesting movements were first observed on 8 June and the last nest laid was observed on 24 June in 2007. Female #73 was picked up and palpated along with Females #110 and #111 on 11 May. While no eggs were felt in any of them at this time, Female #73 seemed to be on a course back toward the field she nested in the previous two seasons. It is unknown whether this female nested again in 2007 as her transmitter signal was unable to be located after this date. Females #110 and #111, having both nested in 2006, nested again in 2007. Nesting in successive years was observed in all three females tracked for more than one season (#73, #110, and #111). Neither Females #110 or #111 showed fidelity to a nesting site in successive years.

Female #110 was observed in the canal north of the Lattimore region of WPM on 8 June during the afternoon. By 21:00 she had left the canal and was observed wandering in the cornfield north of Lattimore. She was seen making nesting movements by 23:10. Nest excavation was observed at 03:50 with no sign of eggs yet, but by 05:40 Female #110 had completed nesting and began moving off the site just before sunrise. The soil in this field was moist and loose, and the field been recently tilled and planted. Corn plants at this time were 30–60 centimeters tall.

A new female (Female #119) was observed attempting to nest during 2007 in the gravel maintenance yard at WPM on 8 June. Her attempt continued until at least 01:20, but by 02:20 she had returned to the marsh. The attempted nest was 5–6 cm deep and moist, but limestone gravel was tightly packed throughout the walls of the cavity. She returned to this location the following night but failed to nest again. This female then traveled through over 915 meters of marsh north to a series of cornfields known to be used by Female #74 in 2005. On 10 June, she exited the marsh into the field by 20:45 and was observed making nesting movements at 00:45. She was still digging and there was no sign of eggs at 02:15. The temperature at 02:15 was about 12°C, and at 03:20 she was observed moving at a very slow pace (may have been laying eggs). By 04:30 the female was beginning to cover the nest. At 06:05 she had completed nesting and was moving off the site by sunrise. This field had been recently tilled and planted; consequently, the soil was loose and the corn plants were no more than 30 centimeters tall. The soil was relatively moist at the time of nesting. Female #119 was the youngest individual observed in this study with an approximate age of 12 years estimated from clear plastral annuli indicating approximate years of growth.

Female #111 did not nest during the morning hours in 2007 as she had in 2006. Instead she made an early foray onto land near her 2006 nest site on 8 June before reentering and traveling west in the canal and north up the agricultural ditches surrounding the nearby fields. She exited the ditch system again on 14 June and attempted to nest in a fallow field. She spent the next two days on land in an overgrown field before entering a deep, steep-sided pond behind a local landowner's home. The pond was a relatively sterile environment with no emergent vegetation, the banks were lined with limestone cobble, and the water was regularly treated with an aquatic weed-suppressing dye. From 17–23 June, Female #111 exited the east end of the pond nightly around 20:30 to make forays across the mowed lawn to the edge of the nearby fallow field, including a nesting attempt that lasted until 04:30, before returning to the pond. Soil in this location was extremely hard and dry, and noticeably hindered nesting attempts. On 24 June, she again left the east end and was observed nesting at 22:10 near the site of her previous prolonged attempt. She was observed still nesting at 02:00, but by 04:30 the nest was complete and she was located back in the pond. The nest was located in dry, compacted soil on the border between a close cropped lawn and a fallow field with relatively sparse vegetation 30–60 centimeters high. Interestingly, Female #111 was briefly located in this same isolated pond the previous year on 5 July, soon after nesting that year.

Nests 6 and 7 were laid in recently tilled and planted cornfields on 8 June and 10 June, 2007, by Females #110 and #119. Both nests contained 13 eggs each. Nest 8 was laid by Female #111 on 24 June on the edge of a mowed lawn and fallow field behind a local landowner's home and contained 11 eggs (Table 16). The locations of nest sites and female ranges in 2007 are shown in Figure 30. Nests 6 and 7 seemed to be in better, more easily worked soil. The depth to the top egg in both of these nests was approximately 4 cm and the nests were flask-shaped. The depth to the bottom of Nest 6 was 13 cm and the chamber measured approximately 7 cm high × 10 cm wide. The depth to the bottom of Nest 7 was approximately 12 cm and the chamber measure approximately 5 cm high × 10 cm wide. Similar to 2006 nests, Nest 8 was laid in harder, more compacted soil (which seemed to prevent her nesting on previous nights) and the depth to the top egg was within 1 cm of the surface of the soil. Moreover, Nest 8 was shaped more as a cylinder than a flask, and the nest was approximately 10 cm deep and 8 cm wide.

Approximately 8,000 observations of temperature (every five or six minutes) per month were recorded from each nest in 2007. A one-way ANOVA among the three nests for the month of July showed a significant difference between the mean temperatures for at least two of the nests ($p = 2.2\times10^{-16}$). Furthermore, a conservative Tukey Test revealed that the mean temperature was significantly different between all nests ($W = 0.10$). The mean temperature for Nest 6 was significantly cooler than the mean temperature for Nest 7, and the mean temperature for Nest 7 was significantly cooler than the mean temperature for Nest

8 (Table 18). Both Nests 6 and 7 were located in cornfields, but the corn around Nest 6 was higher and denser than that around Nest 7 (Fig. 35).

2005–2007: The remains of three adult females were also salvaged after what appeared to be fatal nesting migrations. In 2006 two females were found dead on the highway (SR53) north of fields used for nesting during the month of June (Fig. 29). In June of 2007, Female #105, who was last seen in the summer of 2005 was found predated at the edge of the same field that Female #119 nested in (Fig. 30). The female's head and legs were missing, but it was estimated that she had been predated within the last week or so, presumably while moving to or from nesting in that field.

After nesting some of the females apparently sought out nearby ponds and ditches to recuperate and spend the next few days or weeks. Female #110 spent at least nine days in an agriculture ditch near her nest site in 2006. The ditch was steep-sided and relatively deep without emergent vegetation (unlike the habitat she otherwise resided in). In 2007, Female #110 spent nearly two months in a small farm pond near the cornfield she nested in. Again, the pond was steep-sided with overhanging banks and devoid of emergent vegetation. The female was repeatedly tracked to the same location over a few weeks time. She was approximately one meter into the bank inside a muskrat burrow. Incidentally, this female may have remained here longer if it were not for a near fatal encounter with the local landowner who unknowingly buried the turtle while stabilizing the banks of his pond with a backhoe. She was subsequently rescued and returned to the marsh.

This same pond was used by Female #77 in 2005 for an extended period after she also nested in a nearby field.

Figure 36 shows the location of all known nest sites, nest attempts, and mock nests. Of the eight females observed nesting from 2005–2007, nesting was observed in successive years by all three females which were tracked in consecutive springs. Timing of nesting was closely coupled with planting of fields for corn, buckwheat, and soybeans. Applications of herbicide took place at multiple nest sites after nests had already been laid. A wheat field adjacent to a known *Emydoidea blandingii* nesting area was harvested and later tilled on 14 August, 2006. Artificial flooding of fields for hunting during teal and goose season occurs around the first week of September and coincides closely with hatchling emergence dates. In dry weather, soils surrounding nests laid in untilled fields became very dry and hard with deep cracks running along the surface. Nests in tilled fields became similarly dry and cracked; however, the soil was noticeably looser. During heavy rain events water often ponded in fields and was most severe in untilled fields. Water was relatively slow to drain away such that seepage into well sealed PVC capsules that were used to house thermal recording equipment at nest sites was problematic. Apparent activity by potential nest predators was observed around the protective screen of both Nests 1 and 6, with Nest 6 being nearly predated just four days after being laid. Moreover, PVC capsules (buried within ~30 cm of the nest screens) in all but Nest 7 were exposed by animals on numerous occasions.

Figure 37 shows the diel pattern of temperatures for Nest 2 that was typical for all nests. Mean temperatures for Nests 2 and 6, which successfully produced hatchlings, were 24.89 °C and 21.29 °C, respectively, during the month of July. Max temperatures during the month of July reached levels (30°C) capable of producing female hatchlings in every nest except Nest 2 and Nest 6, the two nests located in the tallest and densest cornfields (Table 15). The cumulative effects of daily temperature fluctuation resulted in mean, mode, and median temperatures congruent with the production of males (Ewert and Nelson, 1991). None of the presented temperature measures can be confirmed as an accurate representation of the sex determining temperature; however, taken together they can provide a rough estimation of what sex is likely to have been produced. Figure 33 and Figure 34 depict the effect that vegetation height can have on nest temperatures.

Hatchlings:

2006: Heavy rains on 21 June and 22 June flooded Nests 1 and 3; with Nest 3 being under about 30 centimeters of water. It took about five days for the surface of Nest 1 to completely dry out and six days before Nest 3 was no longer underwater. Nests 1 and 3 failed to hatch and were excavated on 5 October after 123 days and 110 days respectively. Nest 1 was found to contain 15 unhatched eggs in poor condition (all broken in some way), for a total clutch of 17 eggs including the 2 inadvertently destroyed in the initial excavation of the nest for probe insertion. The top two eggs in Nest 1 were exposed at the surface to rain and winds. Nest 3 contained 17 unhatched eggs some of which were broken and all were coated in soot. The nest cavity was invaded by the roots of nearby plants and a white mold was found in and around the eggs.

On 27 August, after 80 days of incubation, Nest 2 yielded 12 hatchlings from a clutch of 13 eggs during a light rain which moistened the soil. The nest screen was opened at 13:15 to reveal eight turtles wandering under the cage and four turtles (free from their eggs) still inside the nest cavity. One egg near the surface of the nest failed to develop. Mass of hatchling turtles averaged 10.9 grams (min = 10 g; max = 11.8 g), and transmitters added 0.6 grams (including 0.1 g of epoxy) to each hatchling. Radio transmitters constituted an average 5.5% of body mass (min = 5.1%; max = 6.0%). Other measurement means were as follows: carapace length = 38.2 mm; carapace width = 33.7 mm; plastron length = 34.0 mm; head width = 10.0 mm; and tail length = 21.5 mm (Table 19).

Hatchlings were released at the nest site the next day (28 August). Hatchlings were tracked for an average of 11.7 days; excluding Hatchling .221, which was tracked for 60 days by consecutive transmitters, and Hatchling .101 which was never located after release. Hatchlings moved an average of 27.4 meters per day (max = 188.2 m; min = <1 m) (excluding Hatchling .221 after its first 20 days of active movement toward water). Mean distance traveled per day for individuals ranged from 11.3–53.3 meters. Mean distance from the nest to the last known location of hatchlings was 231.2 meters. Direction of travel from the nest was widely dispersed and individual paths were generally convoluted with frequent direction change and back-tracking (Fig. 38). The field that Nest 2 was located in was surrounded on three sides (north, south, and west) by a steep-sided irrigation ditch which was sparsely vegetated throughout most of its reach and held water at an approximate depth of one meter. Hatchlings were occasionally located in this ditch, but individuals were never observed in it for two consecutive days. Nine of the 12 hatchlings crossed the ditch and continued on away from the buckwheat field. Additionally, Hatchling .491 was found at the edge of a small, soft-bottomed pond with sparse vegetation on 7 September, which it apparently crossed and promptly exited. Signals from 6 of the 12 radio transmitters were lost prior to 12 days. These transmitters either failed prematurely (dead battery) or were located out of the receiver's range. These hatchlings may have traveled out of range or been carried off by predators. Three transmitters were located without turtles indicating possible predation (Hatchlings .131, .311, and .400), though this could not be confirmed. Two hatchlings (Hatchlings .431 and .162) were confirmed predated; partial remains of the first were found on 9 September and bite marks indicate predation by an unidentified small mammal. The sex of this hatchling was determined from the salvaged remains and the hatchling was positively identified as male by presence of the epididymus and one intact testis. Dissection of the digestive tract (the stomach was missing and apparently consumed along with the head) was carried out to elicit previously unreported information on hatchling diet. Dissection revealed that the animal had consumed items prior to death. Gritty debris was found throughout the colon, but no specific prey items were identifiable. The contents included a couple grains of sand, some bits of vegetation, and two small pieces of a pliable (yet rigid) material not unlike the exoskeleton of a crayfish. The second predated hatchling was found on 11

September as tracking clearly indicated that the hatchling was consumed by an adult Bullfrog (*Lithobates catesbeianus*). Attempts to capture the bullfrog over the next two days (prior to failure of the transmitter) proved unsuccessful. The two hatchlings confirmed predated (Hatchlings .431 and .162) were also the furthest from the nest at 439.4 meters and 491.8 meters (respectively). Assuming that transmitters found without the hatchlings were predated individuals, the predation rate for hatchlings during the first two weeks after emergence was at least 41.7%.

Hatchling .221 was tracked for 60 days by reaffixing a new transmitter as the battery life expired on the former (the first transmitter lasted 16 days and subsequent transmitters were switched out approximately every 10 days). This hatchling actively moved for the first 20 days upon which time it reached the corner of a flooded field where it seldom moved more than one meter per day. The location was characterized by Reed Canary Grass (*Phalaris arundinacea*) and bordered by willows (*Salix sp.*). The field was intentionally flooded in August to prepare for the duck hunting season. The hatchling spent most of its time along the bank in just a few centimeters of water and was often found buried an additional few centimeters into the organic substrate. Movements in the month of October, as water temperatures cooled considerably, were rarely more than a meter and the hatchling often remained in the same location for days at a time. Water temperatures in the month of October ranged from 17.5–6°C and were generally below 15°C. The hatchling was last located on 27 October still in the same shallow water location. This field, including the last known location of the hatchling, was drained of all water by 18 December.

2007: Nest 7 failed to hatch and was excavated on 9 October after 120 days of incubation. The nest was still intact, but in preparation for duck hunting season the landowner no longer permitted access to this field. The cornfield Nest 7 was located in was in the process of being flooded for duck hunting; however, it did not seem likely that the water level would raise high enough to top the nest. The soil surrounding Nest 7 was very moist, but was relatively loose. Seven of the 13 eggs were found broken and the other 6 eggs were still intact. Skeletal remains, consisting largely of carapace scutes, were observed in each of the broken eggs. Remains appeared to indicate well developed embryos. Dissection of the six intact eggs showed two of the eggs to be undeveloped (full of dried yolk), and four with well developed turtles still possessing large yolk sacks. The developmental stage appeared to be consistent with death around 71 days of incubation which would correspond to field-note entries describing saturated soil due to heavy storms on 20 August and 21 August

Nest 8 also failed to hatch and was excavated on 22 October after 119 days of incubation. The top two eggs were barely below the surface of the soil and were exposed to the elements through a large crack in the soil which ran across the surface of the nest cavity. These two eggs, including a third egg, were broken open and their contents were absent. Six additional eggs were also broken, but contained the partial remains of developing turtles (represented largely by carapace scutes). The remains were well decomposed and too far gone for accurate identification of the approximate developmental stage. The remaining two eggs from Nest 8 were intact. Dissection of the intact eggs showed them to be undeveloped with one being full of yolk and the other full of white mold. Previously mentioned heavy rainstorms during August likely flooded the nest chamber, and would correspond to 56 days of incubation for Nest 8. This time period was not inconsistent with the remains found.

On 18 September, hatchlings emerged from Nest 6 after 101 days of incubation. Two hatchlings were found moving about under the nest screen and two more were sitting in the opening of the nest cavity at 10:45. A fifth hatchling was found behind the two at the opening and a sixth hatchling was seen moving below the surface of the soil. The five hatchlings at the surface of the nest were removed, cleaned, measured, and fitted with radio transmitters. The nest screen was replaced to allow the remaining hatchlings to emerge on their own. Mean mass for the five hatchlings was 10.3 grams (min = 9.7 g; max = 11.0 g). Percent body mass incurred by radio transmitters was held between 5–7%. Three of these five hatchlings had kinks in their tail ranging from minor to severe. The carapace was asymmetric in some individuals and one hatchling had an extra piece of neural scute. Additionally, one hatchling appeared partially paralyzed in front left limb, and was unable to bring it forward beyond perpendicular to the shell (forcing it to move with an irregular gait). Hatchlings were released the same day at 14:00 next to the nest. The following day a sixth hatchling was seen pipping through the soil at the surface of the nest (presumably the same individual seen moving below the soil the previous day). The hatchling was removed from the nest; however, the individual appeared to be under-developed with an unusually large yolk spot. The yolk spot was weeping and three small white maggots were observed on it. The hatchling was believed to have emerged prematurely due to disturbance of the nest surface and was thus excluded from tracking. The hatchling was held for observation, but died four days later. Dissection revealed this hatchling to be consistent with the anatomy of a male, and large amounts of yolk were still present within the body cavity.

After 128 days of incubation the remainder of Nest 6 was excavated on 15 October. Two additional hatchlings were found alive within the nest cavity. One hatchling was free of its egg and had already lost its egg-tooth, the other was still half inside its eggshell and was tightly held in the nest by the surrounding soil. Both hatchlings appeared very lethargic. Measurements for these two hatchlings were similar to those taken for the underdeveloped hatchling which was believed to have emerged prematurely due to researcher disturbance at the nest. With a mean mass of 9.3 grams (min = 9.1 g; max = 9.6 g), mass for these three hatchlings was lower than any of the five hatchlings which emerged from this nest naturally. The two hatchlings were held overnight for observation and fitted with radio transmitters the next day (percent body mass of transmitters was 5.4% and 6%). Because the cornfield was expected to be harvested imminently and because the hatchlings had not emerged on their own, they were released to a nearby wet ditch immediately south of the cornfield. Consequently, tracking of these two hatchlings was carried out primarily to observe their survivorship and not their movements from the nest. Mean measurements for all eight hatchlings which successfully survived incubation in Nest 6 were as follows: mass = 9.9 g; carapace length = 35.1 mm; carapace width = 29.2 mm; plastron length = 29.7 mm; head width = 9.8 mm; tail length = 18.1 mm; and shell height = 18.5 mm (due to the severity of its developmental abnormality, one hatchling's tail length could not be accurately measured and was thus eliminated from this calculation). Means for all measurements were lower for Nest 6 hatchlings than for Nest 2 hatchlings the previous year. Measurements of all hatchlings are compared in Table 19. The remaining five eggs exhumed from Nest 6 were largely intact except for small tears at one end. Each of these eggs contained the decomposing remains of a fully formed turtle. These decomposing turtles still possessed large yolk sacks indicating that they were nearly but not yet completely developed. The developmental stage observed in the decomposing embryos was similar to that found for deceased embryos in Nest 7. The remains were consistent with death around 69 days of incubation, which would correspond well to the heavy storms during that period.

Hatchlings tracked from Nest 6 moved a mean of 10.4 meters per day; however, the five hatchlings which emerged on their own averaged 12.7 meters per day versus 0.5 meters per day averaged by the two hatchlings excavated from the nest and placed in the nearby ditch. Movements for all hatchlings ranged from no movement to a max of 114.4 meters in a single day. The mean distance traveled from the nest to the last observed location was 193.9 meters (excluding the two hatchlings placed in the ditch). The shortest distance traveled from the nest to the last observed location was 16 meters, traveled by Hatchling .220 (which was partially paralyzed in its front left limb). This hatchling survived 16 days before it was believed to have died naturally and ultimately been scavenged. A second hatchling (Hatchling .281) was believed to have been predated the same day (4 October) when only its transmitter was located. This hatchling, which had a severely hooked tail, traveled the second shortest distance from the nest (54.1 meters). The most rapidly moving hatchling (Hatchling .160), averaging 20 meters per day, traveled across the cornfield until it reached a mowed opening on the other side. The individual spent 11 days at the edge of the field (rarely moving more than a meter), before resuming its rapid march. When it reached a shallow muddy ditch at the edge of the property line, it spent another three days barely moving position. The hatchling then moved a short distance, to a small vernal pool along a tree/shrub line at the border of two pieces of property, where it spent another three days hidden in the shallows along the bank. The hatchling was finally found sitting on the open ground of a tire tread atop the adjacent dike where it appeared lethargic. The hatchling did not move again and was found dead of uncertain causes in this same location two days later. Dissection of this hatchling was also consistent with male anatomy. Furthermore, dissection of the digestive tract positively revealed the chitinous remains of what appeared to be an adult dytiscid beetle (approximately 5 mm long if articulated) and other unidentifiable remains located in the colon. The stomach was distended and filled with an unknown pink gummy material. Small perforations were also observed through the wall of the stomach which was not believed to be a result of researcher handling, and suggested a possible cause of death.

Two of the five hatchlings that emerged naturally from the nest ended up in a shallow ditch south of the cornfield. One of these (Hatchling .102) was presumed predated when only the transmitter was found sitting on open ground at the top of the ditch's bank. Animal runs at this location and the presence of scat in the vicinity indicate mink as a potential predator of this hatchling. The other hatchling (Hatchling .341) spent 20 days in and around this ditch (rarely moving more than a meter) before exiting and rapidly moving northwest back into the cornfield. On 25 October, this hatchling was located in the cornfield as a harvester combine came through. The next day the hatchling was located 67 meters northeast in the field, sitting in a tread left behind by tractor tires (cornstalks were cut approximately 30 cm from the ground). The hatchling remained on land in the middle of this cornfield until it was last observed on 19 November. From late October through mid-November, this individual often took refuge under any available cover (typically corn husks), and even nestled into the surface soil layer, when temperatures dropped below approximately 10°C. Despite overnight air temperatures frequently dropping around and below freezing during the month of November, no apparent ill-effects were observed in this hatchling. The afore mentioned cornfield was scheduled for no-till planting of soybeans the following May. The two lethargic hatchlings (Hatchlings .252 and .372) which were found in the nest during excavation, and which were moved to the ditch south of the cornfield, rarely moved more than one meter per day. One of these hatchlings was found partially eaten, located under some thatch in a rodent's run along the ditch. Dissection of this individual was again consistent with male anatomy and examination of the colon (stomach was missing along with the head) revealed the presence of unrecognizable material. Additionally, the lining of the colon appeared very thin and translucent in this individual. Water temperatures in this ditch rarely climbed above 10°C and dipped as low as 4.5°C during the month of November. Survivorship for the eight hatchlings which successfully developed in Nest 6 was 25% over 63 days of tracking. Figure 39 shows the movements of hatchlings from Nest 6.

DISCUSSION

In this study, comparisons made between both diet and movements of males versus females must be considered with caution. Due to the small sample size for females (seven individuals) results may not reflect true differences between the sexes. Similarly, results for nesting behaviors and hatchling success incorporate a limited number of individuals and observations. Nevertheless, it is believed that due to the general uniformity of soil characteristics and land use practices adjacent to the marsh, the observations presented here may be considered to be representative of this population. The results presented for movements, and specifically the general homeranges and activity centers of individuals are meant as complimentary information to the overall ecology of these individuals. Due to the limited tracking (bimonthly) and number of observations for each individual, the homerange estimates should be considered tentatively. The mean size of adults in this Ohio population falls within the typical range reported elsewhere throughout the species' range (Rowe, 1987; Rowe, 1992b; Joyal et al., 2000; Pappas et al., 2000; Banning, 2006; Congdon and Keinath, 2006).

DIET:

Lymnaeid snails were the predominant food item identified in the diet of *Emydoidea blandingii.* More specifically, the Marsh Pond Snail, *Stagnicola elodes,* makes up the overwhelming bulk of the diet for turtles in this population (Table 3). This finding is in opposition with the general consensus of *E. blandingii* feeding predominantly on crayfish (Lagler, 1943; Kofron and Schreiber, 1985), and appears to be in agreement with Rowe (1992a) who also identified pulmonate snails as the dominant food item. In addition, *E. blandingii* appear to feed preferentially on items approximately ≥1 cm despite smaller prey items being more readily available in their habitat. Although large differences were observed between 2006 and 2007, the diversity of items ≥1 cm available in the marsh (as seen in dip net samples) was, in all cases, greater than that found in the diet of the turtles. Also, in spite of insects being the most abundant item ≥1 cm in dip net samples, turtles seem to either prefer gastropods or simply have more success capturing them. Moreover, they do not appear to take advantage of all the insect taxa available. The most frequent and abundant item ≥1 cm found in dip net samples, Order Zygoptera, was not identified in stomach contents. It is unclear why this potentially valuable food item was not consumed. Similarly, Rowe (1992a) found no zygopterans in any stomach samples and identified only one in fecal samples from 22 individuals in Illinois. Lagler (1943) found two specimens in 66 individuals from Michigan, and Kofron and Schreiber (1985) found none in 15 individuals from Missouri.

While *Stagnicola elodes* was the second most frequent and the most abundant consumed item identified in dip net samples, observations made in the field suggest that the species is even more abundant than is suggested by the dip net results. This species was regularly observed cruising inverted just below the surface of the water. Because *S. elodes* is active near the surface of the water, it was often observed in heavy densities where apparent wind action had congregated them together along with thick mats of surface floating vegetation like *Lemna*. Although the densities of *S. elodes* were very high in these concentrated patches (which were common throughout the marsh), it is believed that the limited sampling performed by dip net did not accurately reflect this. Rowe (1992a) suggested the colonial or clumped behavior of snails might explain the importance they held in the diet of turtles in Illinois. The relative abundance of *S. elodes* and its larger size, coupled with the ease of capture (especially when found in large congregations), likely explains their large contribution to the diet of turtles in this population. Furthermore, gastropods were the only item found in numbers greater than 14 in any individual stomach sample. In fact, when *S. elodes* was present in a stomach sample it averaged 16 individuals per sample, and samples were recorded to contain as many 162 individual snails. Consequently, it can be said that feedings on gastropods, an item that is often observed in congregations, typically occurred as binge feedings. Thus, the prevalence of this item in the diet of turtles is probably an opportunistic feeding strategy.

Further evidence of the opportunistic exploitation of *Stagnicola elodes* as an easily-obtainable food item might be taken when you consider its disproportionate importance during the month of May. The lower diversity and evenness in stomach samples during this month suggests that individuals may feed more selectively and on fewer prey items at this time. In spite of this, May exhibited the greatest mean volume and mean number of items for stomach samples of any month of the year. If feeding is opportunistic, then this trend appears contradictory when seasonal availability of *S. elodes* is inferred from dip net sampling; however, the poikilothermic nature of this species may provide the answer. At a time when water temperatures are still cooler and activity of this species is notably slowed, easily captured food items like snails could be at peak value. Consequently, it might be expected to make up the bulk of the diet until rising temperatures make other items more obtainable. As the season draws on, the diet becomes more diverse and larger, more-voluminous items appear to be consumed.

Other major food items identified were Class Insecta (with Order Anisoptera being foremost), Family Hirudinidae, Order Decapoda, and fish. Insects were often represented only by chitinous remains whose volume may not have accurately represented their contribution to the total dietary volume. The apparent rapid rate of digestion of the soft parts of insect items may also indicate a relatively greater value for these items as nutritional components of the species' diet when compared to less digestible items. The importance of gastropods over insects in the diet of these turtles, despite the greater availability of insects, likely reflects a difference in the effort required to obtain the two food items.

The relative importance of insects in the diet over May, June, July and August does not seem to be influenced by the seasonal availability of these food items as reflected in the dip net sampling. It would seem that the relatively constant availability of insects (≥1 cm) throughout the season (Table 12) makes their apparent seasonal variability in consumption (Table 4) difficult to explain. However, it is certainly conceivable that their consumption is simply another case of opportunism. Though not directly examined, greater consumption of insects during June and July may correlate with water temperatures more conducive to capturing faster moving food items such as insects. Seasonal data comparing stomach contents and dip net items must be considered with caution, however.

Because dip net sampling was conducted in 2006 alone, annual fluctuations in food item availability are not considered. Moreover, the pooling of stomach samples from two seasons (2006 and 2007) for analysis of samples according to month collected, does not account for annual variation in diet either.

In another potential case of opportunistic behavior, leeches were not particularly abundant in dip net samples throughout the year, but were often found in large numbers attached to the body of turtles. It seems logical that greater consumption of Hirudinae during May could be a function of the level of infestation present on given individuals. Kofron and Schreiber (1985) reported the level of leech infestation on individuals was greatest on and after 26 May. Leeches moving onto and across the body may also present another easily obtainable food item when other items are more difficult to procure. Future studies might attempt to evaluate the level of infestation and its relation to leeches in the diet.

Within Order Decapoda, the invasive species *Procambarus clarkii* (Swamp Red Crayfish), which has been widely introduced, appears to be the most likely species consumed as this was the crayfish species overwhelmingly most abundant in traps. It is unclear whether the native species *Procambarus acutus* was present in the diet as the remains were not complete enough for reliable identification beyond genus. The apparent consumption of *P. clarkii,* as evidenced from both stomach and fecal samples, appears to coincide seasonally with abundance data from crayfish traps (Table 4 and Fig. 12). It may be that an increase in crayfish activity made them more readily available to turtles as a food item during the month of June. A study of nine predators in a freshwater marsh in Portugal revealed a similar seasonal pattern with spring/summer peaks in predation on introduced *P. clarkii* (Correia, 2001), and Gherardi et al. (2000) showed *P. clarkii* enters stationary phases followed by bursts of nomadic movement in spring and summer. Furthermore, the occurrence of crayfish in the diet of *Emydoidea blandingii* during the month of June coincides with a decrease in the relative importance of *Stagnicola elodes* at this time. It is unclear what causes the seasonal increase in crayfish abundance; however, one possible explanation may be the water temperature. Whatever the reason, it would seem that when crayfish activity is at its peak, the incidence of its consumption by *E. blandingii* increases while consumption of *S. elodes* decreases. This trend may indicate preferential feeding upon crayfish over gastropods when crayfish are readily available.

Fish flushed from the stomach were often in an advanced state of digestion that made species identification difficult. Most fish identified were Cyprinids (likely small *Cyrinus carpio*); however, small Centrarchids also appeared to have been represented. Both fish and crayfish, although not high in total frequency of occurrence, made up a relatively higher proportion of the total volume due to their overall bulk. Additionally, their inherent bulk may make flushing more difficult, and as such, may lead to their under-representation within the stomach contents analyzed. Crayfish appeared in just four stomach samples and two of those were obtained by dissection of road-killed specimens. It is uncertain whether these items might be under-represented, as no animals were sacrificed to verify the efficacy of the flushing technique.

It is interesting to note that during the stomach flushing study conducted by Kofron and Schreiber (1985), they describe capturing a total of 77 *Emydoidea blandingii* (177 total captures and recaptures); however, they report obtaining the stomach contents of only 15 individuals. In personal communications with Christopher Kofron, he could not recall what their retrieval rate for stomach flushing was, nor how many of those individuals they attempted it on; but he did recall that it required a lot of water to get stomach contents. Rowe (1987) reported successfully retrieving stomach contents in 23 of 46 flushing attempts (50% retrieval rate). Furthermore, Rowe describes inserting the tube beyond the pyloric sphincter in order to flush fecal contents out through the cloaca. Flushing of fecal contents in this manner was not attempted in this study and it should be noted that the retrieval rate for stomach flushing during 2006 was 25% compared to a 42.7% retrieval rate for 2007. While some of this discrepancy can likely be attributed to experience with the flushing technique, it is also believed to be attributed in large part to the amount of water used during flushing. Rowe (1987; 1992a) does not report the volume of water used during his flushing attempts, but attempts made during this study began conservatively, using less than 500 ml. The volume was gradually increased to as much as 1,800 ml, and the nozzle was eventually adjusted to allow maximum flow. The mean volume used during 72 flushing attempts during 2006 was 858 ml, while the mean volume used during 110 attempts in 2007 was 1,398 ml.

Plant matter rarely appeared to be anything more than incidentally ingested with other items. Although frequency of occurrence appears high at 37.9%, this usually is represented only by a few small pieces of *Lemna sp.* On only a few occasions was plant matter found in large enough quantities to suggest that its ingestion was intentional. On those few occasions, the plant material ingested was *Lemna* and filamentous algae. Results of this study are in agreement with previous work characterizing *Emydoidea blandingii* as an omnivore with a propensity for carnivorous behavior. Furthermore, descriptions of this species as an opportunistic feeder are supported in this population. Despite the relatively low diversity of items in stomach samples when compared to the diversity of potential food items available in the marsh habitat, *E. blandingii* appears to readily take advantage of a wide range of food items within its ecosystem. As evidenced by the presence of bird remains in stomach samples, this likely includes any opportunity to scavenge an easy meal. It is uncertain whether the presence of bird material (represented by little remains) is indicative of scavenging or if it represents predatory behavior on fledgling individuals, but this study makes the appearance of bird in the diet of *E. blandingii* the third such observation in studies of this type (Lagler, 1943; Rowe, 1992a). Additionally, the apparent rapid growth rate (22.2 cm CL at ~12 years of age) and early maturation of Female #119 might be considered evidence for a rich nutritional diet in this population.

Diversity between the diets of males and females appeared to be similar (Table 5) and there was a high degree of overlap between their diets. Evenness was moderate across the diets of both sexes and likely reflects this species' opportunistic nature, selectively taking advantage of the easiest prey items. When importance of consumed items was compared between the sexes some possible differences seemed to stand out (Table 6). It is unclear whether males truly consume more insects and leeches than females while females consume more crayfish than males, or whether this is simply an artifact of small sample size. To understand this potential trend better, more diet samples would need to be collected for each sex. In particular, more females and female diet samples are needed to make a compelling argument for differential feeding between the sexes. Further investigation into the diets of males versus females is warranted, and could perhaps include temporal differences between each sex. An interesting byproduct of repeated sampling from this relatively small number of individuals was the observable trends for individual dietary preferences. When analyzing the stomach samples of individuals it appeared clear that while some possessed a relatively diverse diet, others exhibited a greater tendency toward specialist behavior. Specifically, those individuals that displayed the lowest measures of diversity and evenness in their diet were consuming the lymnaeid snail, *Stagnicola elodes,* as their primary food source (Tables 7 and 8). Whether due to the relative abundance of this food item in the marsh or the ease with which it may be captured, it seems probable that numerous individuals in this population had formed a search image for *S. elodes* in their environment and were taking advantage of it as a valuable dietary resource. Depending on the geographic location, and presumably the availability of food items, *Emydoidea blandingii* has been characterized as a generalist predominantly consuming either crayfish or pulmonate snails. Future studies of this type might draw greater attention to the position of *E. blandingii* as a facultative specialist, quick to capitalize on a specific food item when the opportunity presents itself.

The ability to analyze stomach contents according to the microhabitat individuals were collected in was limited by small sample sizes (Table 9). In particular, 77% (n = 50) of stomach samples came from individuals which were collected in PEM habitat whereas only 3% (n = 2) came from PUB. Despite this bias, the distribution of stomach samples is similar to the overall usage of habitat observed from April–September. Larger samples sizes are thus required to determine if true difference in diet occur depending on the microhabitat utilized. It is noteworthy that, in spite of higher diversity and evenness having been observed in the dip net samples from PEM habitat, the diversity and evenness for stomach samples from PEM habitat was considerably lower than overall diversity and evenness in the stomach samples as a whole (Table 10). This suggests that microhabitat selection may be influenced by the availability of specific food items. Speculatively speaking, previous experience could have led individuals to seek out PEM habitat for feeding, where a possible search image for items like *Stagnicola elodes* could explain contraction of the dietary diversity in this habitat.

The overall diversity and evenness of available items ≥1 cm, does not appear to vary greatly among the wetland classes throughout WPM. DCA analysis revealed some possible trends present for taxa assemblages across microhabitat types. Most notably, the assemblages of shallow marsh and wet woods taxa exhibited a fair degree of overlap (Fig. 14). This is not surprising considering that trees (which were not abundant in this marsh) typically grew in shallower areas when present. Moreover, the principle food item, *Stagnicola elodes,* appeared to be associated with the shallow marsh/wet woods grouping (Fig. 15). *Emydoidea blandingii* was also located in shallow marsh the majority of the time (66.3%). It is uncertain whether turtles feeding on *S. elodes* in shallow marsh and wet woods were utilizing these microhabitats for selective feeding, or whether *S. elodes* was the principle food item because it frequently occurred in the microhabitat preferred by these turtles for other reasons. However, the relative abundance of items ≥1 cm across wetland classes, with particular regard to PEM habitat, may help explain the habitat preferences observed for tracked turtles (Table 15).

A possible explanation for some perplexing dip net results lies in the subjectivity present in selecting sampling sites. Habitat types within the marsh exist along a continuum rather than in defined units; for this reason, attempts to classify habitat is prone to bias. The great variability in habitat types encountered from location to location throughout WPM may have rendered the limited dip net sampling insensitive to actual trends in food item availability. Furthermore, this natural variability was compounded by management practices taking place in much of the study area. Management practices consisted primarily of manipulation of water levels designed to control invasives and promote vegetation diversity. Areas normally exhibiting emergent vegetation were often in an intermediate state of decline giving way to vegetation more indicative of deeper water habitat. Because hoop-net trap sites were ultimately chosen to optimize chances of capturing individuals for the study, it would have been preferable to designate dip net sampling sites independent of trap sites and according to Cowardin wetland cover type classification. However, site selection would still be complicated by changes in vegetation cover over the course of the growing season (PUB vs. PAB). A possible solution to this conundrum would be to select dip net sites according to dominant species of vegetation and attempt to detect trends along that parameter. This would permit distinctions to be made between native species and invasive non-natives such as *Phragmites australis* and *Typha angustifolia,* which are increasingly blanketing Ohio's wetlands. A 2005 study at WPM by Cook (2007) conducted such an analysis, comparing dip net samples from *T. angustifolia* stands with those of *Sparganium eurycarpum* and *Pontedaria cordata,* and found that lymnaeid snails were abundant in *S. eurycarpum*, common in *T. angustifolia,* and rare in *P. cordata.*

The retrieval rate for stomach flushing in combination with the changes in mass for individuals throughout the 2006 and 2007 seasons are believed to be a good indication of trends in feeding activity for *Emydoidea blandingii.* It has previously been discussed that this species begins feeding early in spring with the early warming of water temperatures (Kofron and Schreiber, 1985). Our results support this hypothesis and suggest that feeding activity generally occurs April through September in Ohio, and peaks from May through July. There did not appear to be a strong biphasic feeding pattern, as suggested in previous studies (Kofron and Schreiber, 1985; Rowe, 1987). Overall activity appeared to increase and decrease gradually, and varied among individuals. An exception to this occurred in April 2007, when masses recorded for several individuals were observed to drop precipitously at the same time. This drop in mass is believed to be the result of a brief plunge in water temperatures, and demonstrates the role that temperature plays in activity. Sajwaj and Lang (2000) demonstrated the profound effect of water temperature on body temperature of *E. blandingii,* and reiterated its potential for impacting ingestion and digestion in poikilotherms. Furthermore, some individuals were observed apparently aestivating, or ceasing observable activity, for several days in the middle of this spring-summer activity period. Individuals were observed to aestivate both on land and in muskrat burrows in the banks of ponds and canals. Aestivation was also observed in Illinois, Wisconsin, and Maine on both land and in water, and did not appear to be correlated with water temperatures (Rowe, 1987; Ross and Anderson, 1990; Joyal et al., 2001; Banning, 2006). It is unclear whether this is related to temperature extremes or perhaps drought or low water level conditions—natural or otherwise. As mentioned earlier, wetland drawdowns take place frequently at WPM in order to manage for waterfowl and invasive species. Two of the individuals observed aestivating in 2007 were in a region of the marsh that was currently experiencing a drawdown. A study of the impacts of a controlled wetland drawdown on Blanding's turtles in Minnesota showed that individuals were often forced to make long migrations from natural activity centers. Additionally, due to the drawdown being initiated in the fall, high mortality was observed as a result of predation, road kill, and winterkill (Hall and Cuthbert, 2000). The alteration of water levels and/or wetland vegetation can potentially influence the thermal response of these turtles with detrimental effects on energetics (Sajwaj and Lang, 2000).

HABITAT USE:

The general pattern of movement observed for this population was from more open water habitat (PUB) in fall and winter (October through March) to emergent wetlands (PEM) in spring and summer (April through September). The timing of activity observed in this population appears similar to that reported elsewhere (Evermann and Clark, 1916; Gibbons, 1968; Vogt, 1981; Kofron and Schreiber, 1985; Rowe, 1987; Ross and Anderson, 1990; Rowe and Moll, 1991; Pappas et al., 2000; Piepgras and Lang, 2000; Banning, 2006). Despite this general trend, movement patterns and seasonal behaviors varied widely from individual to individual. The activity periods varied between individuals with some apparently beginning activity earlier in the spring and others continuing activity longer into the fall. Additionally, a few individuals were observed to aestivate during summer months while others remained active. Moreover, while a few individuals sought out specific areas in which to overwinter, the location and movements of most individuals appeared only to be a function of the current water temperature. That is, a number of individuals simply ceased movements as temperatures dropped, seemingly regardless of where they were within the marsh habitat and within their homerange. Furthermore, as Kofron and Schreiber (1985) observed in Missouri, individuals do not necessarily remain stationary throughout cold winter months. The variety of behavior observed for individuals while overwintering is similar to that reported for other populations. Like Piepgras and Lang (2000) reported for *Emydoidea blandingii* in Minnesota, some individuals utilize different habitat types between the active season and winter, whereas others remain within the same area. Overwintering within the same range used during the active season appeared to be the most common behavior in the present study and was observed to be the case typical of populations in Wisconsin, Maine, and Illinois (Ross and Anderson, 1990; Joyal et al., 2001; Banning, 2006). The utilization of ponds and canals for hibernacula by some individuals is also similar to that reported elsewhere.

The disproportionately higher use of PUB habitat throughout the year with regard to its availability at WPM is reminiscent of reports on habitat utilization by this species elsewhere. In Wisconsin, where the use of pond habitat was disproportionately high relative to its availability there, descriptions of pond habitat appear to be a combination of PAB and PUB habitat (Ross and Anderson, 1990). Unlike in Wisconsin, turtles at WPM do not make extensive use of ponds (pond habitat was not as widely available at WPM), but they do appear to take advantage of the existing canal system for movement between activity centers and in some cases as winter hibernacula. In particular, females were observed to utilize the canal and ditch systems heavily for nesting migrations. In 2007, Female #111 followed the canal and ditch system about 1,500 meters around the marsh and north into the agricultural fields before her week long residence in an isolated pond (PUB habitat) prior to nesting. Furthermore, Ross and Anderson (1990) reported that turtles in the Wisconsin population avoided wetlands covered by cattail mats, but turtles in the present study made extensive use of cattail marsh (typical PEM habitat). It should be noted that although turtles in this population were frequently found in cattail stands, they were, as in Wisconsin, typically located within the runs and openings created by muskrats within the cattail stands. Heavy use of cattail marsh is similar to behavior reported for turtles in Illinois (Banning, 2006). Assessment of potential food items (those ≥1 cm) available in WPM suggests that movement to emergent wetlands in spring and summer may be a linked to feeding ecology. With proportionately more potential food items observed in PEM habitat it stands to reason that an opportunistic feeder would seek out these areas during peak feeding activity.

As in other studies of this nature, individuals in this study were observed to occupy specific activity centers within their homerange. Some of these activity centers appear to follow a pattern of seasonal use, with individuals seemingly returning to the same locations at specific times of the year (Fig. 33). The grouping of these activity centers together made up the general homerange of an individual. Considerable overlap was observed between the homeranges of males, females, and males with females (Figs. 26–32). This finding is in agreement with observations made for other populations (Rowe, 1987; Ross and Anderson, 1990; Piepgras and Lang, 2000). Moreover, the outlines of general homerange observed in this study almost certainly underestimate the true area encompassed in the homerange of these individuals. This became apparent when the active season homerange of individuals was observed in multiple years. The homerange estimates for individuals showed varying degrees of overlap from year to year, indicating that turtles likely range much further over their lifetime than these limited results suggest. Similar conclusions were made by Grgurovic and Sievert (2005) for *Emydoidea blandingii* in Massachusetts, and such a conclusion suggests a need for more long term monitoring of individuals' movements to accurately determine homerange estimates.

The movements of a number of individuals in this population indicate that they posses and utilize an awareness of their surroundings which allows them make deliberate movements to and from activity centers. Individuals were repeatedly observed to use specific locations in a relatively predictable pattern. The examples of nest site fidelity (Female #73), hibernacula revisiting (Male #59), as well as spring and summer activity centers (Males #95 and #114) can be taken as evidence of impressive cognition. Further investigation should more accurately estimate the size of the homeranges of these individuals and compare those to homerange sizes reported for other populations. This could help determine how the population size at WPM is related to the area of available marsh habitat present and whether this is a limiting factor in this population.

REPRODUCTION:

Despite only eight individual females having been observed nesting in this population, it is believed that some general trends recorded are worth discussion. With male turtles constituting 78.7% of the individuals captured at WPM, the population appears to have experienced a strong skew towards the production of and/or survival of males. While sex ratios in many *Emydoidea blandingii* populations have not been observed to deviate significantly from 1:1 (Graham and Doyle, 1977; Rowe, 1987; Germano et al., 2000; Joyal et al., 2000), female biased sex ratios have frequently been reported (Gibbons, 1968; Ross, 1989; Congdon and van Loben Sels, 1991; Rowe, 1992b; Pappas et al., 2000; Banning, 2006;

Congdon and Keinath, 2006). Capture rates for females by trap netting was lower than that of males, with 66.7% of females being captured by hand versus 40% of males having been captured by hand. It is unclear whether this reflects avoidance to traps by females, or whether this can be taken as further evidence of a strong skew in the sex ratio. Furthermore, two of the seven total study females were captured only because they were found while moving over land toward nesting sites. Pappas et al. (2000) reported significant bias for capturing females due to overland nesting movements. In light of the expected bias toward capturing females, the 3.7:1 (male:female) sex ratio observed in this population is believed to be a conservative estimate.

Since 2003, only 61 *Emydoidea blandingii* individuals were found at WPM and all of those were adults. While no juvenile *E. blandingii* were found during this study, it should be noted that few juveniles of either C*hrysemys picta* or *Chelydra serpentina* were found either. Trapping and marking of *C. picta* in 2006 alone yielded 95 individuals with only 5 recaptures. Of those 95, only 10 were under 12 cm in carapace length and none were less than 9.9 cm. This suggests that regardless of the population size, juveniles might simply be more difficult to find or capture. While it seems unlikely that this is a result of insufficient trapping efforts, that possibility cannot be ruled out. It is possible that trapping efforts were not concentrated in the correct areas or habitat types (Graham and Doyle, 1977; Ross, 1989; Pappas and Brecke, 1992; Congdon et al., 1993; Germano et al., 2000; Joyal et al., 2000; McMaster and Herman, 2000; Bury and Germano, 2003). It is conceivable that juveniles might use the ditches surrounding agricultural fields disproportionately more than the WPM habitat itself. Visual scans in the ditches did not suggest this was the case, but trapping was not carried out in these areas and sampling in these ditches with seines was carried out on a very limited basis. A more disturbing possibility is that the lack of juveniles observed is a true measure of the deficiency of recruitment in this population, as has been postulated for populations in Michigan and suburban Chicago (Congdon et al., 1983; Rubin et al., 2004). Considering the scarcity of females found in this investigation that would appear to be a real possibility; however, caution must be taken when interpreting such results. Continued search and more thorough trapping efforts in peripheral habitats are warranted to gain a better understanding of the population structure at WPM. In addition, future trapping should include additional methods better adapted to capturing target individuals such as: wings on hoop-net traps; greater use of seines; basking traps; traps with tighter mesh sizes; and traps better suited to shallow water habitats.

Mating or courtship was believed to have been observed on several occasions during the months of April, May, June, October and November. These observations fall within the time range previously described for *Emydoidea blandingii* (Ernst and Barbour, 1972; Graham and Doyle, 1979; Vogt, 1981). It is uncertain whether all these encounters were directly related to mating, but the close proximity of turtles of the opposite sex was perceived to be indicative of mating behaviors. Late season encounters could also have represented congregation at hibernation sites. Similar encounters of males in close proximity to each other may have represented territorial encounters between males, or there may have been an undetected female in the area. Additionally, the presence of multiple males apparently in pursuit of a single female, and the observations of individual females mating with multiple males in a single season are in agreement with Osentoski's (2001) evidence for individual clutches commonly fathered by multiple males.

Nesting activity generally began in the evenings around 19:00 with wandering of the fields by turtles in search of suitable nesting sites. This time frame is in agreement with reports from other populations of this species (Congdon et al., 1983; Linck et al., 1989; Standing et al., 1999; Congdon et al., 2000). Females spent two to ten days on land, typically in thick vegetation adjacent to fields; and as many as nine days in nearby ponds and flooded ditches prior to nesting (e.g., Female #111 in 2007) Most of those nights prior to nesting included a foray into the field before returning to the vegetation or nearby ditches and ponds for the remainder of the night. Some of these forays included the partial excavation of nests that were subsequently abandoned and occasionally carried on well into the night (e.g., Females #111 and #119 in 2007). The incomplete construction of nests has been observed in other populations (Rowe, 1987; Standing et al., 1999; Joyal et al., 2000; Banning, 2007). When nesting took place, it would begin with wandering of the field until approximately sunset. Then nest excavation typically began after dark and continued throughout the night with completion and departure from the nest at approximately sunrise. This late completion time for nests is well beyond that typically reported for any other populations. Ambient temperatures during nesting were cooler than those reported elsewhere and likely played a role in the rate of nest completion (Banning, 2007). Cooler nights were observed to slow the nesting process in Nova Scotia (Congdon et al., 1983; Standing et al., 1999; Congdon et al., 2000).

Soil analysis for nesting sites and observations of nesting behaviors indicate that nest excavation in this population are likely made more difficult by the local soil characteristics. Additionally, long-term land-use practices have likely resulted in the compaction of the soil in agricultural fields. Ironically, the practice of no-till farming carried out to decrease erosion and improve water quality seems to make nest excavation more difficult in the short term. This practice also increases the need for herbicides whose effects on developing embryos deserves further study. Although freshly plowed soils would seem ideal for nesting, the long term effects of farm machinery likely degrade the quality of nesting habitat. Furthermore, a freshly plowed field which may seem to be ideal nesting habitat to wandering females in June may ultimately prove unsuitable as crops can rapidly grow to excessive nest shading heights and densities.

In addition to the extremely long duration that was observed to be required for nest construction in this population, the difficulty of nest excavation in these tough soils appears to result in shallower and smaller nest cavities. In at least one instance it even appeared to result in the inability to fit all eggs in the nest (Nest 1). Additionally, another female (Female #109) was observed to nest in a pile of burned automobile tires, though this may have been due in part to the spool-and-line tracking apparatus becoming entangled in the remnants of the steel belts. The inability to excavate a nest capable of accommodating all eggs in poor nesting substrate, and utilizing artificial substrates (abandoned roofing material) has also been observed for a population in Illinois (Banning, 2007). Furthermore, nest dimensions observed in the present study were similar to those made by turtles on the pebble beaches of Nova Scotia, and nest construction there was reported to finish as late as 02:00 (Standing et al., 1999). How the depth and dimensions of the nest might affect the incubation success is not certain, but at the least it would be expected to impact temperature regimes and moisture levels. Moreover, the extended duration of nest construction would likely put females under added stress and further vulnerability to predation. Additionally, the soil is prone to rapid and deep cracking as it dries out. It seems reasonable to conclude that the cracking of the soil would further increase the risk of desiccation and or predation, and it is noteworthy that the top egg in the successfully hatching 2006 nest was the only one which failed to hatch out of a clutch of 13. The compaction and heavy soil characteristics in the region also appear to leave nests more susceptible to flooding during heavy storm events. Flooding of the nests is believed to have drowned developing embryos in five of the six nests monitored during 2006 and 2007.

Mean sizes observed for Ohio hatchlings fall within the range reported for Michigan (Congdon and van Loben Sels, 1991; Congdon and Keinath, 2006); however, the carapace length for two individuals and the plastron length for six individuals (max = 39.2 mm; max = 35.2 mm, respectively) (all from Nest 2) were in excess of the maximums reported for Michigan (max = 39.0 mm; max = 33.9 mm, respectively). Individual plastron lengths reported by Graham and Doyle (1979) for Massachusetts and Power (1989) for Nova Scotia also fell outside the range of those reported for Michigan, and it seems likely that if measurements of maximum and minimum were reported for other populations this size range would be expanded. Hatchlings did not seem to show any specific movement patterns. Direction for departure from the nest appeared to be random and widely dispersed. Because hatchlings were cleaned after emergence, so that radio transmitters could be glued to the carapace, it is conceivable that scent trails were diminished. Consequently, this may explain the lack of observable evidence for trailing between siblings as suggested by Butler and Graham (1995). It also seems reasonable to assume that the predation rate observed may underestimate the true predation rate on hatchlings having recently emerged from the nest with scent fully intact. Hatchlings seemed to display an aversion to deep, sparsely vegetated water found in the ditches around the perimeter of the field. Hatchlings in 2006, which wandered into flooded sections of fields, where thick emergent vegetation and shallow depths were present, seemed to show their strongest affinity for these locations (Hatchlings .251 and .281). Similarly, hatchlings in 2007 which reached ditches with shallow water and emergent vegetation typically spent more time and moved less in these locations than when located on drier ground (Hatchlings .102 and .341). Ambient air temperature did not seem to affect movements of hatchlings until temperatures fell below approximately 10°C when movement of hatchlings generally ceased. On sunny days between the hours of 10:30 and 13:30, hatchlings were often observed in plain view, presumably to warm their bodies in the sunshine. Observations of hatchlings in Ohio appear to be in general agreement with those reported for Nova Scotia. While hatchlings often entered water, they did not necessarily remain in aquatic habitats and results suggest that hibernation probably takes place in both terrestrial habitats and the shallow margins of aquatic habitats. It has been suggested that hatchlings employ a mixed strategy upon emergence from the nest, with wide dispersal allowing some individuals to survive in an unpredictable environment (Standing et al., 1997; McNeil et al., 2000). Wide dispersal may reduce pressure from predation, and variable distances to water and vegetation for cover from year to year may provide an adaptive basis for this behavior. It remains uncertain whether hatchlings can survive in these terrestrial locations; however, it is logical to assume that this behavior has been perpetuated by success in at least some years.

Presence of food items in the digestive tracts of hatchlings provides previously unknown insight into the post emergence behavior of this species. Observations of narrow growth annuli on juveniles have previously hinted and pre-hibernation activity in hatchling *Emydoidea blandingii* (Pappas et al., 2000), but this is apparently the first confirmed recording of post-emergence feeding activity in hatchlings prior to their first winter hibernation.

The impacts of unnatural flooding and draining of fields on the survival of hatchlings seeking out safe refuge is uncertain. It is possible that the flooding of fields would be advantageous to hatchling turtles; however, draining of fields during cold winter months may have negative effects on survivorship. How the removal of wetlands from natural hydrologic cycles affects hatchling survivorship is unclear and warrants further investigation. In addition to hydrologic conditions associated with agriculture, the planting and harvesting of crops presents substantial danger to turtles. In particular, nests in wheat fields are almost assuredly destroyed during incubation when the crop is harvested and the field tilled around mid-August. In fields of corn and soybean, any hatchlings remaining in the fields into October are also at high risk when these crops are harvested. These three crops make up the majority of upland habitat adjacent to WPM and all where observed to be utilized by nesting females.

Nest temperatures fluctuated greatly between day and night (Fig. 37). Additionally, factors such as the surrounding vegetation played a role in nest temperature. Although the sex of all the hatchlings was not determined, temperatures from the nests could be used to infer the sex of offspring which would likely have been produced in those nests. The mean temperature of Nest 2 (2006) during the month of July (24.89 °C) was in agreement with experimental (constant) temperatures that produce males and the sex of the predated hatchling from this nest was also consistent. Similarly, the mean temperature for Nest 6 (2007) during the month of July (21.29 °C) was consistent with experimental temperatures expected to produce males and was also consistent with the sex of the three salvage hatchlings. How the cumulative effects of daily fluctuations in temperature influence the development of sex in hatchlings is a topic which requires further study. Nevertheless, by comparing temperature regimes collected from nest sites, the relative effect different nesting habitats might have on the sex of resulting offspring can be compared and evaluated. Moreover, the mean, median, and mode temperatures for Nest 6 throughout incubation were consistently around (within 1°C) the lower limit for development (22.0–22.5 °C) observed during experimental incubation of *Emydoidea blandingii* (Gutzke and Packard, 1987; Ewert and Nelson, 1991). As has been discussed by Standing et al. (2000), cool conditions during natural incubation of *E. blandingii* nests can deleteriously affect hatchling development. This is supported by the late and incomplete emergence, small size, lethargic state, and developmental abnormalities observed in Nest 6 hatchlings. Survivorship of all or some of these hatchlings appears to have been impacted by the resulting developmental abnormalities. In particular, Hatchling .220 displayed severe locomotor limitations and was frequently observed motionless on its back in the days prior to its death. The cultivation of tall crops like corn had an obvious cooling effect on nests (Figs. 34 and 35), and nests in the tallest, densest crops (Nests 4 and 6) were found to be significantly cooler than all others. Ultimately, this cooling effect could be expected to, at the very least, influence the sex ratio of a given nest toward male offspring. Moreover, if a large enough portion of the population was to routinely nest under these conditions, one could anticipate a population sex ratio dominated by males. In fact, this appears to be the situation encountered in the WPM. The sex ratio of *Chrysemys picta* at WPM was not significantly different from a 1:1 ratio; however, it was skewed slightly toward the male sex (1.1:1). However, it is noteworthy that although many *C. picta* were observed nesting during this study, they were never seen nesting deep in the fields like *E. blandingii.* Instead, *C. picta* were often observed nesting on the edges of fields away from the dense crop rows and much nearer the water; or they were seen nesting along the road and in the mowed lawn of the maintenance yard. Presumably these less shaded areas would lead to higher incubation temperatures than those locations observed for *E. blandingii*. Furthermore, *C. picta* possess a second, lower threshold temperature (20°C) for TSD (Pattern II) at which females again develop (Gutzke and Paukstis, 1984; Schwarzkopf and Brooks, 1985), which may help explain the more balanced sex ratio for this species. Coupled with mortality on roads and natural predation, a continued skew of this type could potentially threaten a slow reproducing species like *E. blandingii* over the long-term. The data presented for this population should be taken as evidence for the importance of suitable habitat types throughout the range of this species. Both aquatic and terrestrial habitats must be present in sufficient abundance and quality to maintain populations of *E. blandingii*.

CONCLUSIONS:

Both diet and reproduction must be considered in plans for conservation and restoration of *Emydoidea blandingii* in Ohio, and each is directly related to the quality and availability of habitat types. Alteration of habitat for agriculture, recreation, or other development, and the introduction of invasive species such as Narrow-leaved Cattail (*Typha angustifolia*) and the Swamp Red Crayfish (*Procambarus clarkii*) have undoubtedly altered the behavior and biology of this species in Ohio. The ability of *E. blandingii* to utilize readily-available food items, both native (*Stagnicola elodes*) and non-native (*P. clarkii*), may help buffer it against some of the effects of a changing marsh ecosystem. However, the alteration of nesting habitat is more problematic for this species. The long life-span of *E. blandingii* is an adaptation that may have inadvertently allowed the species to persist in ecosystems that have been modified by anthropocentric actions; however, it may also mask the precarious position of this species in degraded habitats. Despite the ability of adult turtles to persist over time in marginally-suitable habitats, the long-term prognosis for populations in these locations could be bleak. Without suitable nesting habitat, sufficient recruitment to the population is unlikely and populations in this predicament could slowly dwindle without much notice. Studies of this nature can help to shed light on these issues before populations reach sizes below sustainability. If suitable marsh habitat can be considered a primary limiting factor for populations of *E. blandingii* in Ohio, then the suitability of available nesting habitat should be considered equally as important as the marshes themselves. Conservation of this species must address upland requirements with as much urgency as that provided to the quality of marsh habitat.

The shoreline of Lake Erie has undergone a great deal of alteration. How the pulses in the lake level formerly affected the habitat used by *Emydoidea blandingii* in open systems is uncertain. Kroll et al. (1997) discussed how coastal marshes were once free to expand and contract with the dynamic water level of Lake Erie. It is possible that these pulses once created habitat ideal for nesting during low lake levels, resulting in increased recruitment to the population during these periods. Long-period fluctuations in Lake Erie levels are unpredictable. Dictated by variations in precipitation, evaporation, and runoff, they can occur both seasonally and on the order of several years (Herdendorf, 1992). A long life-span could allow individuals to span periods of high and low lake levels that might affect quality and quantity of nesting habitat. Furthermore, undeveloped upland habitat in these open systems likely provided more vernal pools and seasonally wet areas that could be conducive to survivorship of hatchling and juvenile turtles, and areas that may have served as corridors for movement of adults, thus increasing gene flow among populations. If the current system of dikes serves as a barrier to promote vegetation that is characteristic of the aquatic habitat preferred by this species, then it is unclear what role these barriers may have played in altering the quality of adjacent upland habitat. How these coastal marsh systems once functioned in the life history of this species may be difficult to establish, but the effects of altering those natural hydrologic cycles presents important questions for future conservation management of this species.

This research suggests that management plans aimed at conserving *Emydoidea blandingii* populations in Ohio should concentrate on maintaining diverse wetland habitats with an emphasis on emergent vegetation and areas ≤0.5 meters in depth. Although deeper, more open, areas of marsh were frequented for movements, emergent vegetation provided the preferred habitat in this population of Ohio *E. blandingii* and emergent habitats may be linked to foraging behavior. Furthermore, suitable upland habitat must be maintained to ensure reproductive success for this species. Upland habitat should provide a mosaic of shrub and/or tree cover amid open areas sufficiently buffered from major roads and highways. Ideal upland areas would possess friable, well-drained loamy to sandy soils. Additionally, the inclusion of shallow upland pools and wet areas may provide habitat beneficial as temporary refuge to nesting females and dispersing hatchlings. It is the opinion of this author that survey work is vitally needed to estimate population structure and potential for recruitment in areas with known, historical, and suspected populations of *E. blandingii* in Ohio, so that the status of this species may be more accurately and responsibly determined in the state.

LITERATURE CITED

Bandas, S. J., Higgins, K. F. 2004. Field Guide to South Dakota Turtles. SDCES EC 919. Brookings: South Dakota State University. 35pp.

Banning, W. J. 2006. Ecology of the Blanding's Turtle (*Emydoidea blandingii*) at a northeastern Illinois Prairie Wetland Community. M.S. Thesis. University of Illinois at Urbana-Champaign, Urbana, IL. 115pp.

Banning, W. J. 2007. Nesting ecology of the Blanding's Turtle, *Emydoidea blandingii*, at the Lockport Prairie Nature Preserve, Will County, Illinois. INHS Technical Report 40:1–25.

Bjorndal, K. A. 1997. Foraging ecology and nutrition of sea turtles. *In:* P. L. Lutz and J. A. Musick (eds.). The Biology of Sea Turtles. CRC Press, Boca Raton, FL. pp. 201–233.

Bjorndal, K. A., Bolten, A. B., Lagueux, C. J., Jackson, D. R. 1997. Dietary overlap in three sympatric congeneric freshwater turtles (*Pseudemys*) in Florida. Chelonian Conservation Biology 2:430–433.

Bleakney, J. S. 1963. Notes on distribution and life histories of turtles in Nova Scotia. The Canadian Field Naturalist 77:67–76.

Boarman, W., Goodlett, T., Goodlett, G., Hamilton, P. 1998. Review of radio transmitter attachment techniques for turtle research and recommendations for improvement. Herpetological Review 29:26–33.

Brockman, C. S. 1998. Physiographic regions of Ohio, page-size map with explanatory text, scale 1:2,000,000.

Bull, J. J., Vogt, R. C. 1981. Temperature-sensitive periods of sex determination in emydid turtles. The Journal of Experimental Zoology 218:435–440.

Bull, J. J. 1985. Sex ratio and nest temperature in turtles: comparing field and laboratory data. Ecology 66:1115–1122.

Bury, R. B., Germano, D. J. 2003. Differences in habitat use by Blanding's turtles, *Emydoidea blandingii*, and Painted turtles, *Chysemys picta*, in the Nebraska sandhills. American Midland Naturalist 149:241–244.

Butler, B. O., Graham, T. E. 1995. Early post-emergent behavior and habitat selection in hatchling Blanding's turtles (*Emydoidea blandingii*), in Massachusetts. *Chelonian* Conservation and Biology 1:187–196.

Cahn, A. R. 1937. The turtles of Illinois. Illinois Biological Monograph 35:1–128.

Chen, Tien-Hsi, Lue, Kuang-Yang. 1999. Food habits of the Chinese Stripe-necked Turtle, *Ocadia sinensis,* in the Keelung River, northern Taiwan. Journal of Herpetology 33:463–471.

Conant, R. 1938. The reptiles of Ohio. American Midland Naturalist 20:1–200.

Conant, R., Collins, J. T. 1998. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. Third edition, expanded. Houghton Mifflin Co., Boston, Massachusetts. 616 pp.

Congdon, J. D., Keinath, D. A. 2006. Blanding's Turtle (*Emydoidea blandingii*): A Technical Conservation Assessment. Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project. 54pp.

Congdon, J. D., van Loben Sels, R. C. 1991. Growth and body size in Blanding's turtles (*Emydoidea blandingii*): relationships to reproduction. Canadian Journal of Zoology 69:239–245.

Congdon, J. D., van Loben Sels, R. C. 1993. Reproductive characteristics and body size: relationships with attainment of sexual maturity and age in Blanding's turtles (*Emydoidea blandingii*). Journal of Evolutionary Biology 6:547–557.

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

Congdon, J. D., Nagle, R. D., Kinney, O. M., Osentoski, M., Avery, H. W., Van Loben Sels, R. C., Tinkle, D. W. 2000. Nesting ecology and embryo mortality: implications for hatchling success and demography of Blanding's turtles (*Emydoidea blandingii*). Chelonian Conservation and Biology 3:569–579.

Congdon, J. D., Nagel R. D., Kinney O. M., van Loben Sels R. C. 2001. Hypotheses of aging in a long-lived vertebrate, Blanding's Turtle (*Emydoidea blandingii*). Experimental Gerontology 36:813–827.

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

Cook, C. M. 2007. Microhabitat distribution of macroinvertebrates within a Lake Erie coastal wetland. M.S. Thesis. John Carroll University, University Heights, OH. 93pp.

Correia, A. M. 2001. Seasonal and interspecific evaluation of predation by mammals and birds on the introduced red swamp crayfish *Procambarus clarkii* (Crustacea, Cambaridae) in a freshwater marsh (Portugal). Journal of the Zoological Society of London 255:533–541.

COSEWIC 2005. COSEWIC assessment and update status report on the Blanding's Turtle *Emydoidea blandingii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 40 pp.

Cowardin, L. M., Carter, V., Golet, F. C., LaRoe, E. T. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Crother, B. I., Boundy, J., Campbell, J. A., De Quieroz, K., Frost, D., Green, D. M., Highton, R., Iverson, J. B., McDiarmid, R. W., Meylan, P. A., Reeder, T. W., Seidel, M. E., Sites, J. W. Jr., Tilley, S. G., Wake, D. B. 2003. Scientific and standard English names of amphibians and reptiles of North America north of Mexico: update. Herpetological Review 34:196–203.

DePari, J.A., M.H. Link, and T.E. Graham. 1987. Clutch size of the Blanding's turtle, *Emydoidea blandingii* in Massachusetts. Canadian Field Naturalist 101:440–442.

Dinkelacker, S. A., Costanzo, J. P., Iverson, J. B., Lee, R. E. 2004. Cold-hardiness and dehydration resistance of hatchling Blanding's turtles (*Emydoidea blandingii*): implications for overwintering in a terrestrial habitat. Canadian Journal of Zoology 82:594–600.

Dinkelacker, S. A., Costanzo, J. P., Iverson, J. B., Lee, R. E. 2005. Survival and physiological responses of hatchling Blanding's turtles (*Emydoidea blandingii*) to submergence in normoxic and hypoxic water under simulated winter conditions. Physiological and Biochemical Zoology 78:356–363.

Dodd, C. K., Jr. 2001. North American Box Turtles: A Natural History. Vol. 6 of Animal Natural History Series. The University of Oklahoma Press, Norman. 231pp.

Ehrenheld, D. W. 1979. Behaviour associated with nesting. *In:* M. Harles and H. Morlock (eds.). Turtles/Perspectives and Research. John Wiley & Sons, New York, NY. pp. 417–434.

Ernst, C. H., Barbour, R. W. 1972. Turtles of the United States. The University Press of Kentucky, Lexington. 347pp.

Ernst, C. H., Lovich, J. E., Barbour, R. W. 1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington, D.C. 578pp.

Evermann, B. W., Clark, H. W. 1916. The turtles and batrachians of the Lake Maxinkuckee region. Proceedings of the Indiana Academy of Science 26:472–518.

Ewert, M. A. 1979. The embryo and its egg: development and natural history. *In:* M. Harles and H. Morlock (eds.). Turtles/Perspectives and Research. John Wiley & Sons, New York, NY. pp. 333–413.

Ewert, M. A., Nelson, C. E. 1991. Sex determination in turtles: diverse patterns and some possible adaptive values. Copeia 1:50–69.

Feldman, C. R., Parham, J. F. 2002. Molecular phylogenetics of emydine turtles: taxonomic revision and the evolution of shell kinesis. Molecular Phylogenetics and Evolution 22:388–398.

Gee, G. W., Bauder, J. W. 1986. Particle-size analysis. *In:* A. Klute (ed.). Methods of Soil Analysis. Part 1. Agronomy series No. 9, 2nd Edn. American Society of Agronomy, Madison, WI. pp. 383–411.

Germano, D. J., Bury, R. B., Jennings, M. 2000. Growth and population structure of *Emydoidea blandingii* from western Nebraska. Chelonian Conservation and Biology 3:618–625.

Gherardi, F., Barbaresi, S., Salvi, G. 2000. Spatial and temporal patterns in the movement of *Procambarus clarkii,* an invasive crayfish. Aquatic Sciences 62:179–193.

Gibbons, J. W. 1968. Observations on the ecology and population dynamics of the Blanding's Turtle, *Emydoidea blandingii.* Canadian Journal of Zoology 46:288–290.

Gist, D. H., Dawes S. M., Turner T. W., Sheldon S., Congdon J. D. 2001. Sperm storage in turtles: a male perspective. Journal of Experimental Zoology 292:180–186.

Graham, T. E., Doyle, T. S. 1977. Growth and population characteristics of Blanding's turtles, *Emydoidea blandingii* in Massachusetts. Herpetologica 33:410–414.

Graham, T. E., Doyle, T. S. 1979. Dimorphism, courtship, eggs and hatchlings of the Blanding's Turtle, *Emydoidea blandingii* (Reptilia, Testudines, Emydidae) in Massachusetts. Journal of Herpetology 13:125–127.

Grgurovic, M., Sievert, P. R. 2005. Movement patterns of Blanding's turtles *(Emydoidea blandingii)* in the suburban landscape of eastern Massachusetts. Urban Ecosystems 8:203–213.

Gutzke, W. H. N., Packard, G. C. 1987. The influence of temperature on eggs and hatchlings of Blanding's turtles, *Emydoidea blandingii.* Journal of Herpetology 21:161–163.

Gutzke, W. H. N., Paukstis, H. L. 1984. A low threshold temperature for sexual differentiation in the Painted Turtle, *Chrysemys picta.* Copeia 2:546–547.

Hall, C. D., Cuthbert, F. J. 2000. Impact of a controlled wetland drawdown on Blanding's turtles in Minnesota. Chelonian Conservation and Biology 3:643–649.

Harding, J. H. 1997. Amphibians and Reptiles of the Great Lakes Region. The University of Michigan Press, Ann Arbor. 378pp.

Hart, D. R. 1983. Dietary and habitat shift with size of red-eared turtles (*Pseudemy scripta*) in a southern Louisiana population. Herpetologica 39:285–290.

Herdendorf, C. E. 1992. Lake Erie coastal wetlands: an overview. Journal of Great Lakes Research 18:533–551.

Heyer, W. R., Donnelly, M. A., McDiarmid, R. W., Hayek, L. C., Foster, M. S. 1994. Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press, Washington. 364pp.

Horn, H. S. 1966. Measurement of "overlap" in comparative ecological studies. The American Naturalist 100:419–424.

Hyslop, E. J. 1980. Stomach contents analysis—a review of methods and their application. Journal of Fish Biology 17:411–429.

Joyal, L. A., McCollough, M., Hunter, M. L. Jr. 2000. Population structure and reproductive ecology of Blanding's Turtle (*Emydoidea blandingii*) in Maine, near the Northeastern Edge of its Range. Chelonian Conservation and Biology 3:580–588.

Joyal, L. A., McCollough, M., Hunter, M. L. Jr. 2001. Landscape ecology approaches to wetland species conservation: a case study of two turtle species in southern Maine. Conservation Biology 15:1755–1762.

Kofron, C. P., Schreiber, A. A. 1985. Ecology of two endangered aquatic turtles in Missouri: *Kinosternon flavescens* and *Emydoidea blandingii*. Journal of Herpetology 19:27–40.

Kroll, R. W., Gottgens, J. F., Swartz, B. P. 1997. Wild rice to rip-rap: 120 years of habitat changes and management of a Lake Erie coastal marsh. Transactions of the North American Wildlife and Natural Resources Conference 62:490–500.

Lagler, K. F. 1943. Food habits and economic relations of the turtles of Michigan with special reference to fish management. The American Midland Naturalist 29:257–312.

Legler, J. M. 1977. Stomach flushing: a technique for chelonian dietary studies. Herpetologica 33:281–284.

Linck, M. J., DePari, A., Butler, B. O., Graham, T. E. 1989. Nesting behavior of the turtle, *Emydoidea blandingii* in Massachusetts. Journal of Herpetology 23:442–444.

MacCulloch, R. D., Weller, W. F. 1988. Some aspects of reproduction in a Lake Erie population of Blanding's Turtle, *Emydoidea blandingii.* Canadian Journal of Zoology 66:2317–2319.

McMaster, N. L., Herman, T. B. 2000. Occurrence, habitat selection, and movement patterns of juvenile Blanding's turtles (*Emydoidea blandingii*) in Kejimkujik National Park, Nova Scotia. Chelonian Conservation and Biology 3:602–610.

McNeil, J. A., Herman, T. B., Standing, K. L. 2000. Movement of hatchling Blanding's turtles (*Emydoidea blandingii*) in Nova Scotia in response to proximity to open water: a manipulative experiment. Chelonian Conservation and Biology 3:661–664.

Mitchell, J. C. 1988. Population ecology and life histories of the freshwater turtles *Chrysemys picta* and *Sternotherus odoratus* in a urban lake. Herpetological Monographs 2:40–61.

Osentoski, M.F. 2001. Population genetic structure and male reproductive success in a Blanding's turtle (*Emydoidea blandingii*) population in southeastern Michigan. Ph.D. Dissertation. University of Miami, Miami, FL.

Packard, G. C., Packard, M. J., Lang, J. W., Tucker, J. K. 1999. Tolerance for freezing in hatchling turtles. Journal of Herpetology 33:536–543.

Packard, G. C., Packard, M. J., Lang, J. W. 2000. Why hatchling Blanding's turtles don't overwinter inside their nest. Herpetologica 56:367–374.

Pappas, M.J. and B.J. Brecke. 1992. Habitat selection of juvenile Blanding's turtles (*Emydoidea blandingii*). Journal of Herpetology 26:233–234.

Pappas, M.J., Brecke B. J., Congdon, J. D. 2000. The Blanding's turtles (*Emydoidea blandingii*) of Weaver Dunes, Minnesota. Chelonian Conservation and Biology 3:557–568.

Parmenter, R. R. 1980. Effects of food availability and water temperature on the feeding ecology of pond sliders (*Chrysemys s. scripta*). Copeia 3:503–514.

Peckarsky, B. L., Fraissinet, P. R., Penton, M. A., Conklin, D. J. Jr. 1990. Freshwater Macroinvertebrates of Northeastern North America. Cornell University Press, Ithaca, NY. 442pp.

Penn, G. H. 1950. Utilization of crawfishes by cold-blooded vertebrates in the eastern United States. American Midland Naturalist 44:643–658.

Pieau, C., Dorizzi, M. 1981. Determination of temperature sensitive stages for sexual differentiation of the gonads in embryos of the turtle *Emys orbicularis* (Testudines, Emydidae). Journal of Morphology 170:373–382.

Piepgras, S. J., Lang, J. W. 2000. Spatial ecology of Blanding's Turtle in central Minnesota. Chelonian Conservation and Biology 3:589–601.

Pike, D. A., Dinsmore, A., Crabill, T., Smith, R. B., Seigel, R. A. 2004. Short-term effects of handling and permanently marking gopher tortoises (*Gopherus polyphemus*) on recapture rates and behavior. Applied Herpetology 2:139–147.

Power, T. D. 1989. Seasonal movements and nesting ecology of a relict population of Blanding's Turtle (*Emydoidea blandingii* (Holbrook)) in Nova Scotia. M.S. Thesis, Acadia University, Wolfville, Nova Scotia, Canada.

Refsnider, J., Schlick, P. 2006. *Emydoidea blandingii* double clutching. Herpetological Review 37:341–342.

Rhen, T., Lang, J. W. 2004. Phenotypic effects of incubation temperature in reptiles. *In:* N. Valenzuela and V. Lance (eds.). Temperature-Dependent Sex Determination in Vertebrates. Smithsonian Institution Press, Washington DC. pp. 90–98.

Ross, D. A. 1989. Population ecology of Painted and Blanding’s turtles *(Chrysemys picta* and *Emydoidea blandingii)* in central Wisconsin. Wisconsin Academy of Science 77:77–84.

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

Rowe, J. W. 1987. Seasonal and daily activity in a population of Blanding’s turtles *(Emydoidea blandingii)* in northern Illinois. Unpublished M.S. Thesis. Eastern Illinois University, Charleston IL. 86pp.

Rowe, J. W. 1992a. Dietary habits of the Blanding’s Turtle (*Emydoidea blandingii*) in northeastern Illinois. Journal of Herpetology 26:111–114.

Rowe, J.W. 1992b. Observations of body size, growth, and reproduction in Blanding’s turtles (*Emydoidea blandingii*) from western Nebraska. Canadian Journal of Zoology 70:1690–1695.

Rowe, J. W., Moll, E. O. 1991. A radiotelemetric study of activity and movements of the Blanding’s Turtle (*Emydoidea blandingii*) in northeastern Illinois. Herpetologica 25:178–185.

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

Sajwaj, T. A., Lang, J. W. 2000. Thermal ecology of Blanding’s Turtle in central Minnesota. Chelonian Conservation and Biology 3:626–636.

Schwarzkopf, L., Brooks, R. J. 1985. Sex determination in northern Painted turtles: effect of incubation at constant and fluctuating temperatures. Canadian Journal of Zoology 63:2543–2547.

Standing, K. L., Herman, T. B., Huriburt, D. D., Morrison, I. P. 1997. Post emergence behavior of neonates in a northern peripheral population of Blanding’s Turtle, (*Emydoidea blandingii*) in Nova Scotia. Canadian Journal Zoology 75:1387–1395.

Standing, K. L., Herman, T. B., Morrison, I. P. 1999. Nesting ecology of Blanding’s Turtle (*Emydoidea blandingii*) in Nova Scotia, the northeastern limit of its range. Canadian Journal of Zoology 77:1609–1614.

Standing, K. L., Herman, T. B., Morrison, I. P. 2000. Developmental abnormalities in a northeastern population of Blanding's Turtle, *Emydoidea blandingii*. Chelonian Conservation and Biology 3:661–664.

Valenzuela, N. 2001. Constant, shift, and natural temperature effects on sex determination in *Podocnemis expansa* turtles. Ecology 82:3010–3024.

Vogt, R. C. 1981. Natural History of Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum, Milwaukee. 205pp.

Vogt, R. C., Bull, J. J. 1982. Temperature controlled sex-determination in turtles: ecological and behavioral aspects. Herpetologica 38:156–164.

Voshell, J. R. Jr. 2002. A Guide to Common Freshwater Invertebrates of North America. The McDonald & Woodward Publishing Company, Blacksburg, VA. 442p

Figure 1: Distribution of *Emydoidea blandingii* throughout its geographic range (Conant and Collins, 1998:map p.188). State status designations have been included: E, Endangered; T, Threatened; C, Species of Concern; and S, Stable.

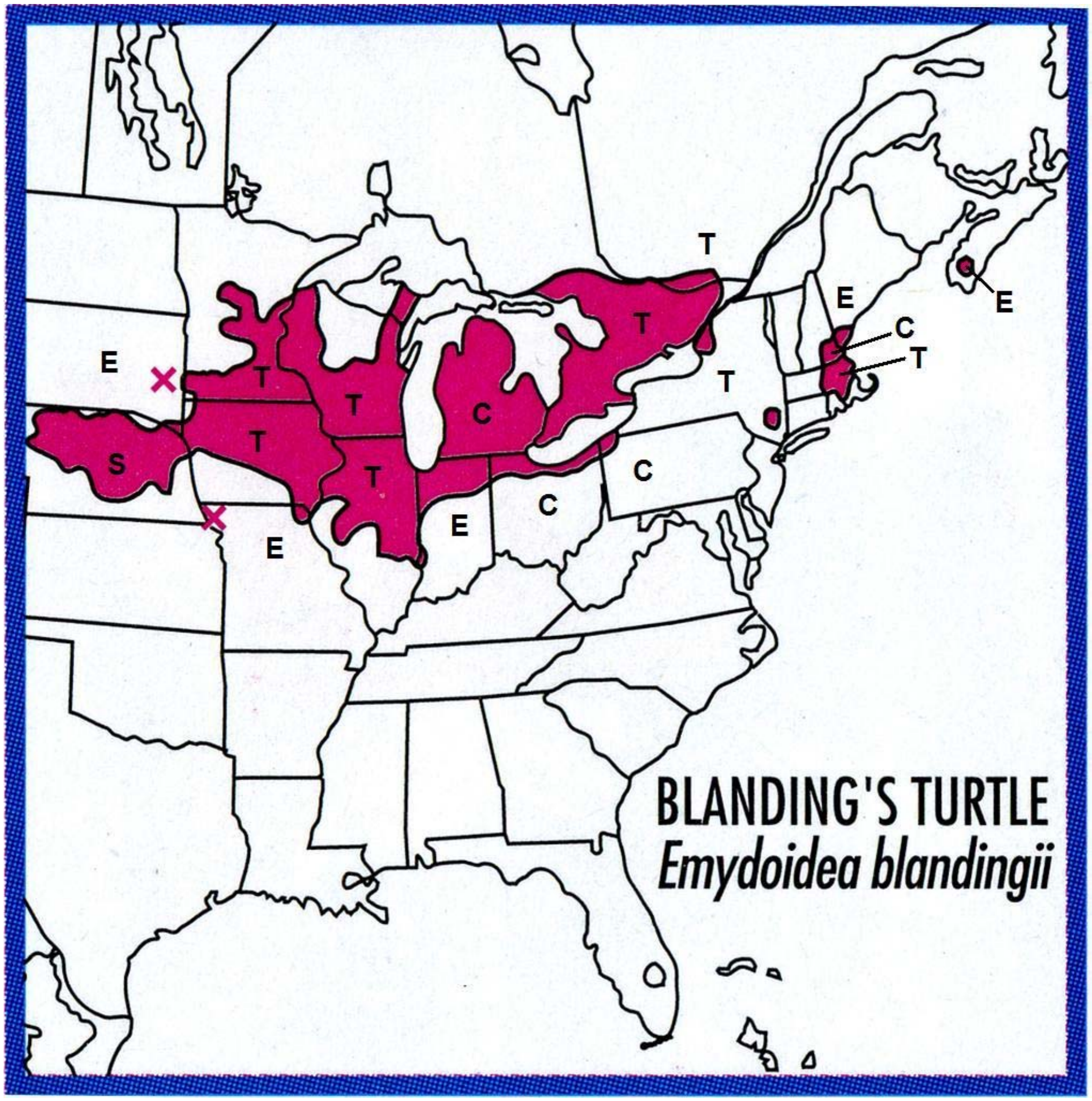
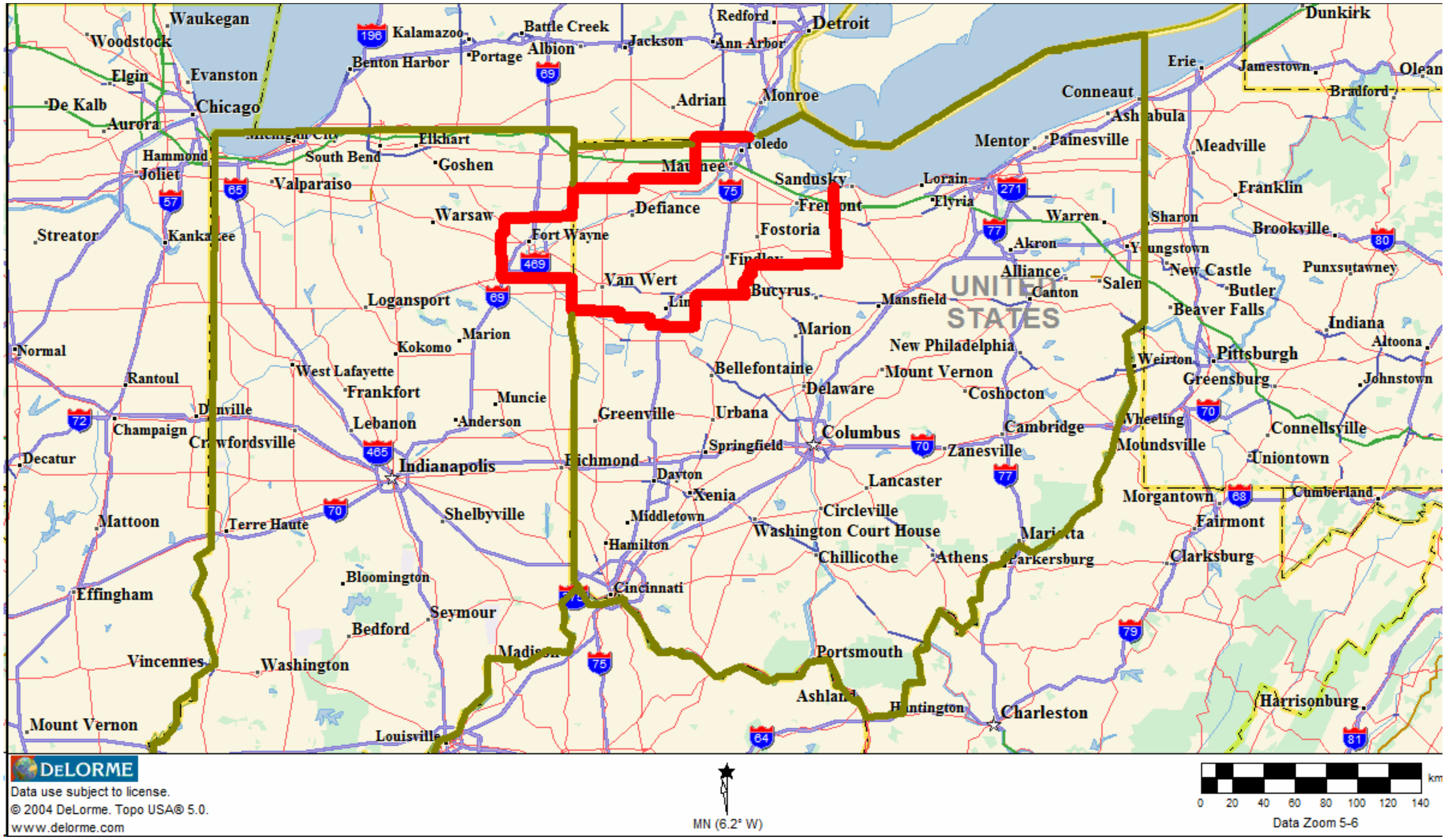

T
E
E
C
T
T
E
T
T
T
C
T
S
T
C
C
E
E
BLANDING'S TURTLE
Emydoidea blandingii

Figure 2: Map of approximate area (along county lines) historically encompassed by the Great Black Swamp (http://www.blackswamp.org). Map created on DeLorme Topo USA 5.0.


Waukegan
Woodstock
Elgin
De Kalb
Aurora
Evanston
Chicago
Hammond
Joliet
Streator
Kankakee
Normal
Rantoul
Champaign
Danville
Decatur
Mattoon
Effingham
Vincennes
Mount Vernon
Kalamazoo
Battle Creek
Portage
Albion
Benton Harbor
Jackson
Redford
Detroit
Ann Arbor
Adrian
Monroe
Michigan City
Elkhart
South Bend
Goshen
Valparaiso
Warsaw
Fort Wayne
Logansport
Kokomo
Marion
West Lafayette
Frankfort
Lebanon
Muncie
Anderson
Crawfordsville
Indianapolis
Terre Haute
Shelbyville
Bloomington
Seymour
Bedford
Washington
Madison
Louisville
Toledo
Maumee
Defiance
Van Wert
Lima
Sandusky
Fremont
Fostoria
Findlay
Bucyrus
Marion
Mansfield
Bellefontaine
Delaware
Mount Vernon
Coshocton
New Philadelphia
Greenville
Urbana
Springfield
Columbus
Richmond
Dayton
Xenia
Middletown
Hamilton
Cincinnati
Lancaster
Circleville
Washington Court House
Chillicothe
Athens
Zanesville
Cambridge
Marietta
Parkersburg
Portsmouth
Ashland
Huntington
Charleston
Lorain
Elyria
Mentor
Painesville
Conneaut
Ashtabula
Warren
Akron
Alliance
Canton
Salem
Youngstown
Sharon
Erie
Jamestown
Dunkirk
Olean
Bradford
Meadville
Franklin
Brookville
New Castle
Butler
Punxsutawney
Beaver Falls
Indiana
Altoona
Weirton
Pittsburgh
Greensburg
Johnstown
Wheeling
Moundsville
Connellsville
Uniontown
Morgantown
Fairmont
Cumberland
Clarksburg
Harrisonburg
UNITED STATES
196
69
65
57
75
469
271
77
80
72
465
70
74
88
79
64
81
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MN (6.2° W)
0
20
40
60
80
100
120
140
km
Data Zoom 5-6

Figure 3: Range map showing the former distribution of *Emydoidea blandingii* in Ohio (Conant, 1938:map#32).

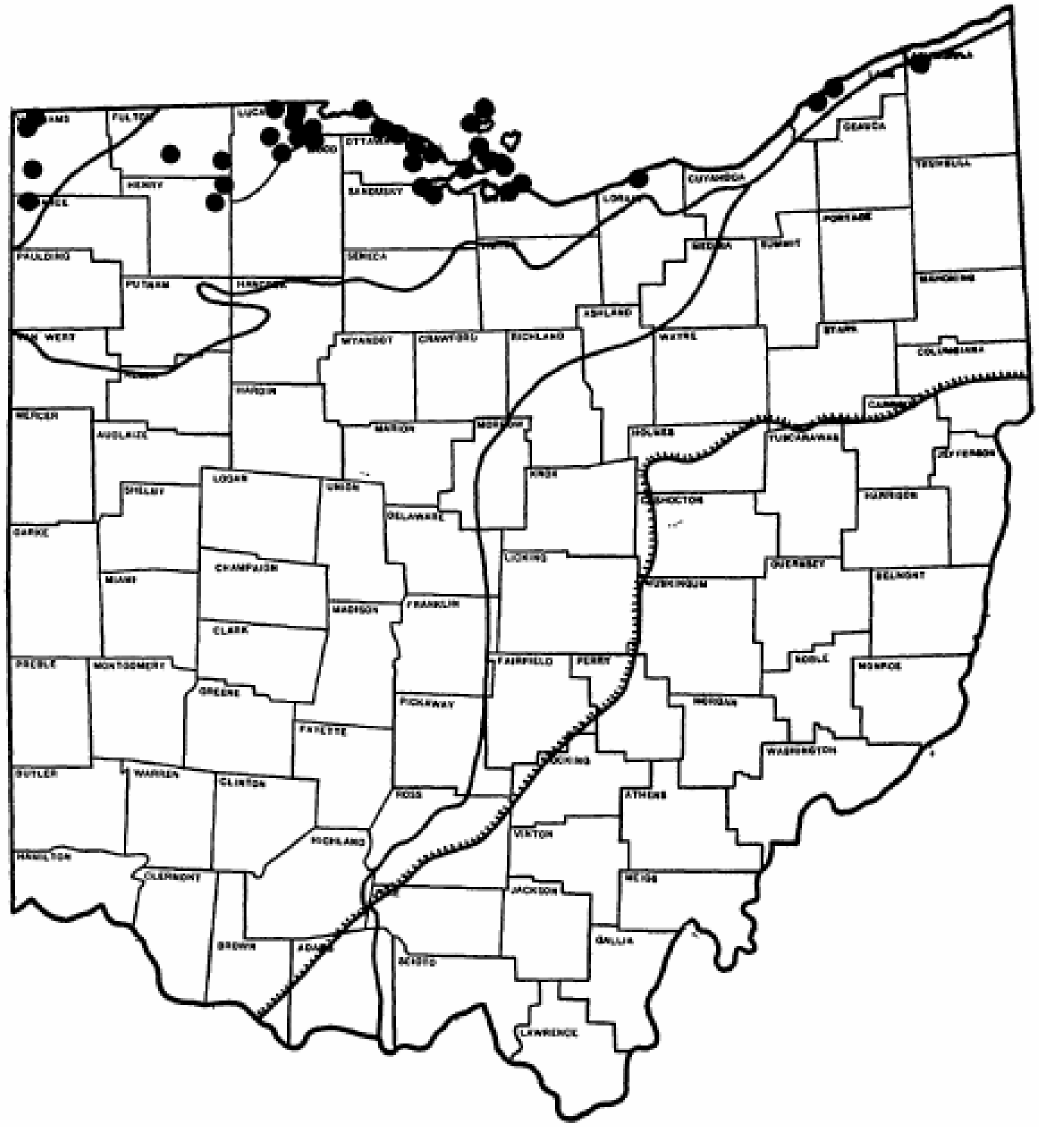
FULTON
LUCAS
OTTAWA
WOOD
HENRY
SANDUSKY
DEFIANCE
CUYAHOGA
LORAIN
GEAUGA
TRUMBULL
PORTAGE
SUMMIT
MEDINA
PAULDING
PUTNAM
HANCOCK
SENECA
MAHONING
ASHLAND
VAN WERT
WYANDOT
CRAWFORD
RICHLAND
WAYNE
STARK
COLUMBIANA
HARDIN
MERCER
AUGLAIZE
MARION
MORROW
HOLMES
TUSCARAWAS
CARROLL
JEFFERSON
LOGAN
UNION
KNOX
SHELBY
DELAWARE
COSHOCTON
HARRISON
DARKE
LICKING
CHAMPAIGN
GUERNSEY
MIAMI
MUSKINGUM
BELMONT
MADISON
FRANKLIN
CLARK
PREBLE
MONTGOMERY
FAIRFIELD
PERRY
NOBLE
MONROE
GREENE
PICKAWAY
MORGAN
FAYETTE
WASHINGTON
HOCKING
BUTLER
WARREN
CLINTON
ROSS
ATHENS
HIGHLAND
VINTON
HAMILTON
CLERMONT
MEIGS
JACKSON
GALLIA
BROWN
ADAMS
SCIOTO
LAWRENCE

Figure 4: Map of study area at WMPC on north shore of Muddy Creek Bay (WMPC also owns marshes on the south shore). Map created on DeLorme Topo USA 5.0.


Portage River
CR 52
2
269
CR 135
Danbury
101
Gypsum
Hickory Grove
53
Edison Bridge
Sandusky Bay
Bay Bridge
Bay View
Canvasback Point
Winous Point
Muddy Creek Bay
Poplar Point
Elm Point
Redhead Cove
53
Squaw Island
Peach Island
Graveyard Island
The Bogs
Crystal Rock
Willow Point
6
Springbrook
Sandusky River
Wightmans Grove
Bayshore
Sunset Harbor
6
Resthaven Wildlife Area
Upton
6
510
269
101
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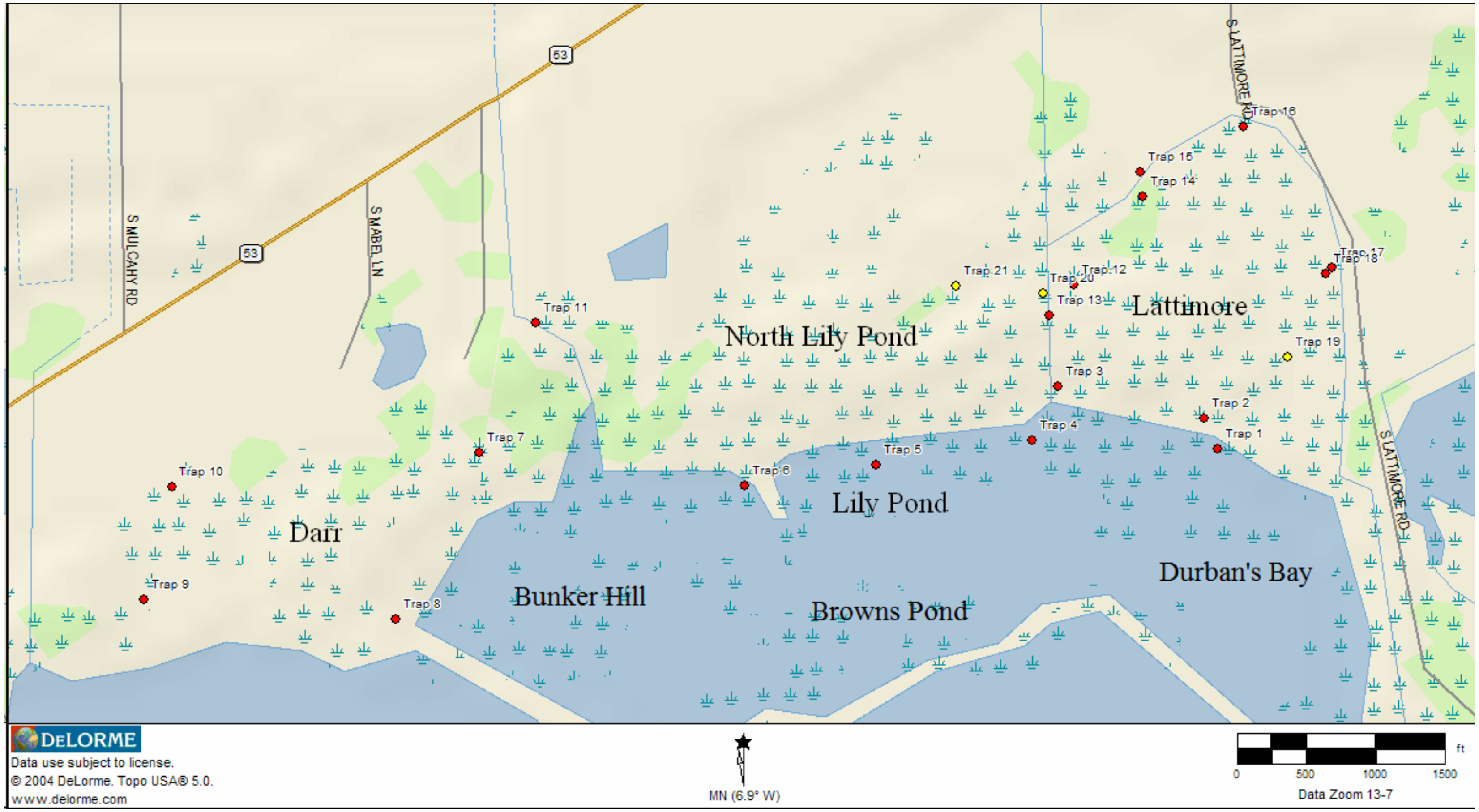
MN (7.1° W)
0
½
1
1½
2
mi
Data Zoom 11-0

Figure 5: Site map of trap locations concentrated at the west end within Winous Point Marsh. Map created on DeLorme Topo USA 5.0.


S MULCAHY RD
53
53
S MABEL LN
S LATTIMORE RD
S LATTIMORE RD
Trap 16
Trap 15
Trap 14
Trap 17
Trap 18
Trap 21
Trap 20
Trap 12
Trap 13
Trap 11
Lattimore
North Lily Pond
Trap 19
Trap 3
Trap 2
Trap 4
Trap 1
Trap 7
Trap 5
Trap 6
Trap 10
Lily Pond
Darr
Durban's Bay
Trap 9
Trap 8
Bunker Hill
Browns Pond
DeLorme
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MN (6.9° W)
0
500
1000
1500
ft
Data Zoom 13-7

Figure 6: Trap placement scheme according to varying depth and vegetation cover. Red boxes highlight breaks between major wetland classes. This figure is courtesy of Cleveland Metroparks (unpublished data).

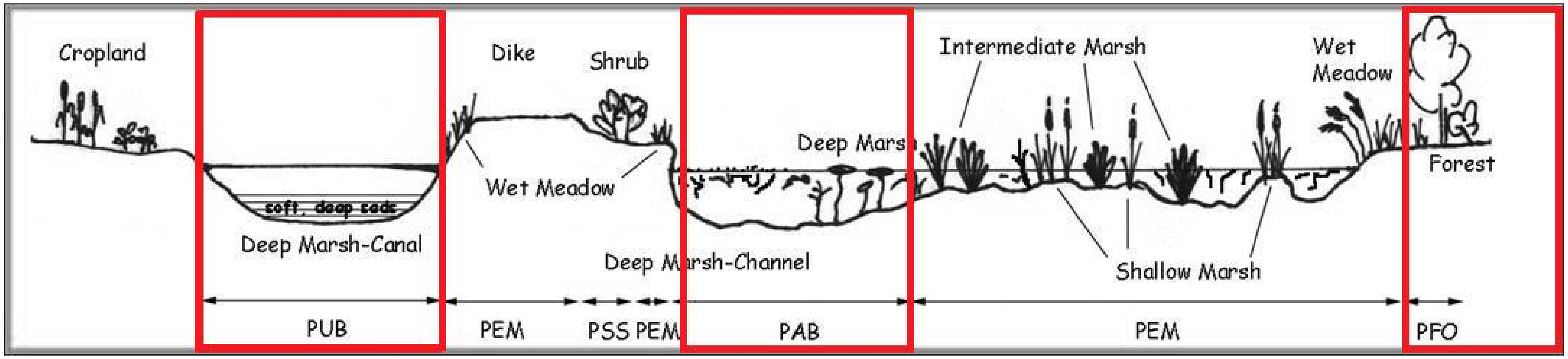

Cropland
Dike
Shrub
Intermediate Marsh
Wet Meadow
Deep Marsh
soft, deep seds
Deep Marsh-Canal
Wet Meadow
Deep Marsh-Channel
Shallow Marsh
Forest
PUB
PEM
PSS
PEM
PAB
PEM
PFO

Figure 7: System for filing permanent identifying notch codes into the marginal scutes of the carapace adopted from Mitchell (1988). The individual depicted here would be identified as Turtle #704 (ones and tens anteriorly, hundreds and thousands posteriorly).

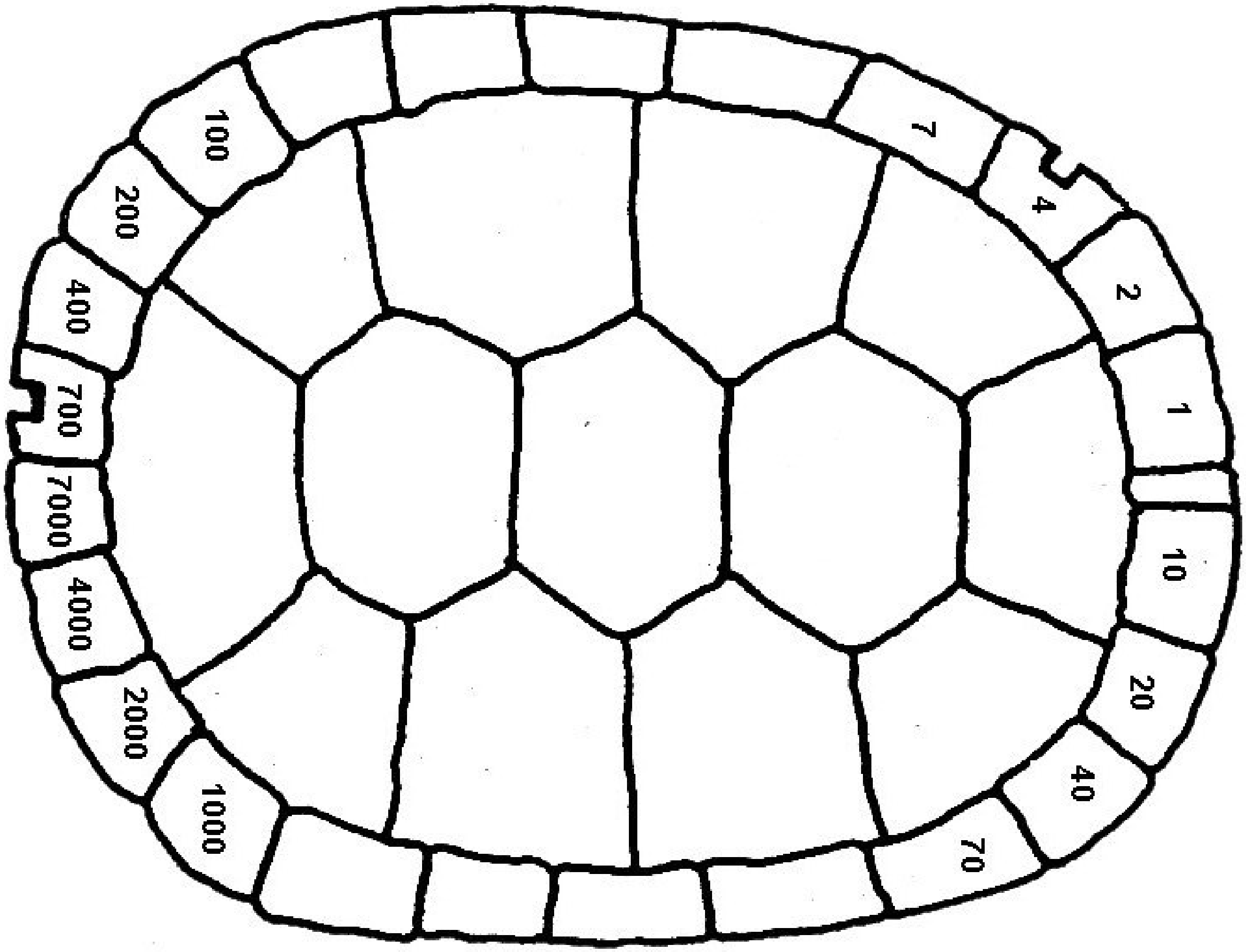

100
200
400
700
7000
4000
2000
1000
7
4
2
1
10
20
40
70

Figure 8: Variability in the rate at which contents were retrieved from stomach flushing across seasons. April is represented by 15 attempts in 2007, May is represented by 3 attempts in 2006 and 23 attempts in 2007, June is represented by 16 attempts in 2006 and 18 attempts in 2007, July is represented by 22 attempts in 2006 and 19 attempts in 2007, August is represented by 18 attempts in 2006 and 22 attempts in 2007, September is represented by 9 attempts in 2006 and 12 attempts in 2007, and October is represented by 4 attempts in 2006 and 1 attempt in 2007. Low retrieval rates for May and June of 2006 are believed to be due to limited experience with the stomach flushing technique. The solid blue line indicates results pooled for 2006 and 2007.

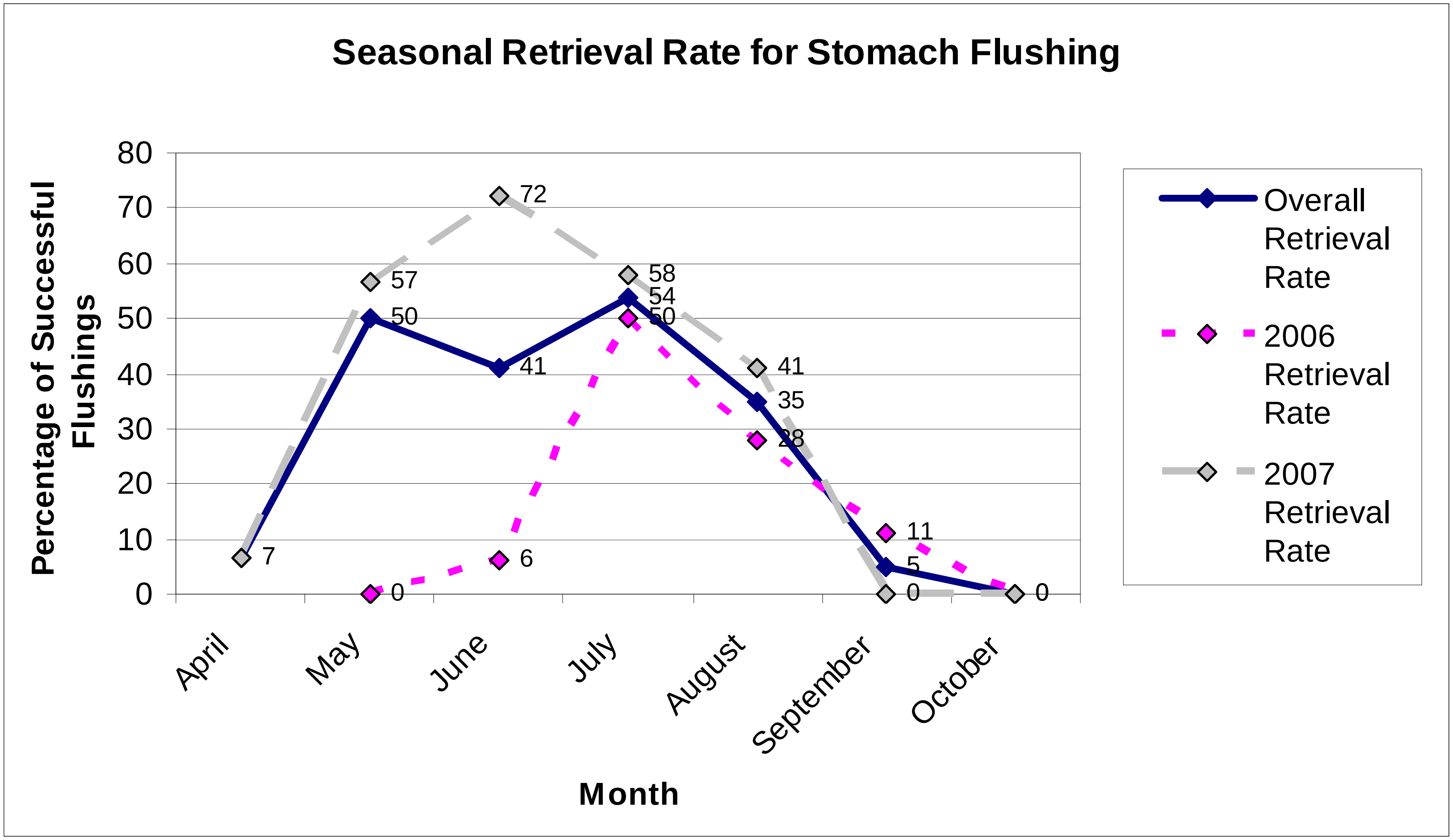

Seasonal Retrieval Rate for Stomach Flushing
Percentage of Successful Flushings
80
70
60
50
40
30
20
10
0
Month
April
May
June
July
August
September
October
7
57
50
0
72
41
6
58
54
50
41
35
28
11
5
0
0
Overall Retrieval Rate
2006 Retrieval Rate
2007 Retrieval Rate

Figure 9: The mean volume and mean number of items flushed from stomach according to month. Measures are based on the pooled results of 2006 and 2007 for each month. Mean number of items is greatest in May and declines through the summer while mean volume proportionately increases, indicating that more voluminous items are consumed as the season draws on.

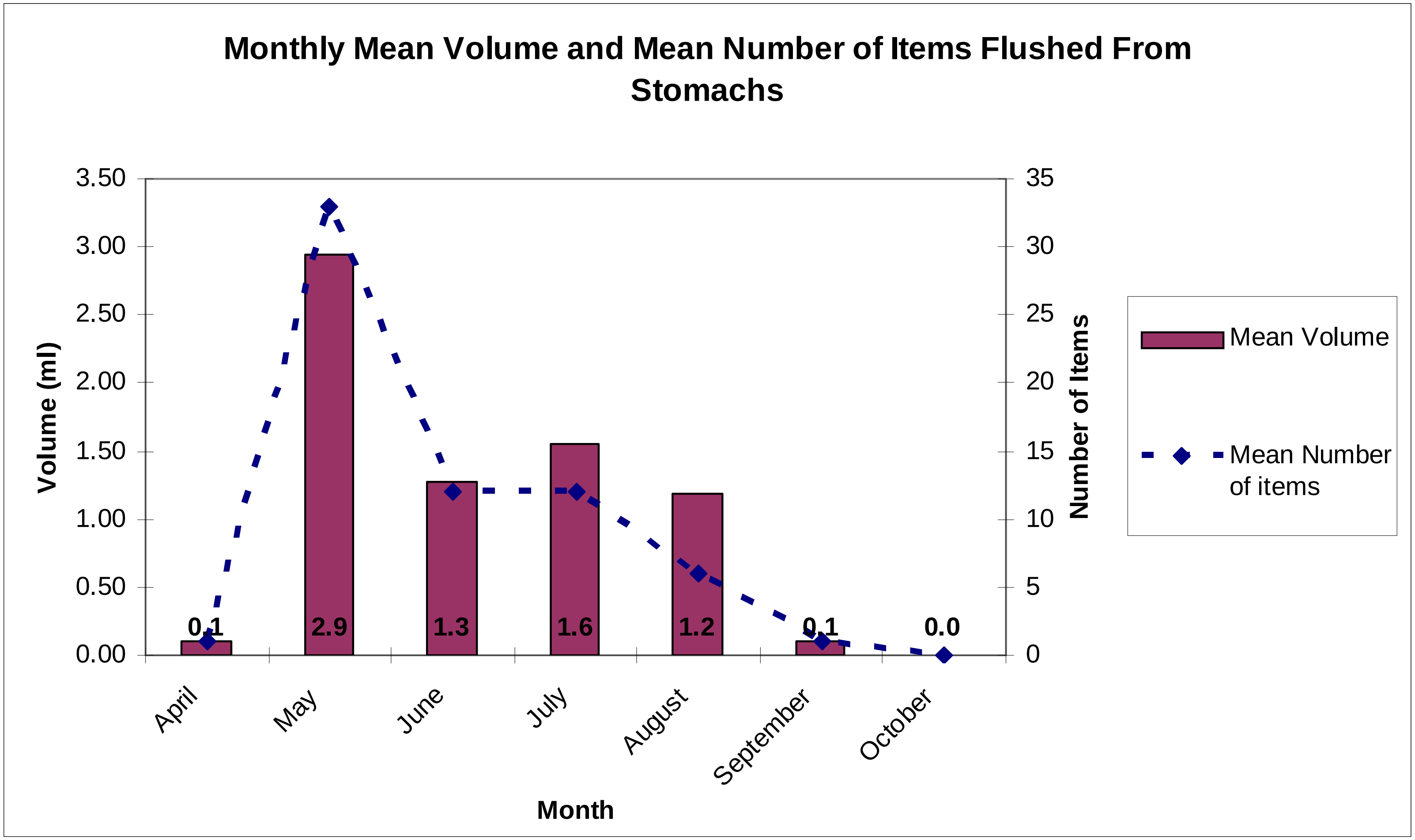

Monthly Mean Volume and Mean Number of Items Flushed From Stomachs
Volume (ml)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Number of Items
35
30
25
20
15
10
5
0
0.1
2.9
1.3
1.6
1.2
0.1
0.0
April
May
June
July
August
September
October
Month
Mean Volume
Mean Number of items

Figure 10: Examples of seasonal fluctuations of mass indicative of feeding activity for four individuals tracked over an extended period. July dips in the mass of Female #111 indicate post nesting measurements. Earliest recordings of mass in 2007 occurred on 4 April; consequently, dips in mass around 20 April indicate that turtles were actively feeding prior to this date but then ceased activity. This crash in April feeding activity is likely the result of a drop in water temperatures.

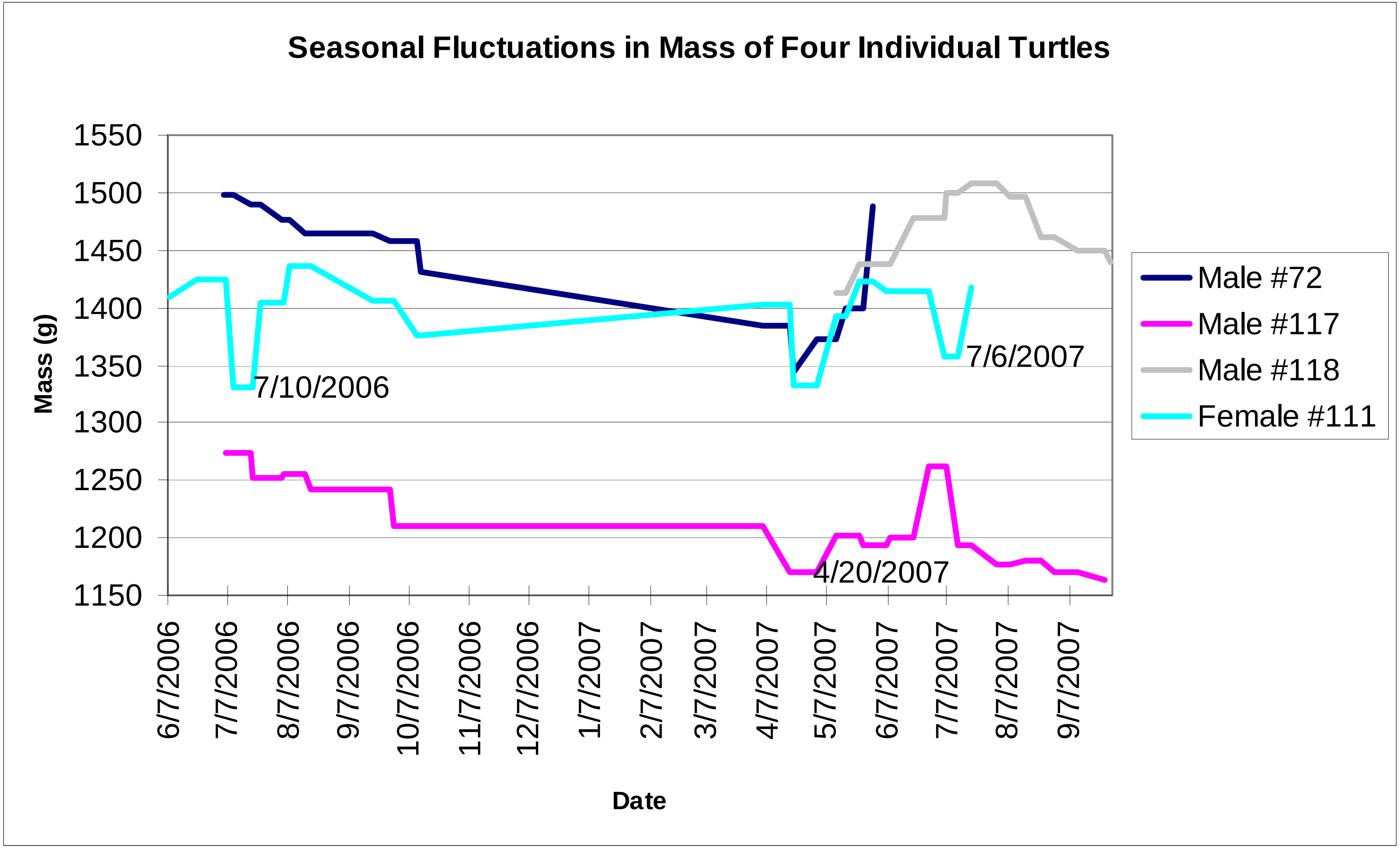

Seasonal Fluctuations in Mass of Four Individual Turtles
Mass (g)
1550
1500
1450
1400
1350
1300
1250
1200
1150
7/10/2006
7/6/2007
4/20/2007
6/7/2006
7/7/2006
8/7/2006
9/7/2006
10/7/2006
11/7/2006
12/7/2006
1/7/2007
2/7/2007
3/7/2007
4/7/2007
5/7/2007
6/7/2007
7/7/2007
8/7/2007
9/7/2007
Date
Male #72
Male #117
Male #118
Female #111

Figure 11: Presence of taxa identified in fecal samples of *Emydoidea blandingii* showing prevalence of crayfish consumption *(Procambarus sp.)* during the month of June, and the occurrence of insect larvae in Family Corydalidae not observed in stomach samples.

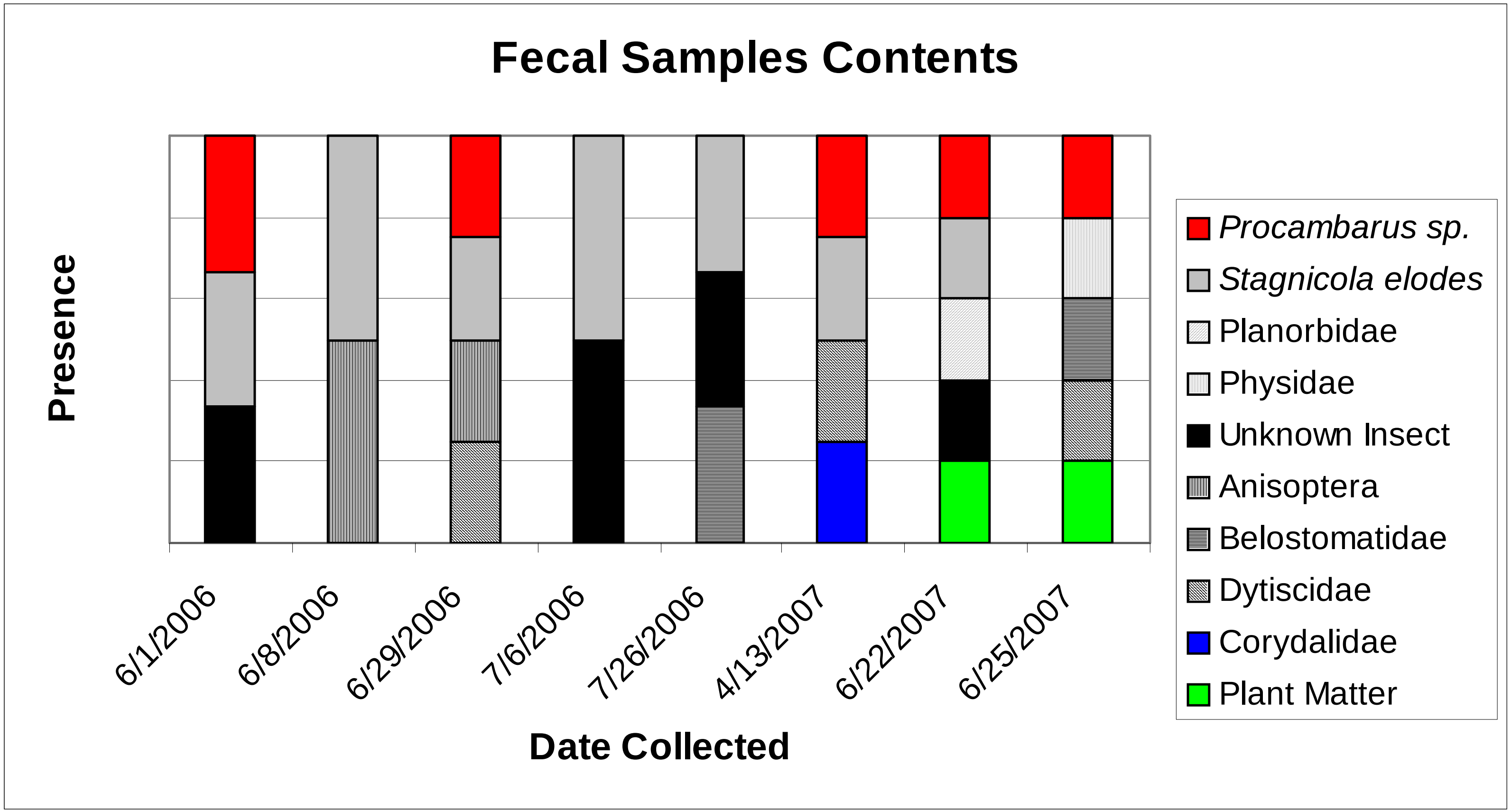

Fecal Samples Contents
Presence
Date Collected
6/1/2006
6/8/2006
6/29/2006
7/6/2006
7/26/2006
4/13/2007
6/22/2007
6/25/2007
Procambarus sp.
Stagnicola elodes
Planorbidae
Physidae
Unknown Insect
Anisoptera
Belostomatidae
Dytiscidae
Corydalidae
Plant Matter

Figure 12: Trapping results for crayfish during 2006 graphed against water temperatures with a general trend line included for water temperature.

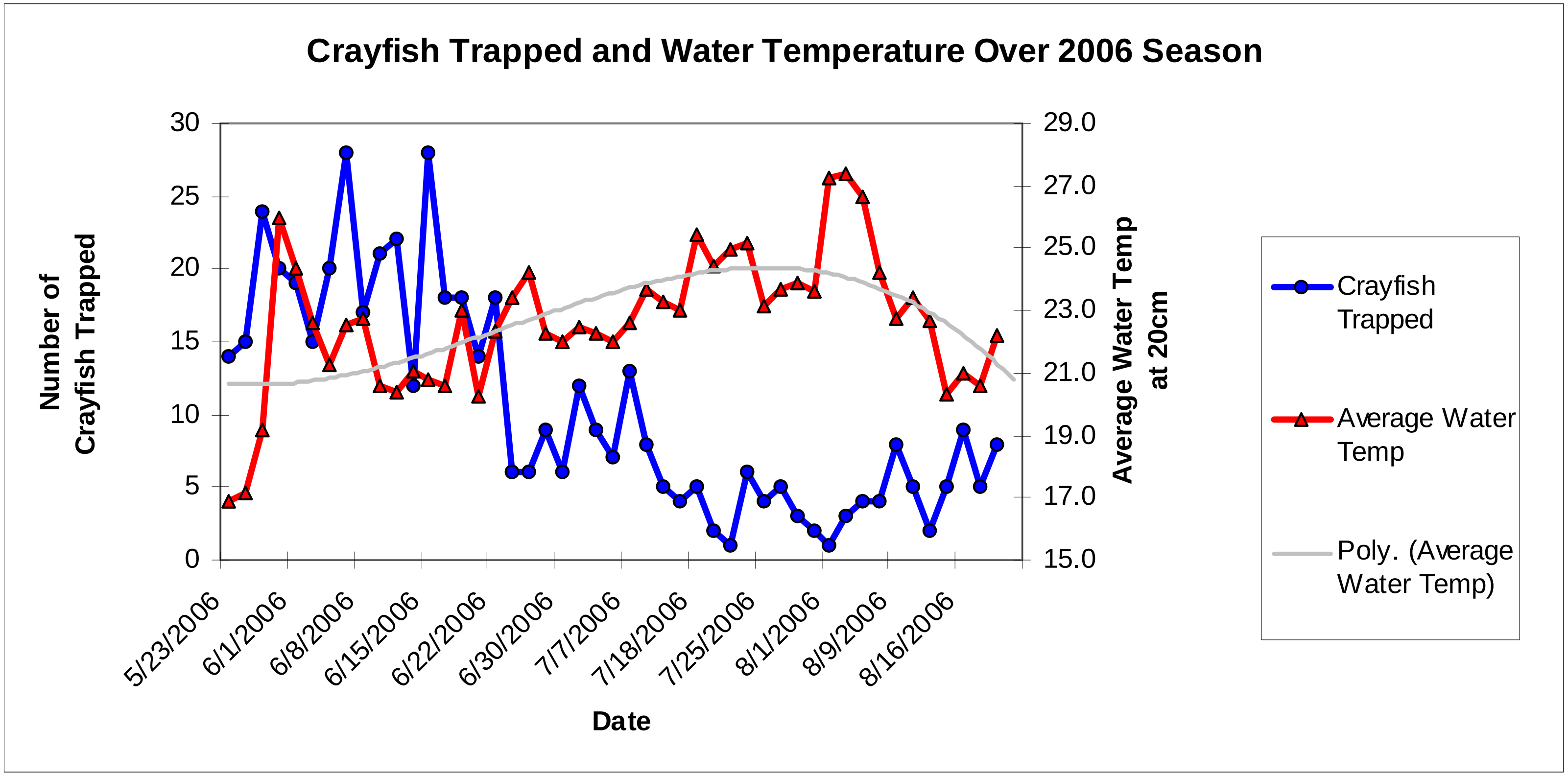

Crayfish Trapped and Water Temperature Over 2006 Season
Number of Crayfish Trapped
30
25
20
15
10
5
0
Average Water Temp at 20cm
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
5/23/2006
6/1/2006
6/8/2006
6/15/2006
6/22/2006
6/30/2006
7/7/2006
7/18/2006
7/25/2006
8/1/2006
8/9/2006
8/16/2006
Date
Crayfish Trapped
Average Water Temp
Poly. (Average Water Temp)

Figure 13: Scattergram of crayfish captured and average water temperature (at 20 cm depth for all trap sites) with line of best fit, shows a weak but significant correlation (p = 0.0006842; correlation coefficient = 0.48).

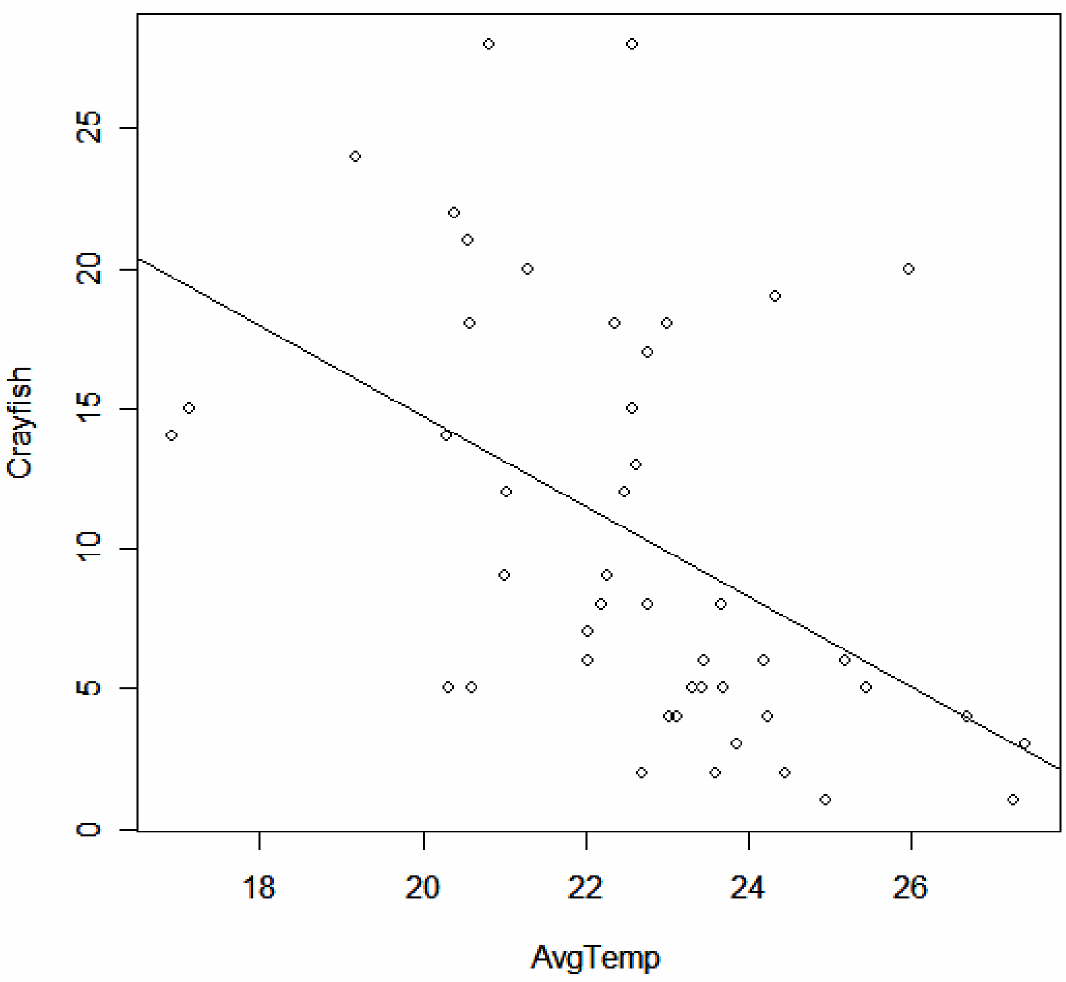

Crayfish
0
5
10
15
20
25
18
20
22
24
26
AvgTemp

Figure 14: Detrended Correspondence Analysis (DCA) showing trends among dietary items (≥1 cm) found in dip net samples across microhabitat types and time. Squares represent habitat which would typically comprise the wetland class PEM (emergent marsh) where turtles were most often located. Grey squares indicate intermediate marsh and black squares indicate shallow marsh. Triangles represent deep water habitat with grey triangles indicating deep marsh and white triangles indicating deep marsh-channel. Black circles indicate wet woods and white diamonds indicate canal habitat. Numbers 1, 2, 3, and 4 correspond to the months of May, June, July, and August respectively.

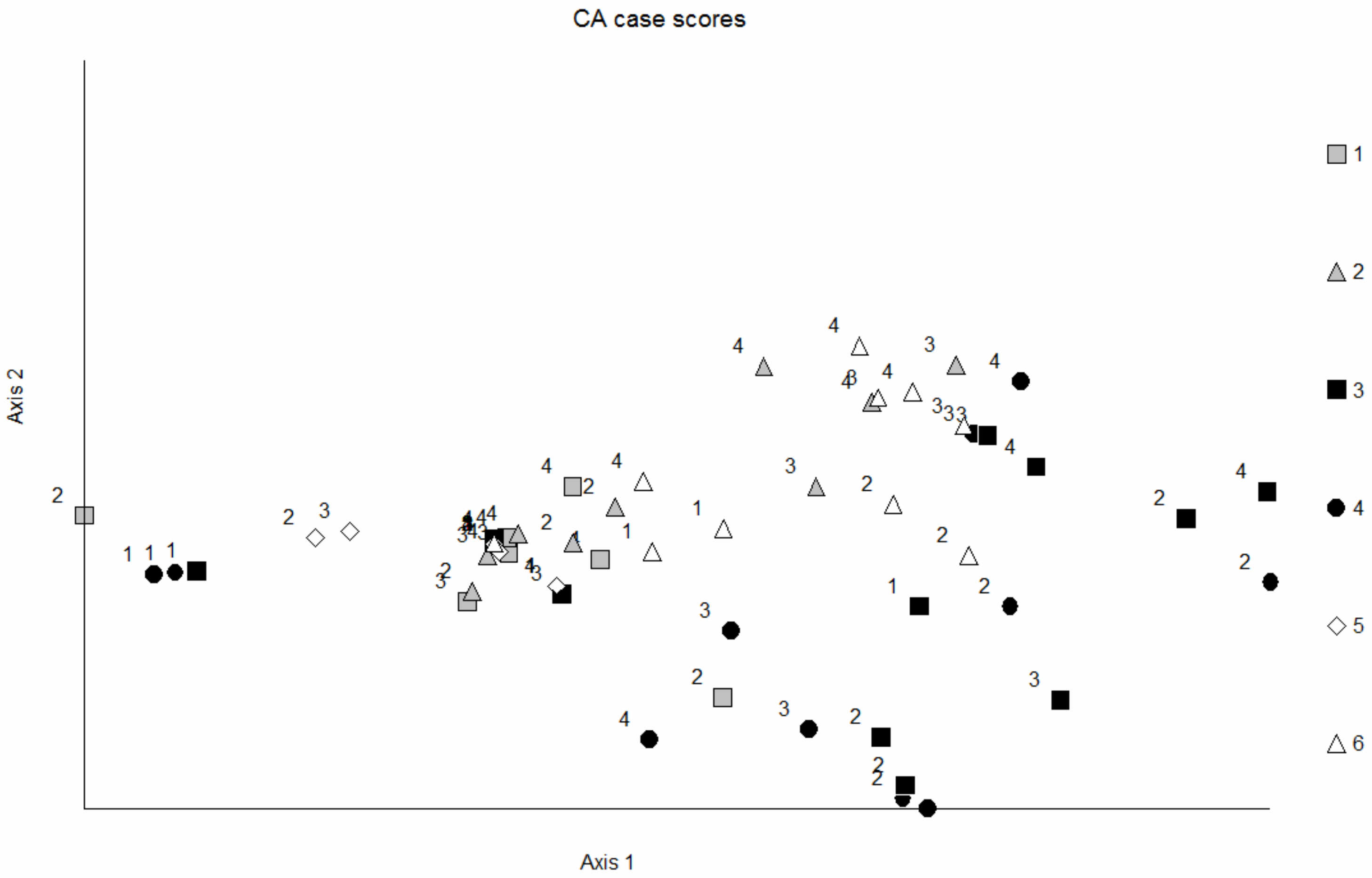

CA case scores
Axis 2
Axis 1
1
2
3
4
5
6

Figure 15: Detrended Correspondence Analysis (DCA) showing the weights for potential food item taxa (≥1 cm) captured in dip nets across microhabitat types and time. Taxa presented in this analysis include only those found in the diet of *E. blandingii* in this study, with the exception of zygopterans which were included due to their overwhelming abundance as an item ≥1 cm in dip net samples. Taxa names have been abbreviated. Consequently, *Stagnicola elodes* is indicated as StelB, Anisoptera is indicated as AniaB, Hirudinidae is indicated as HiruB, and so on (refer to Table 3). LithB refers to tadpoles in the anuran genus *Lithobates.* CycaB and LepoB refer to fish in genera *Cyprinus* and *Lepomis* respectively. CoryB refers to Corydalidae larvae which were only identified in a fecal sample.

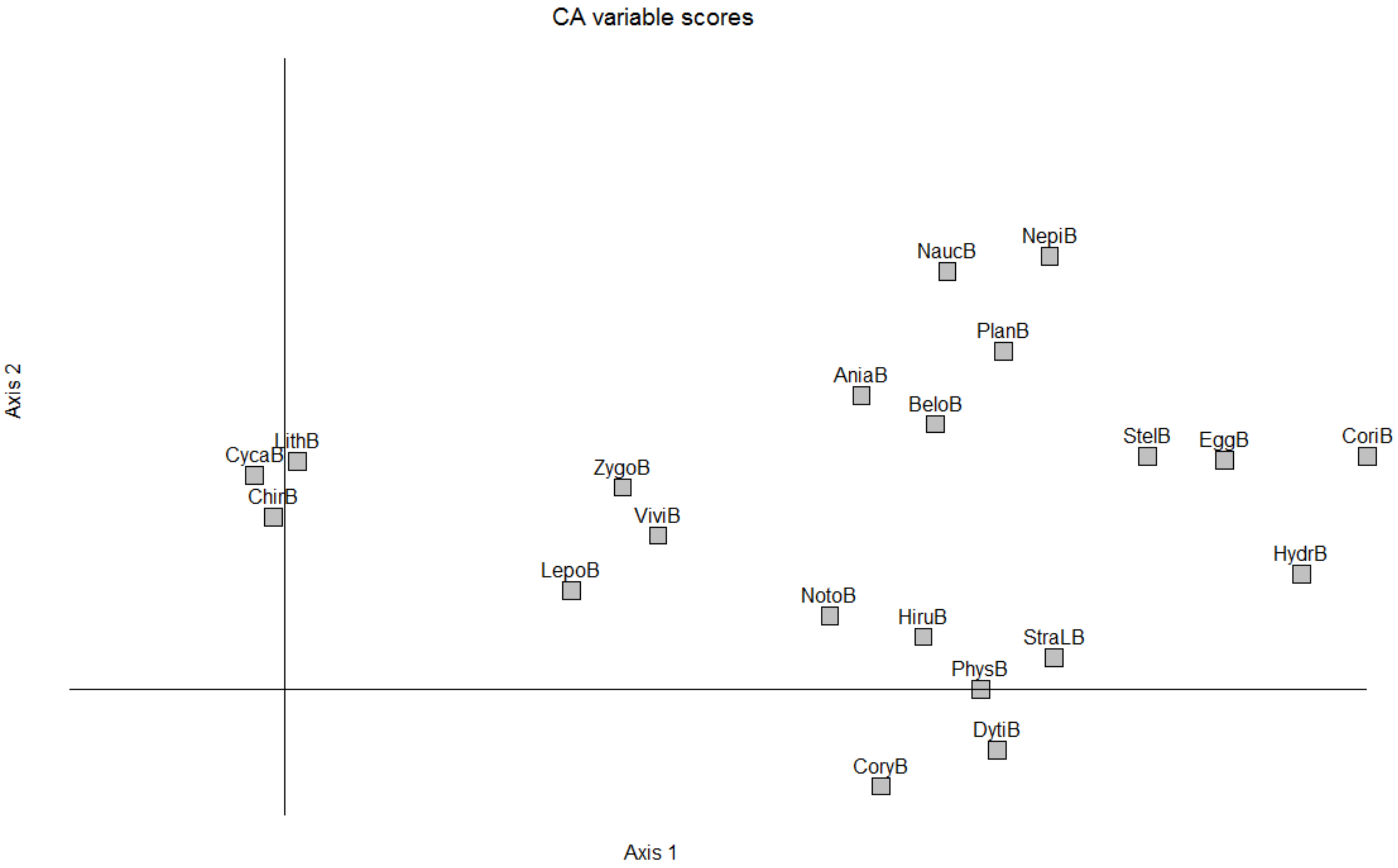
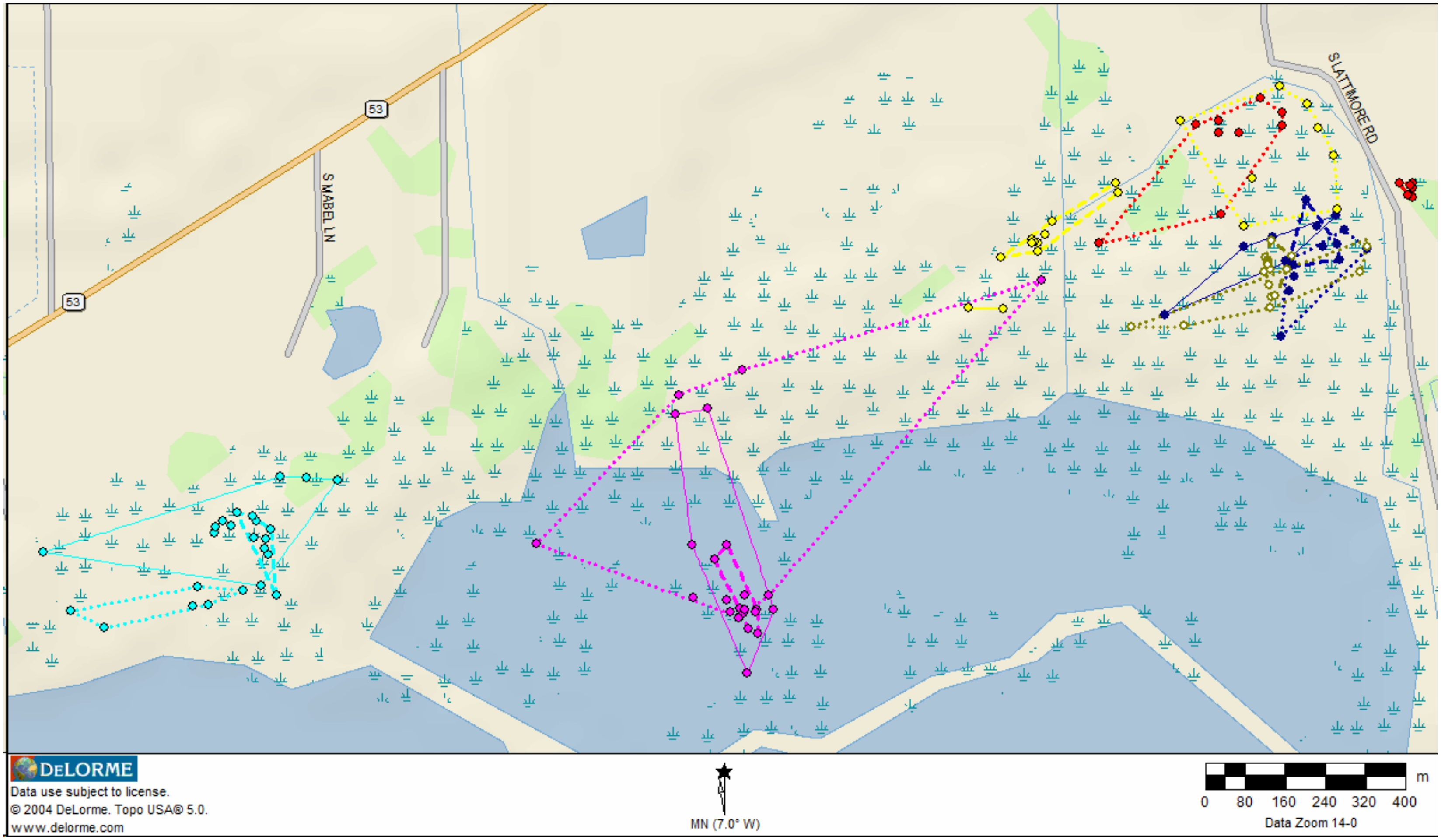

CA variable scores
Axis 2
Axis 1
NepiB
NaucB
PlanB
AniaB
BeloB
StelB
EggB
CoriB
LithB
CycaB
ZygoB
ChirB
ViviB
HydrB
LepoB
NotoB
HiruB
StraLB
PhysB
DytiB
CoryB

Figure 16: Map showing the general homerange of six males in 2006 (dotted line) and 2007 (solid line), with the interceding winter range indicated by a dashed line. The figure also shows the tendency for these general homeranges to drift from year to year. This indicates that the true homerange for each individual is likely to have been underestimated by this general assessment. Map created on DeLorme Topo USA 5.0.


53
53
S MABEL LN
SLATTMORE RD
DELORME
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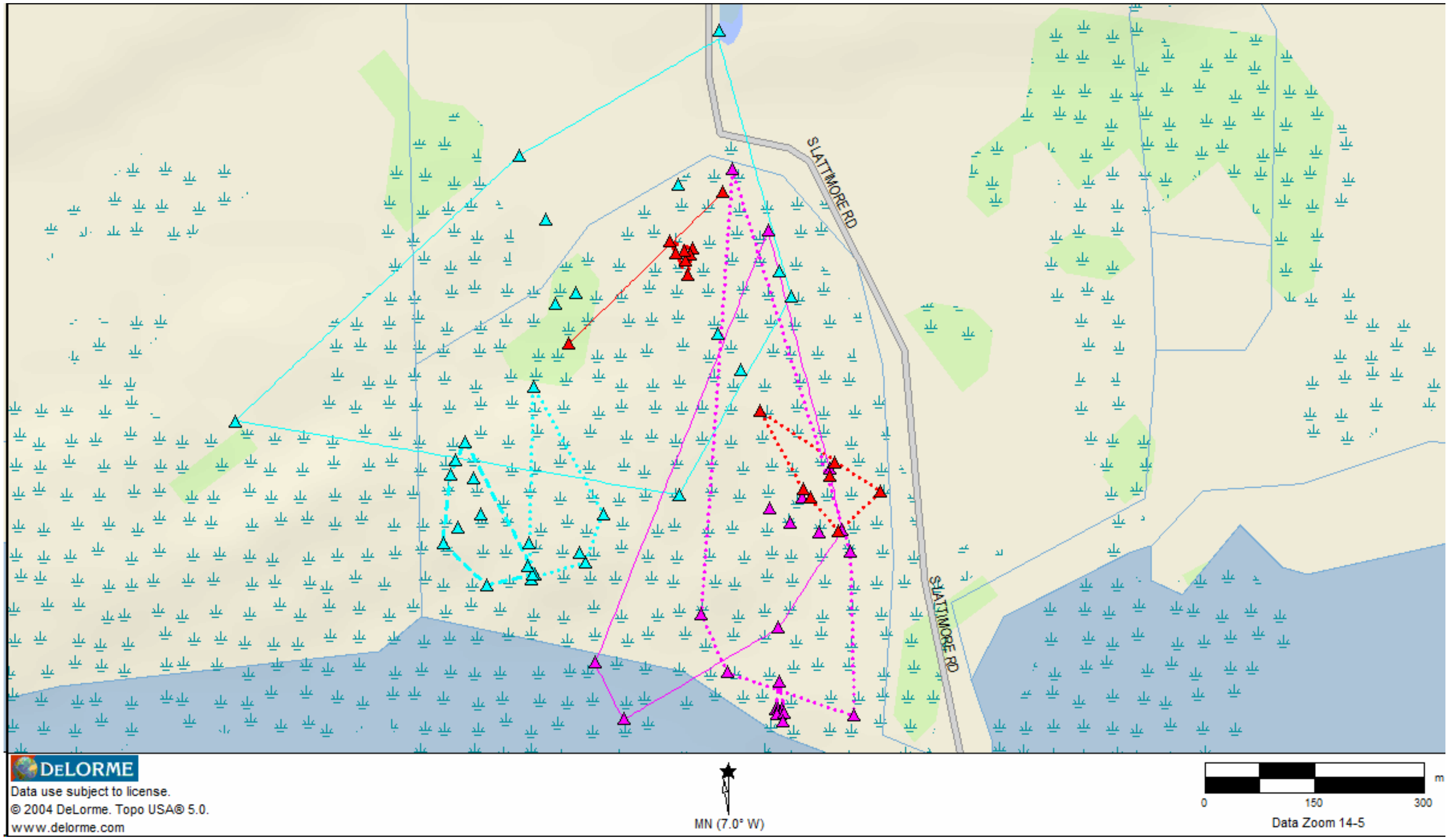
MN (7.0° W)
0 80 160 240 320 400
m
Data Zoom 14-0

Figure 17: Map showing the general homerange of three females in 2006 (dotted line) and 2007 (solid line), with the interceding winter range indicated by a dashed line. The figure also shows the tendency for these general homeranges to drift from year to year. This indicates that the true homerange for each individual is likely to have been underestimated by this general assessment. Map created on DeLorme Topo USA 5.0.


S LATTIMORE RD
S LATTIMORE RD
DELORME
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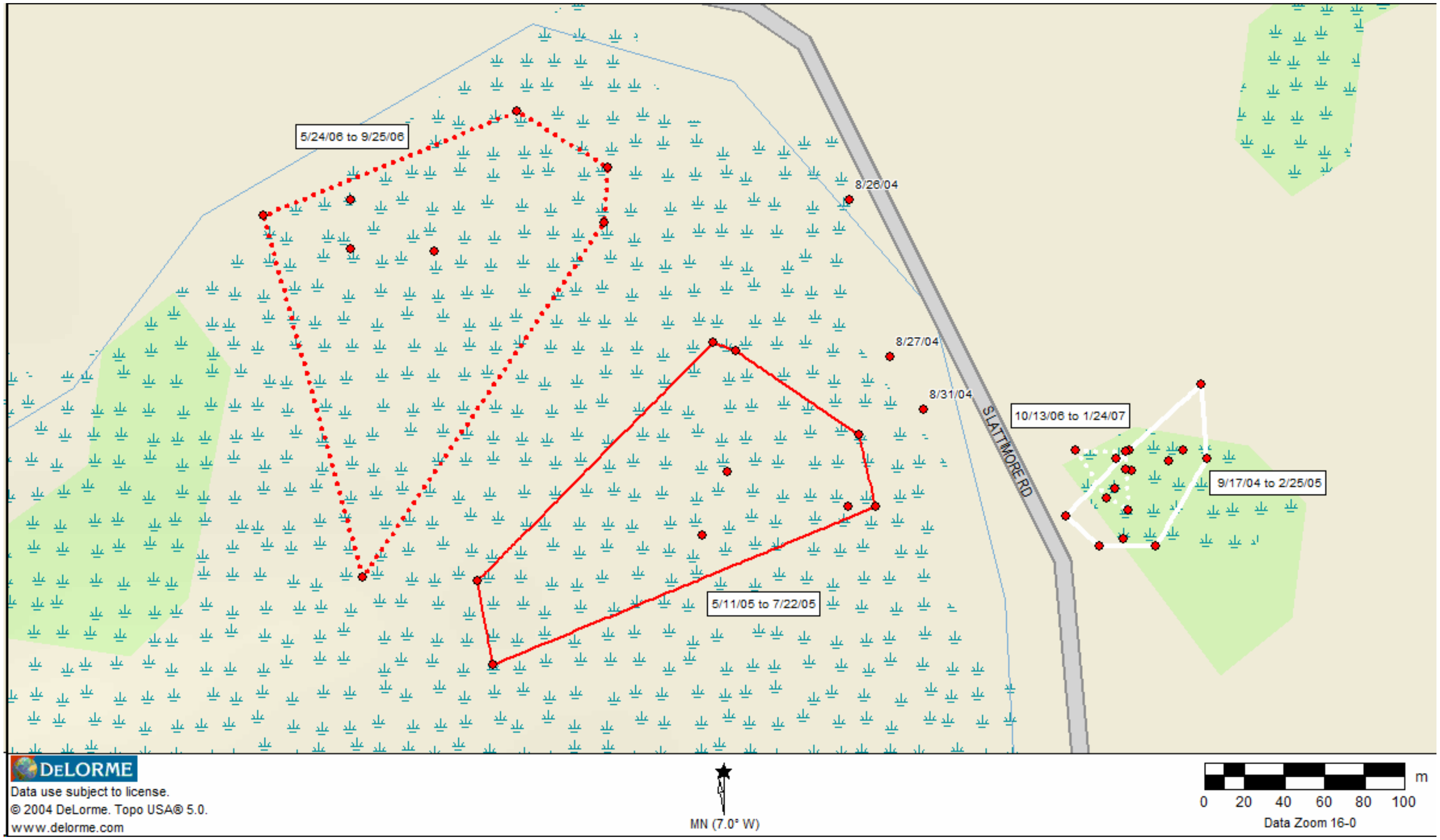
www.delorme.com
MN (7.0° W)
0
150
300
m
Data Zoom 14-5

Figure 18: Map showing three location points for Male #59 during late August of 2004 followed by its migration to an isolated pond for overwintering (solid white line). The general homerange for the following spring–summer (2005) is then indicated by a solid red line. The general homerange in the spring–summer of 2006 is indicated by a dotted red line, and the dotted white line then shows Male #59's return to the same isolated pond for overwintering. Map created on DeLorme Topo USA 5.0.


5/24/06 to 9/25/06
8/26/04
8/27/04
8/31/04
SLATTIMORE RD
10/13/06 to 1/24/07
9/17/04 to 2/25/05
5/11/05 to 7/22/05
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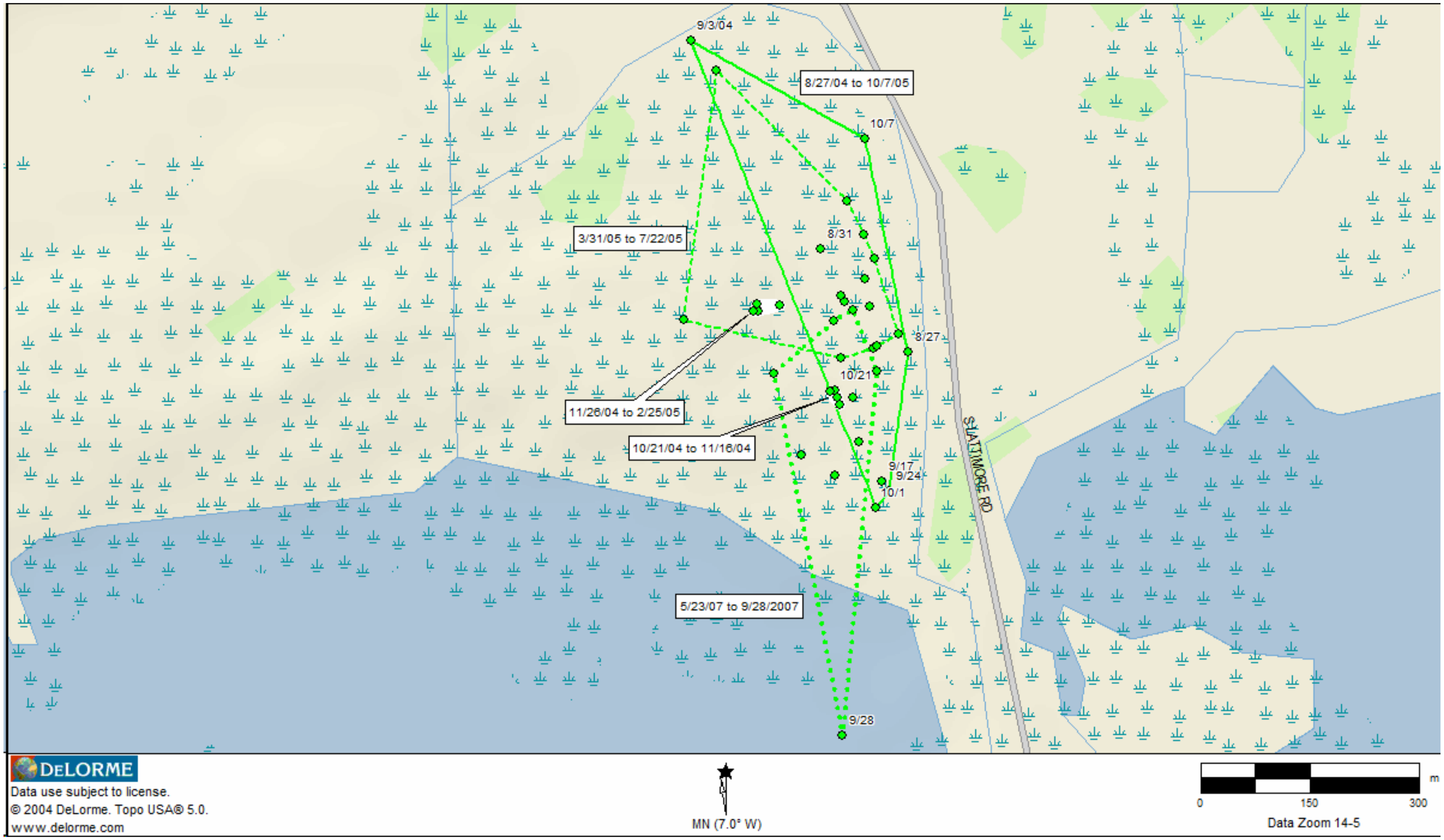
MN (7.0° W)
m
0
20
40
60
80
100
Data Zoom 16-0

Figure 19: Map Male #63 showing the general homerange during the active seasons of 2004 (solid line), 2005 (dashed line), and 2007 (dotted line). Two tight winter ranges are labeled for the winter of 2004–2005. The winter range falls within the active season homerange for Male #63. Map created on DeLorme Topo USA 5.0.


9/3/04
8/27/04 to 10/7/05
10/7
3/31/05 to 7/22/05
8/31
8/27
10/21
11/26/04 to 2/25/05
10/21/04 to 11/16/04
9/17
9/24
10/1
SUATTIMORE RD
5/23/07 to 9/28/2007
9/28
DELORME
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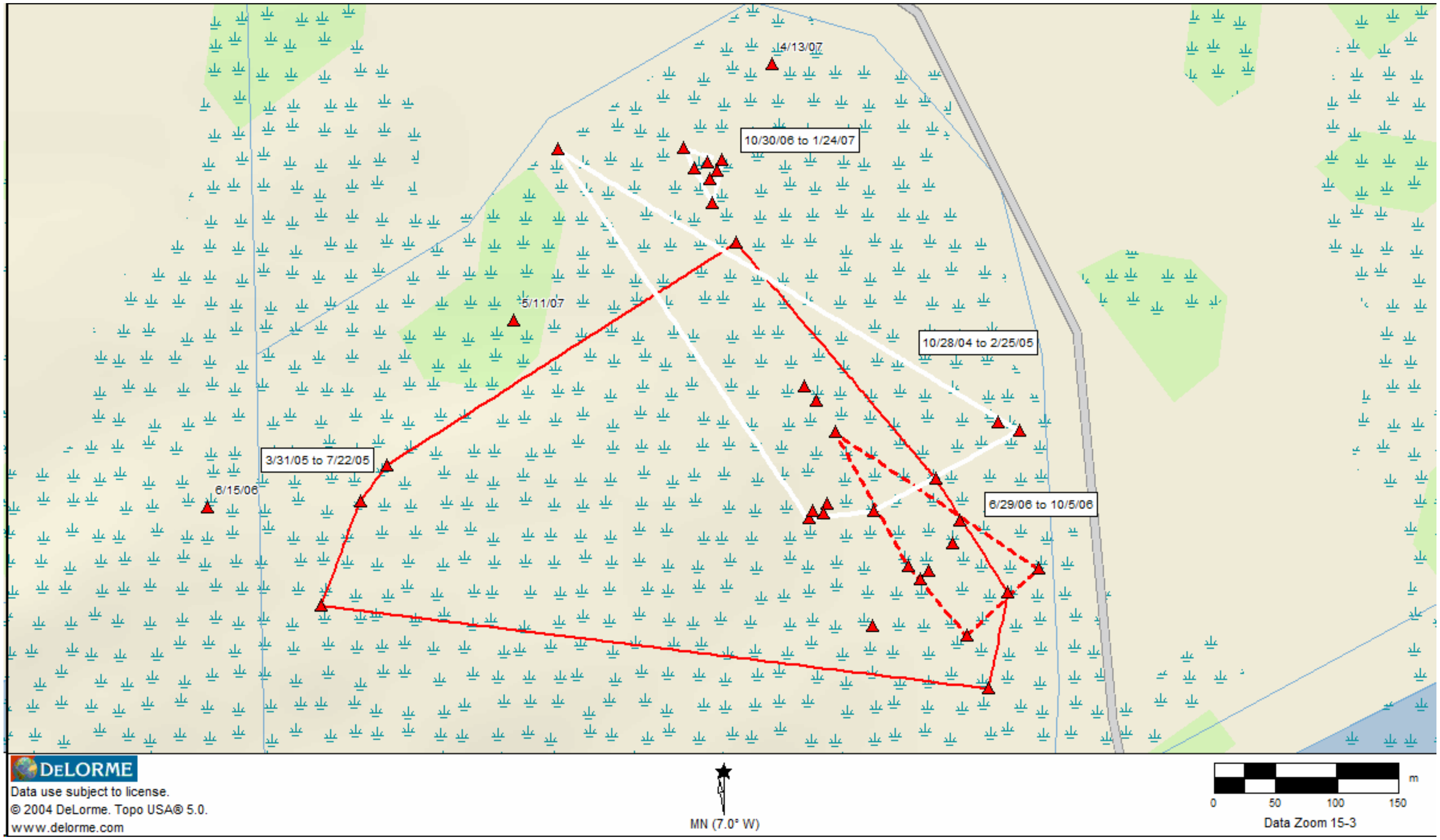
MN (7.0° W)
m
0
150
300
Data Zoom 14-5

Figure 20: Map Female #73 showing the general homerange during the active seasons of 2005 (solid red line) and 2006 (dashed red line). Winter ranges are indicated for the years of 2004–2005 (solid white line) and 2006–2007 (dashed white line). The winter range observed in 2004–2005 overlaps with the active season range, while the winter range observed in 2006–2007 is separate and distinct from the active season range. Map created on DeLorme Topo USA 5.0.


4/13/07
10/30/06 to 1/24/07
5/11/07
10/28/04 to 2/25/05
3/31/05 to 7/22/05
6/15/06
6/29/06 to 10/5/06
DELORME
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www.delorme.com
MN (7.0° W)
m
0
50
100
150
Data Zoom 15-3

Figure 21: Percentage of microhabitat types turtles were located in from April–September in 2006 and 2007 (n = 199). The figure compares the methods used to categorize microhabitat at WPM for trap site selection and ultimately for interpretation of dip net analyses. Grouping of shallow marsh with intermediate marsh and deep marsh-channel with deep marsh shows a close match with PEM and PAB marshes respectively. This grouping is in accordance with Figure 6.

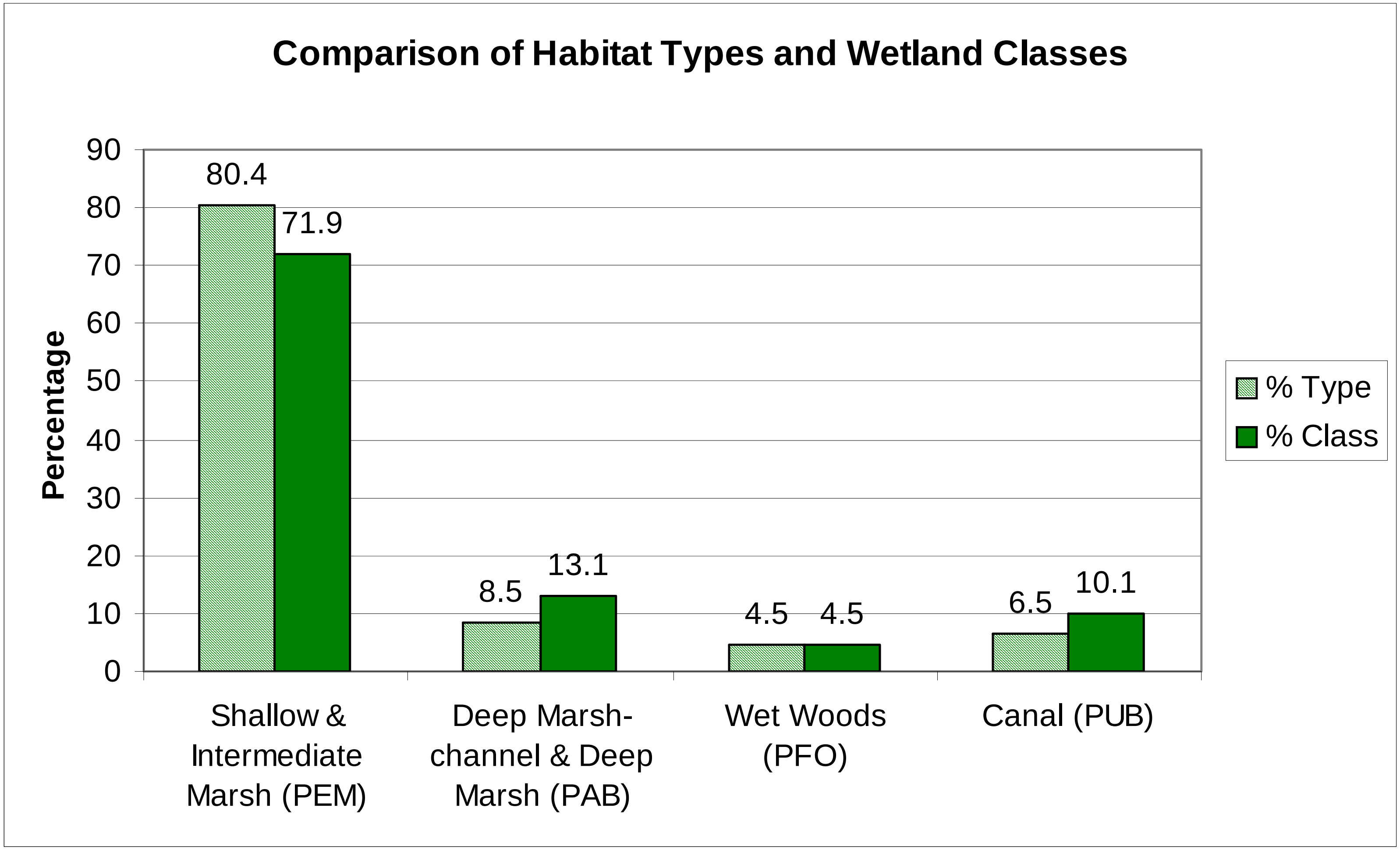

Comparison of Habitat Types and Wetland Classes
Percentage
0
10
20
30
40
50
60
70
80
90
80.4
71.9
8.5
13.1
4.5
4.5
6.5
10.1
Shallow & Intermediate Marsh (PEM)
Deep Marsh-channel & Deep Marsh (PAB)
Wet Woods (PFO)
Canal (PUB)
▨ % Type
■ % Class

Figure 22: Comparison of microhabitat locations males and females were located in during April–September of 2006 and 2007 (n = 199). Heavier use of PUB habitat by females could be a result of the utilization of canal and deep marsh-channel systems for movements to and from nesting areas.

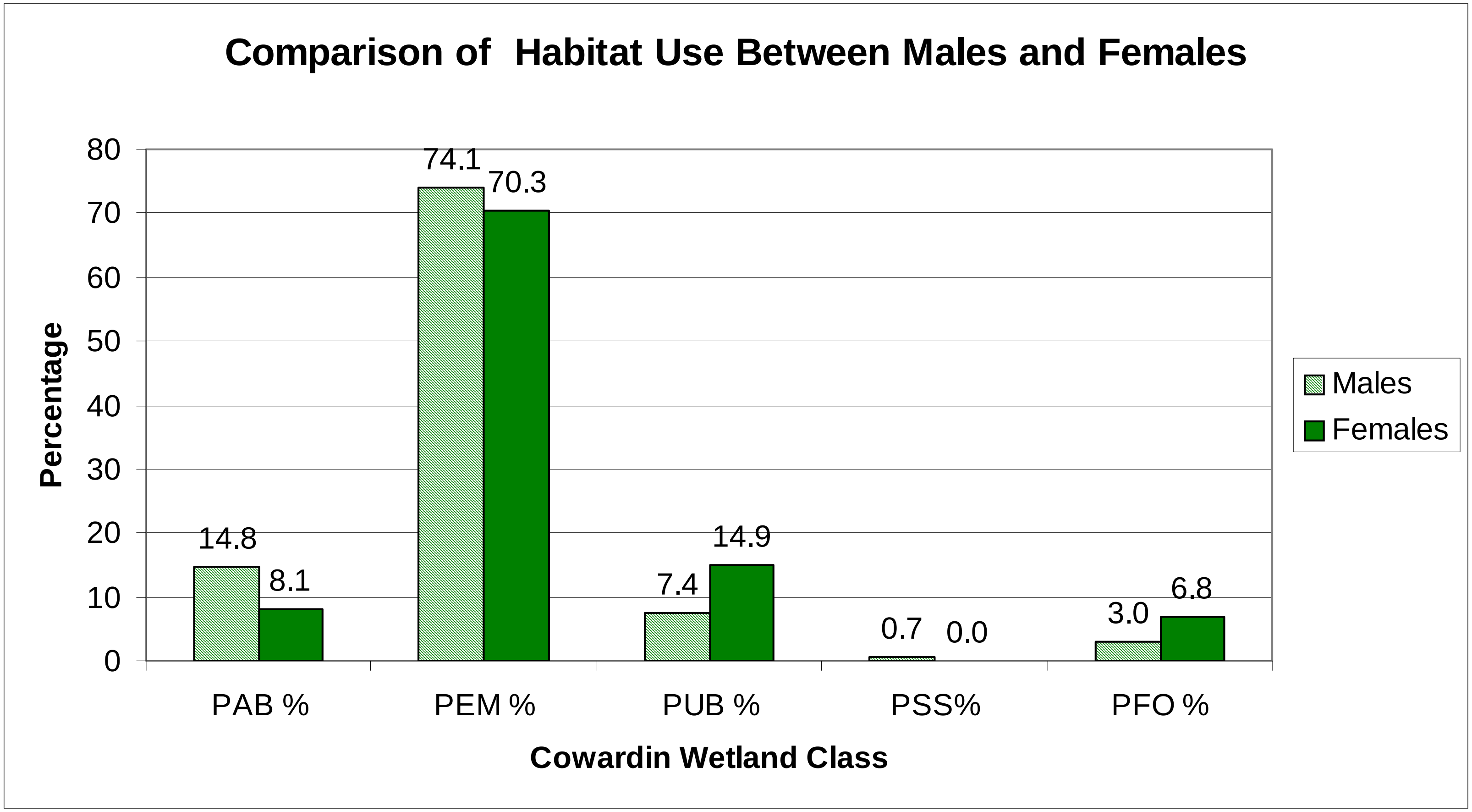

Comparison of Habitat Use Between Males and Females
Percentage
80
70
60
50
40
30
20
10
0
14.8
8.1
74.1
70.3
7.4
14.9
0.7
0.0
3.0
6.8
PAB %
PEM %
PUB %
PSS%
PFO %
Cowardin Wetland Class
Males
Females

Figure 23: Comparison of microhabitat types used between the active season (April–September) and winter (October–January), and for differing activities (feeding vs. hibernation). The heavy usage of PUB habitat observed in winter is likely a combination of canal and pond usage, and die-back of the aquatic bed (PAB) vegetation.

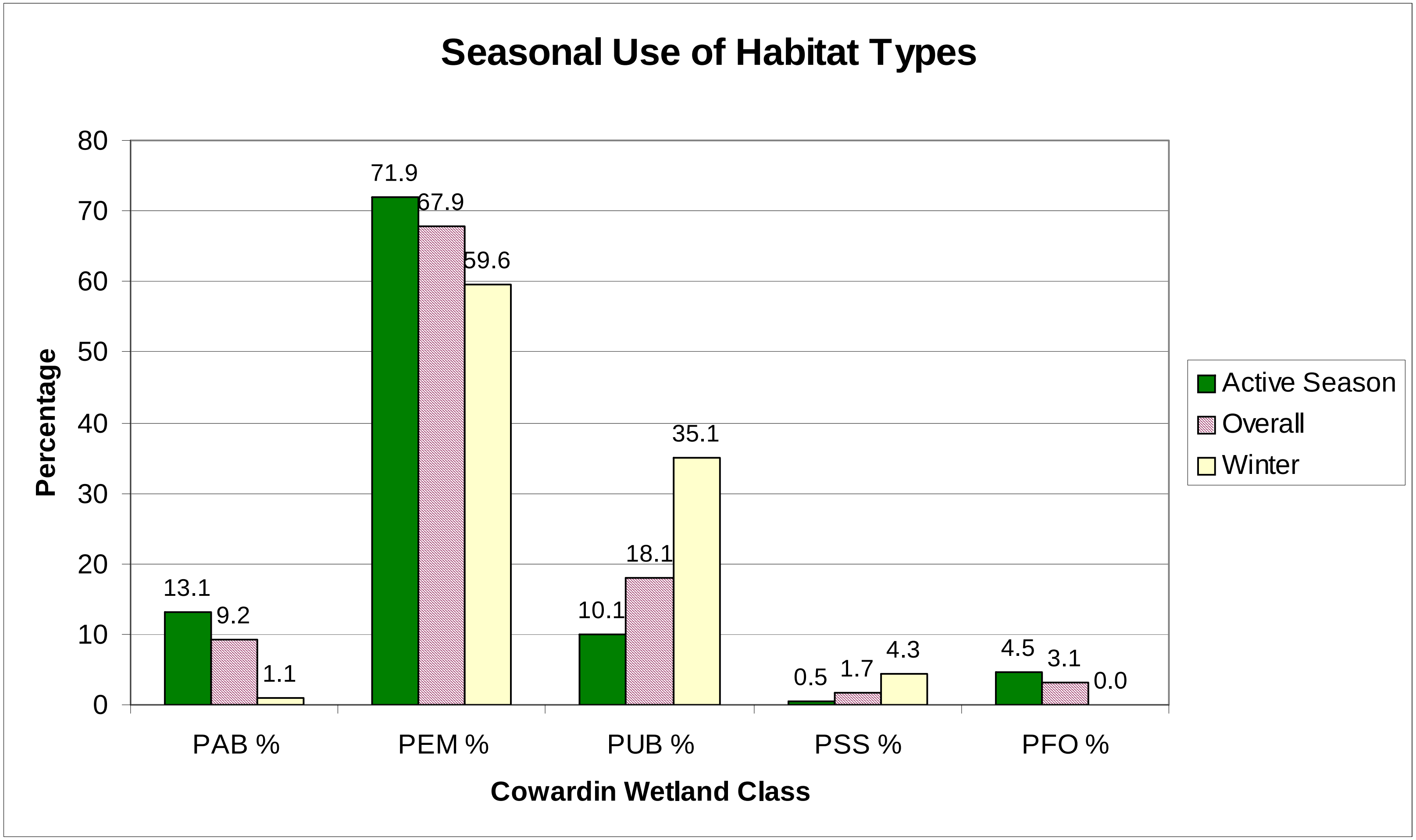

Seasonal Use of Habitat Types
Percentage
80
70
60
50
40
30
20
10
0
13.1
9.2
1.1
71.9
67.9
59.6
10.1
18.1
35.1
0.5
1.7
4.3
4.5
3.1
0.0
PAB %
PEM %
PUB %
PSS %
PFO %
Cowardin Wetland Class
Active Season
Overall
Winter

Figure 24: Map showing random points (yellow and red dots) generated in and around WPM (within a 500 m buffer area) for an estimation of available habitat. The red dots indicate the first 100 random points assessed, after which the proportions for available habitat remained relatively stable. A total of 177 consecutive random points were assessed, from the original list of 300 random points generated, before proportions of available habitat were deemed to have satisfactorily stabilized. This figure is courtesy of Cleveland Metroparks (unpublished data).

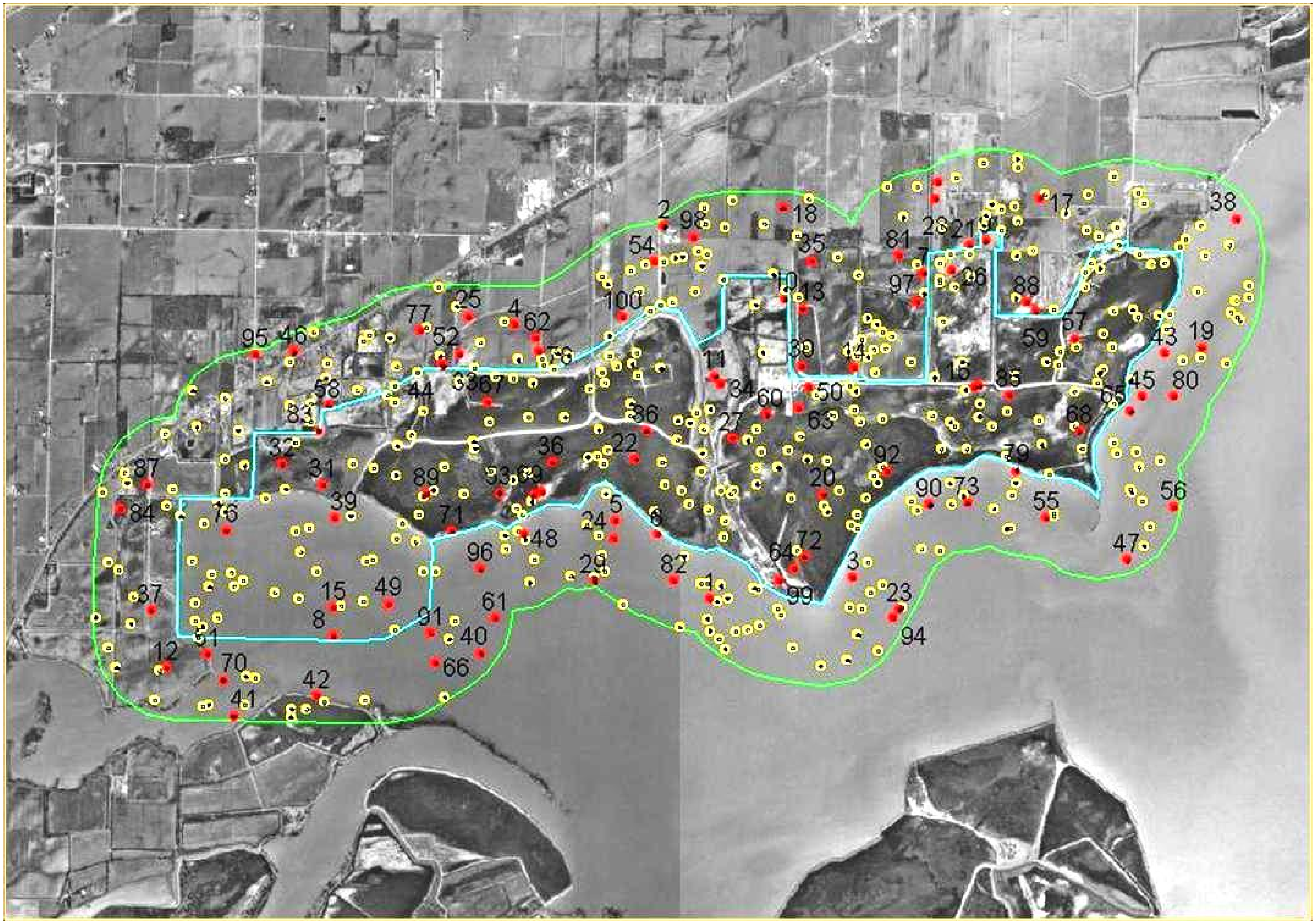


Figure 25: Graph comparing wetland microhabitats available in 2005 (Cleveland Metroparks, unpublished data) to wetland microhabitat used from April–September in 2006 and 2007. Percentages for available habitat were derived from a total of 177 randomly generated points. Of those 177 points, 147 were physically assessed on the ground while the remainder was determined by aerial photographs. Excluded from this analysis are 96 (of the 177 points) identified as lacustrine unconsolidated bottom (open bay) and crops or developed land.

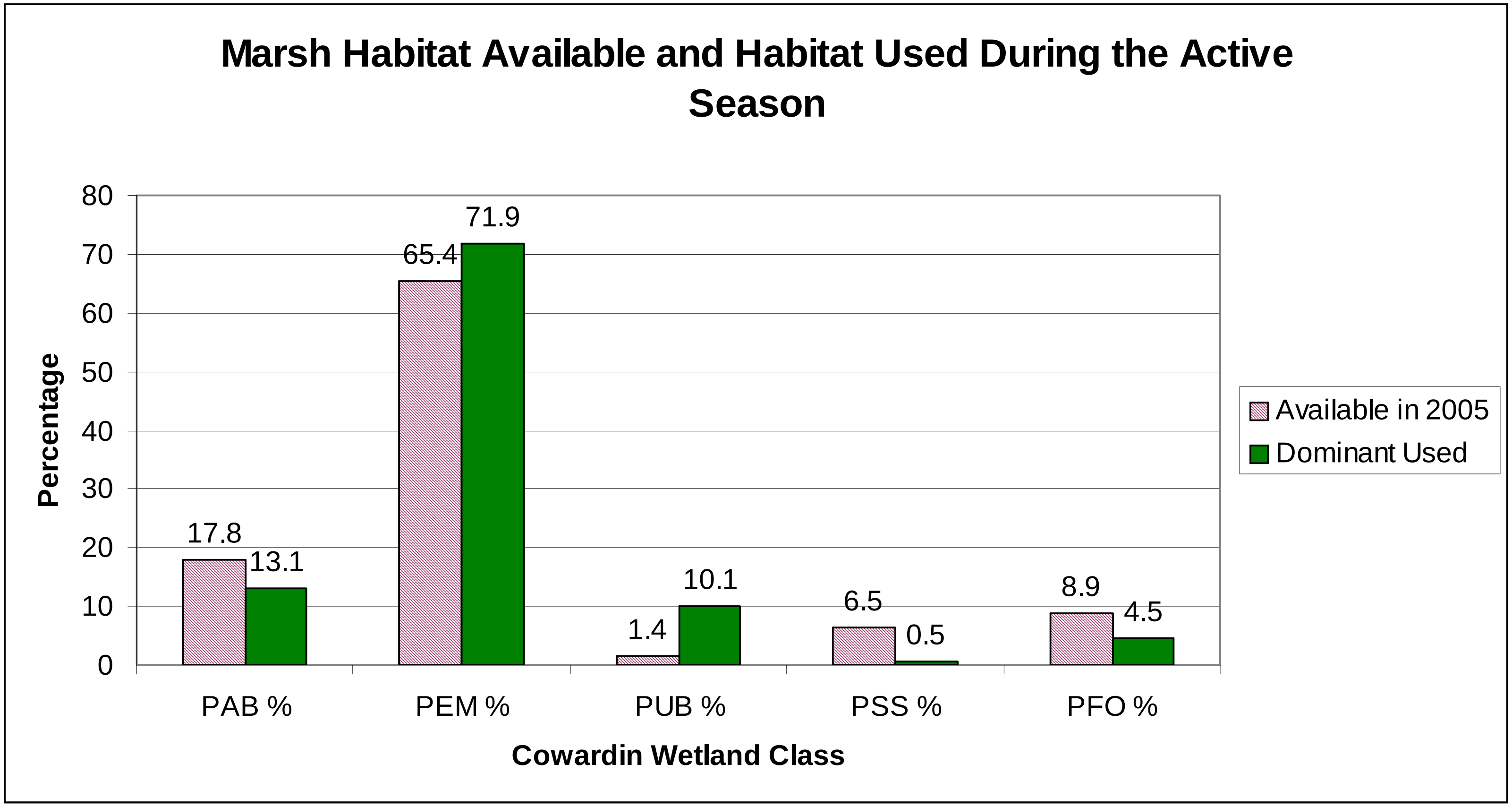
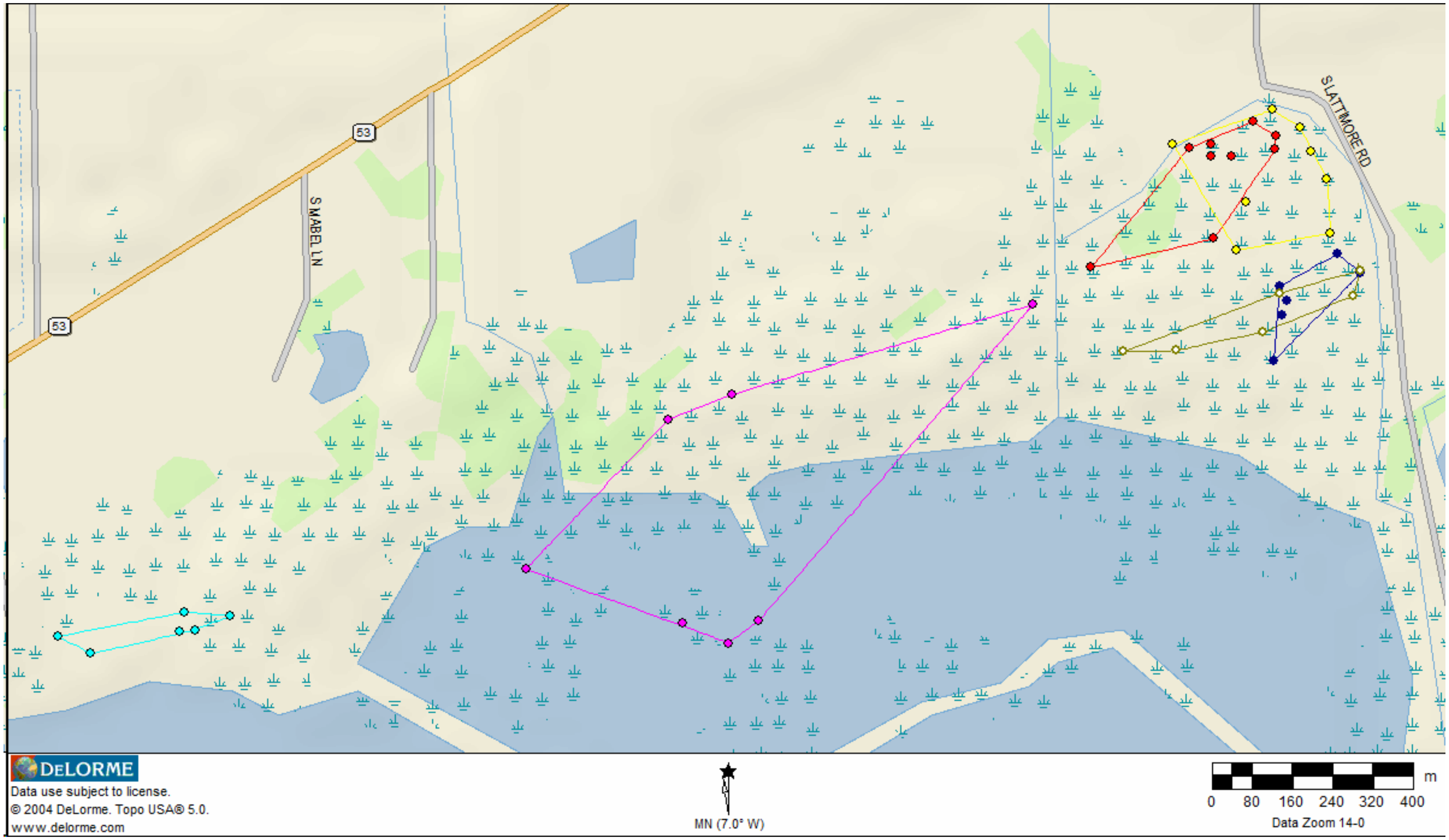

Marsh Habitat Available and Habitat Used During the Active Season

Figure 26: The general homerange for six male individuals tracked during the active season (May through mid-October) of 2006. The homeranges were observed to overlap between individual males in 2006. Map created on DeLorme Topo USA 5.0.


53
53
S MABEL LN
S LATTIMORE RD
DELORME
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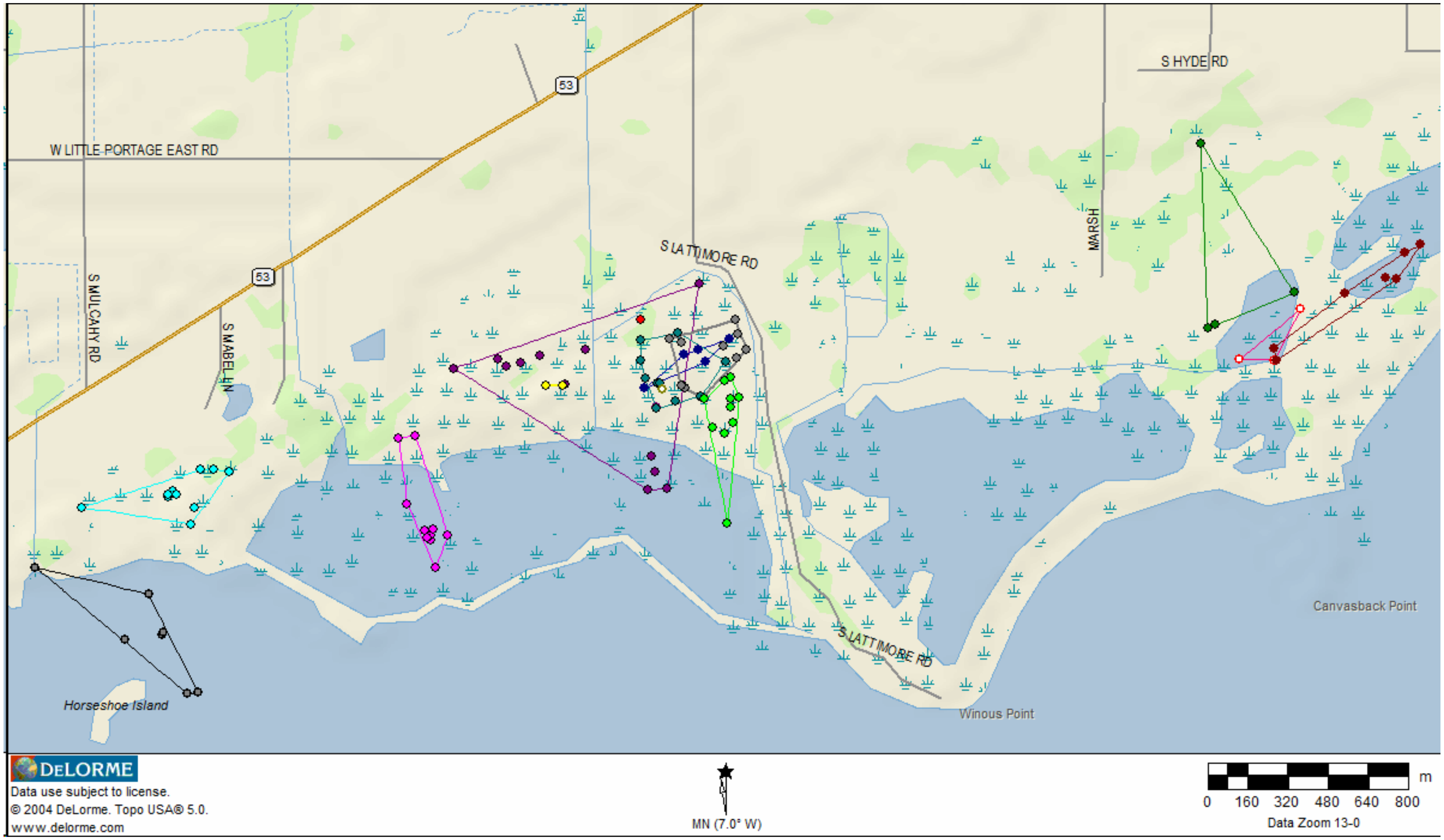
www.delorme.com
MN (7.0° W)
0 80 160 240 320 400
m
Data Zoom 14-0

Figure 27: The general homerange (or limited observations) for 13 male individuals tracked during the active season (April–September) of 2007. The homeranges were observed to overlap between individual males in 2007. Map created on DeLorme Topo USA 5.0.


W LITTLE PORTAGE EAST RD
53
S HYDE RD
S MULCAHY RD
S MABEL LN
S LATTIMORE RD
MARSH
Canvasback Point
Horseshoe Island
Winous Point
DELORME
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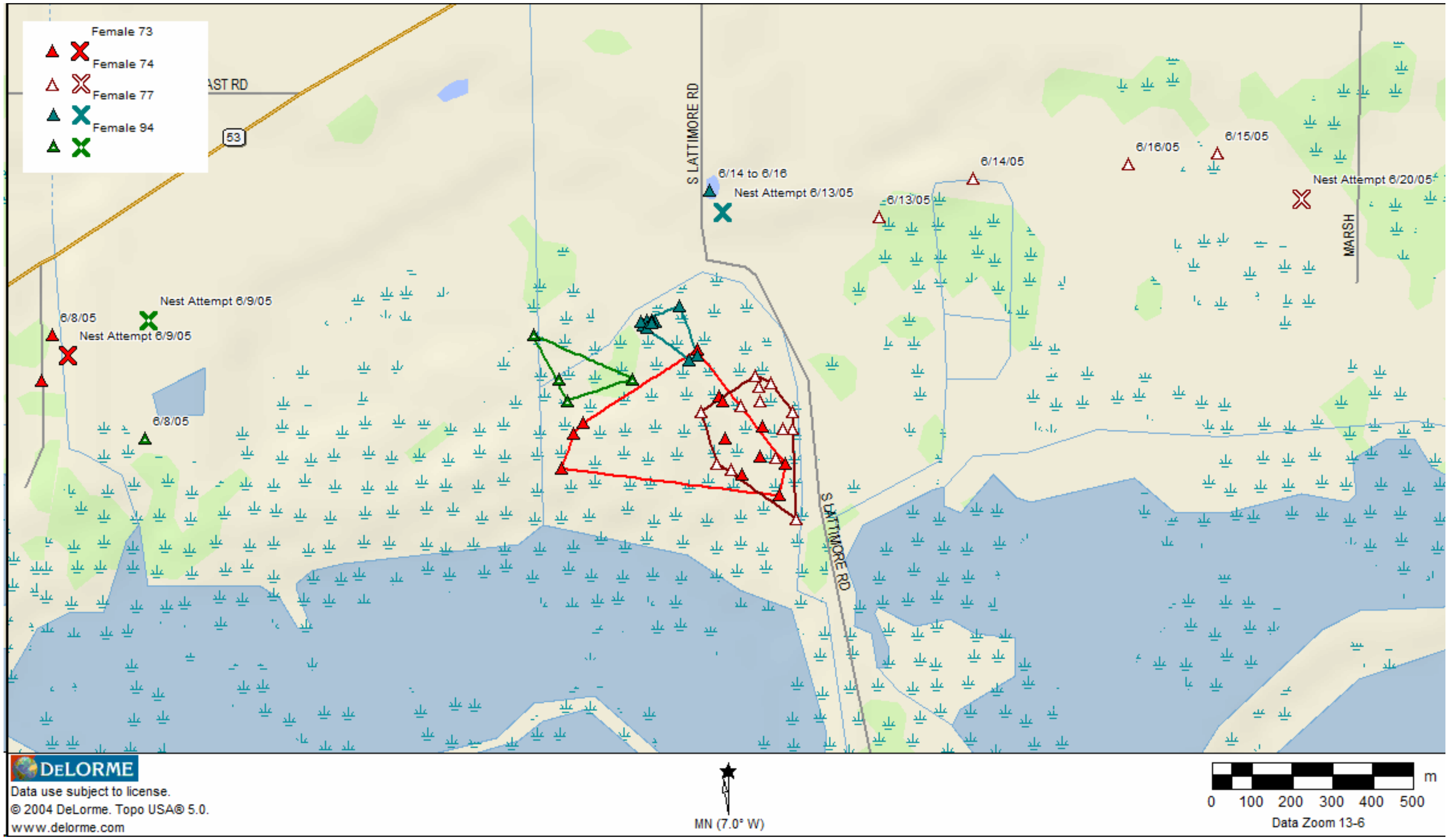
MN (7.0° W)
m
0 160 320 480 640 800
Data Zoom 13-0

Figure 28: Map of 2005 nest attempts and female ranges. Movements of Females #73 and #74 toward nest sites are excluded from delineation of their range. After nesting, Female #77 spent at least two days in the small pond north of her nest site. This location was excluded from delineation of her range. Map created on DeLorme Topo USA 5.0.


Female 73
Female 74
Female 77
Female 94
AST RD
53
S LATTIMORE RD
6/14 to 6/16
Nest Attempt 6/13/05
6/13/05
6/14/05
6/16/05
6/15/05
Nest Attempt 6/20/05
MARSH
Nest Attempt 6/9/05
6/8/05
Nest Attempt 6/9/05
6/8/05
S LATTIMORE RD
DELORME
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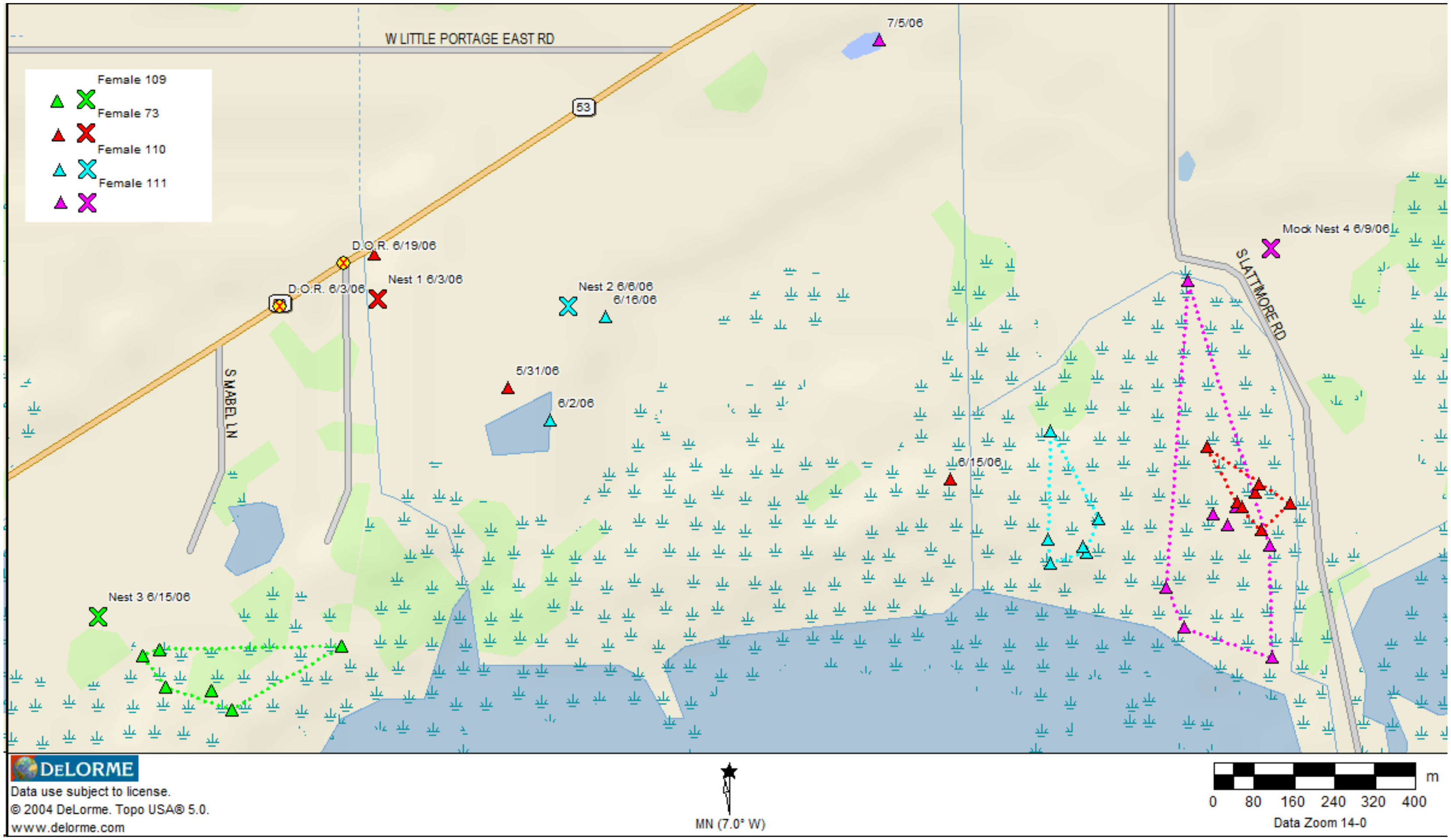
MN (7.0° W)
0 100 200 300 400 500
m
Data Zoom 13-6

Figure 29: Map of 2006 nest sites and female ranges. Mock Nest 4 is located in the approximate area Female #111 was believed to have nested. Female #110 was located in an agricultural ditch just south of her nest site for over a week following nesting. This location was excluded from delineation of her range along with the location she was originally picked up at on 2 June. Female #111 was inexplicably located in an isolated pond (north end of map) on 5 July, nearly a month after nesting. The location of Female #73 north of Nest 1 indicates the location she spent two nights in prior to nesting. Her location on 31 May and 15 June indicate movements to and from nesting, thus these locations were all excluded from delineation of her range. The discovery of two females found dead on SR53 on 3 June and 19 June are indicated near Nest 1 (presumably killed during nesting movements). Map created on DeLorme Topo USA 5.0.


W LITTLE PORTAGE EAST RD
53
7/5/06
Female 109
Female 73
Female 110
Female 111
D.O.R. 6/19/06
D.O.R. 6/3/06
Nest 1 6/3/06
Nest 2 6/6/06
6/16/06
Mock Nest 4 6/9/06
SLATTIMORE RD
S MABEL LN
5/31/06
6/2/06
6/15/06
Nest 3 6/15/06
DeLorme
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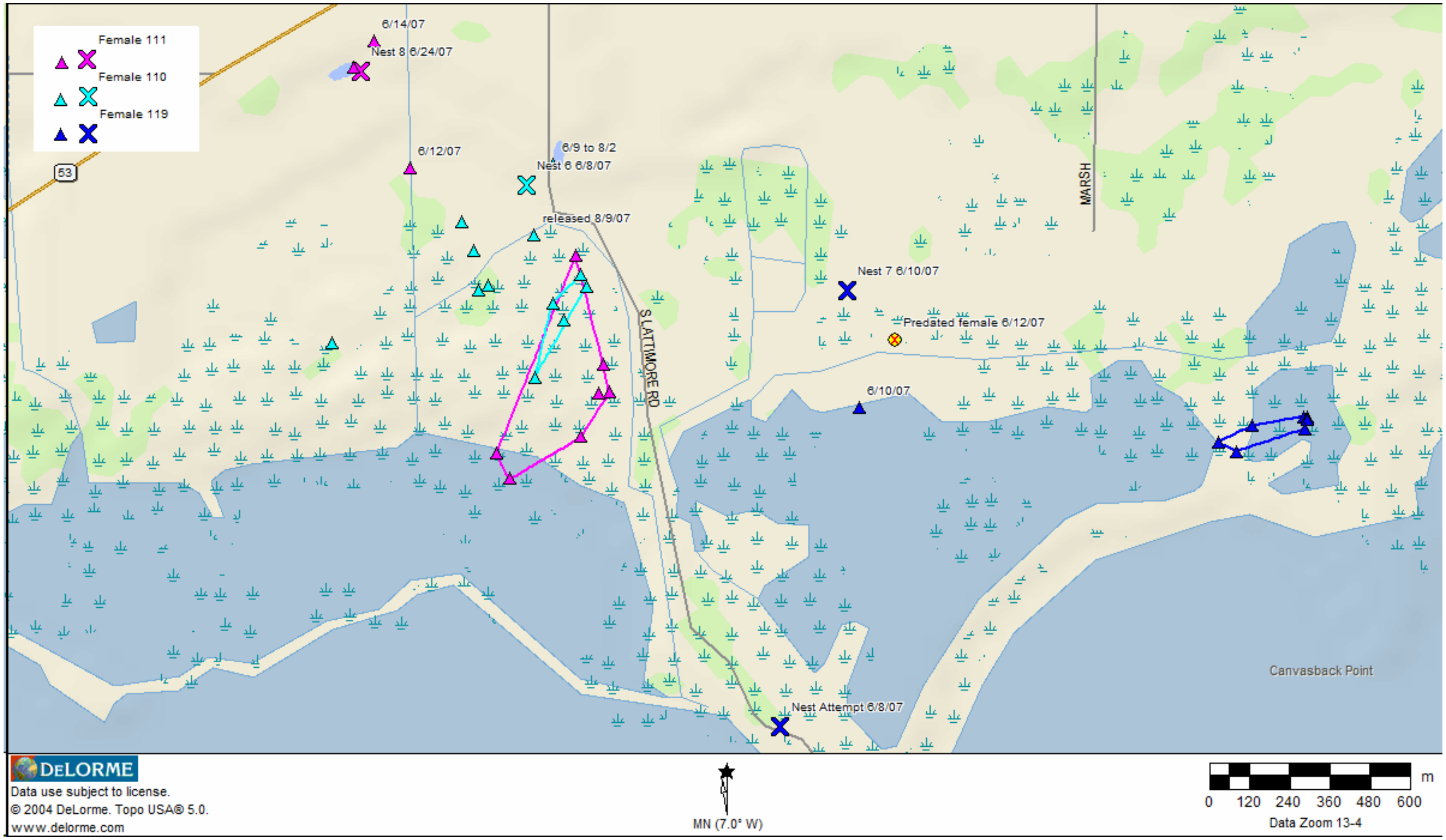
MN (7.0° W)
m
0
80
160
240
320
400
Data Zoom 14-0

Figure 30: Map of 2007 nest sites with female ranges. Female #111 spent at least nine days, prior to nesting, in the same isolated pond (north end of the map) that she was located in the previous summer. After nesting, female #110 resided in the small pond east of Lattimore Rd. (partially hidden by Nest 6 label) from 9 June to 2 August until she was accidentally buried alive in the bank of the pond. She was rescued and held observation. Her release on 9 August and subsequent erratic movements were excluded from delineation of her 2007 range on this map. The discovery of a predated female (Female #105) at the edge of a corn field on 12 June (presumably during nesting movements) is indicated south of Nest 7. Map created on DeLorme Topo USA 5.0.


Female 111
Female 110
Female 119
53
6/14/07
Nest 8 6/24/07
6/12/07
6/9 to 8/2
Nest 6 6/8/07
released 8/9/07
S LATTIMORE RD
MARSH
Nest 7 6/10/07
Predated female 6/12/07
6/10/07
Canvasback Point
Nest Attempt 6/8/07
DELORME
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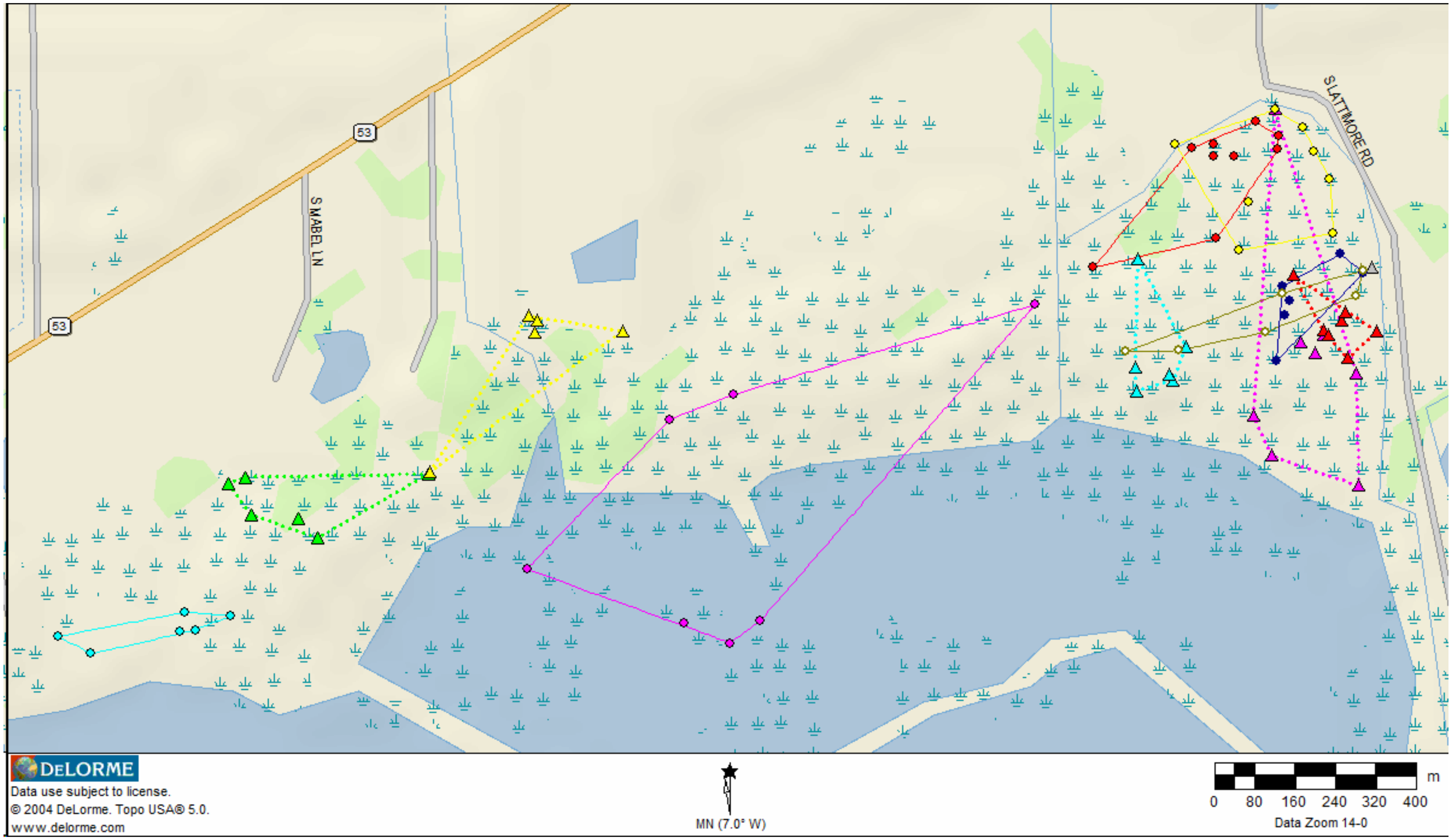
MN (7.0° W)
0 120 240 360 480 600
m
Data Zoom 13-4

Figure 31: The general homerange for all 12 individuals during the active season (May through mid-October) of 2006. Males are indicated by circles with solid lines and females are indicated by triangles with dotted lines. Only one observation was recorded for Female #113 (grey triangle at west end of map). Map shows that ranges of males and females overlap with each other. Map created on DeLorme Topo USA 5.0.


53
53
S MABEL LN
SLATTMORE RD
DELORME
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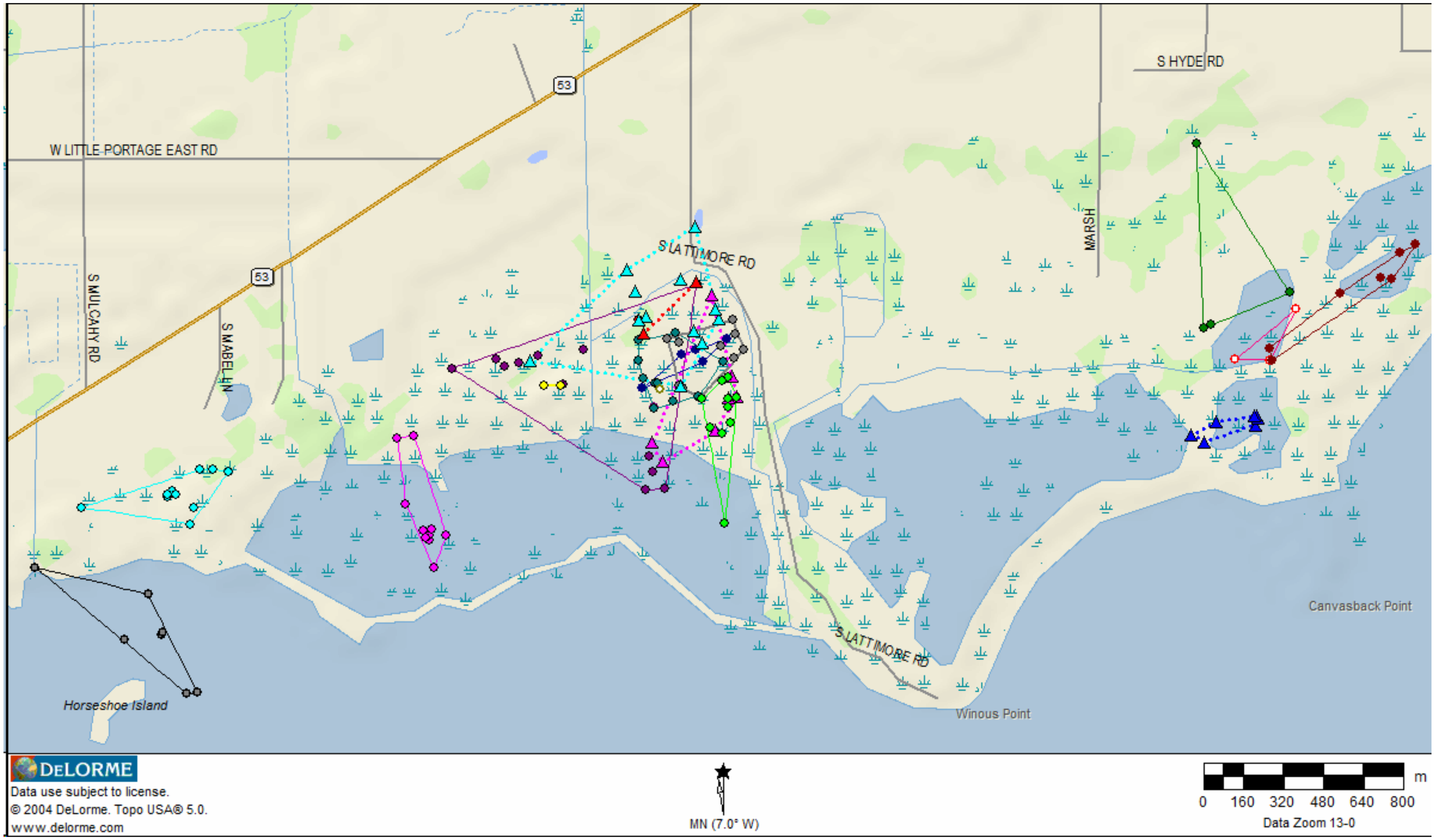
MN (7.0° W)
0 80 160 240 320 400
m
Data Zoom 14-0

Figure 32: The general homerange for 17 individuals observed at some point during the active season (April–September) of 2007. Some individuals are represented by only a very limited number of observations. Males are indicated by circles with solid lines and females are indicated by triangles with dotted lines. Map shows that ranges of males and females overlap with each other. Map created on DeLorme Topo USA 5.0.


W LITTLE PORTAGE EAST RD
53
S MULCAHY RD
S MABEL LN
S LATTIMORE RD
MARSH
S HYDE RD
Horseshoe Island
Winous Point
Canvasback Point
DELORME
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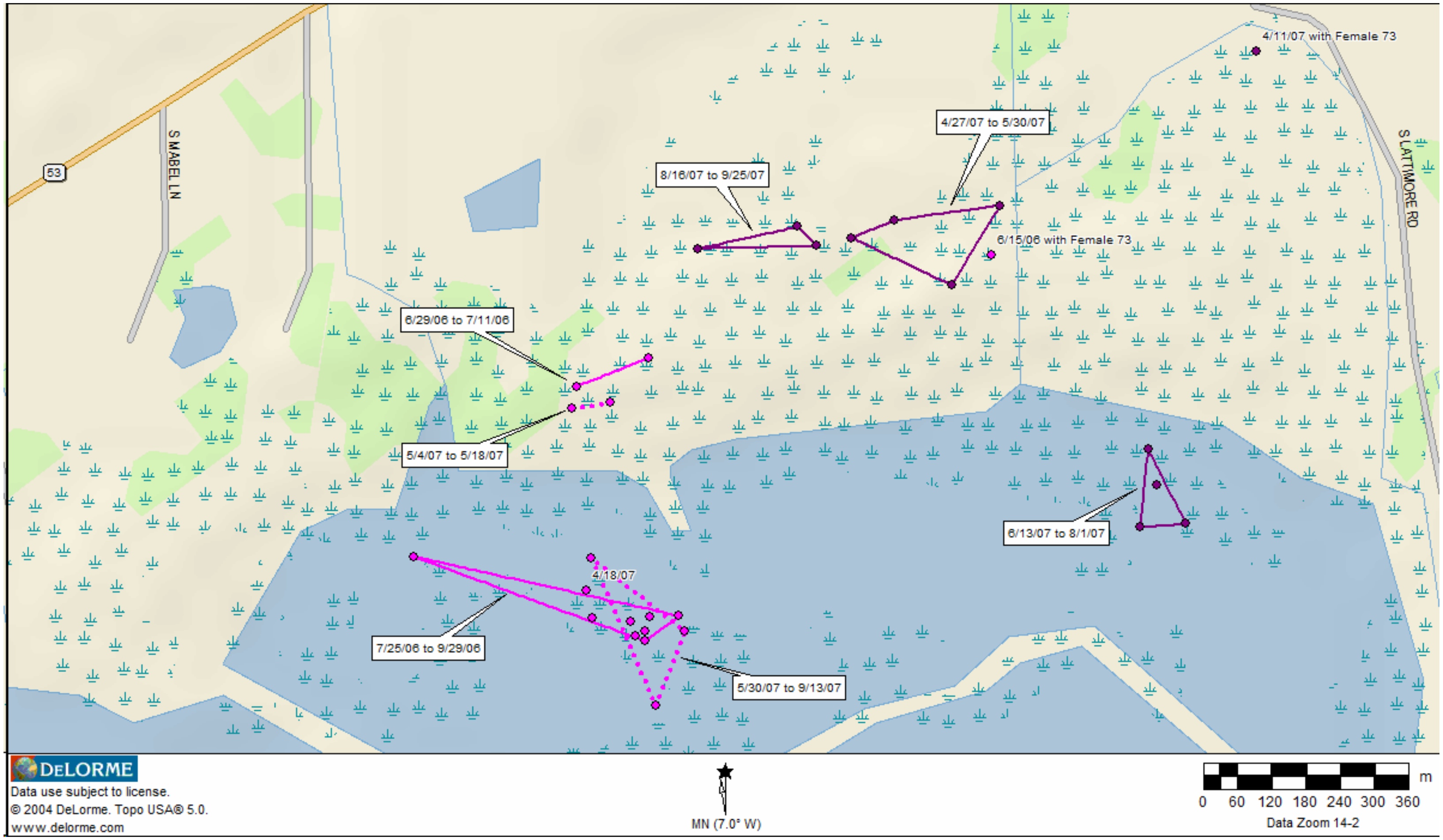
MN (7.0° W)
0 160 320 480 640 800 m
Data Zoom 13-0

Figure 33: Map showing activity centers apparent for Males #114 (pink) and #95 (purple). Male #114 was observed to spend two weeks or more around the months of June–July of 2006 and 2007 at the north end of the marsh and returned to a southern area later in the summer of both years. Male #95 was located at the north end of the marsh for over a month in spring, and then moved south for most of the summer only to return north again to the same general area as fall approached. Both males were briefly located in distant areas of the marsh accompanied with a female (these locations are excluded from delineations of concentrated activity centers). Map created on DeLorme Topo USA 5.0.


53
S MABEL LN
S LATTIMORE RD
4/11/07 with Female 73
4/27/07 to 5/30/07
8/16/07 to 9/25/07
6/15/06 with Female 73
6/29/06 to 7/11/06
5/4/07 to 5/18/07
6/13/07 to 8/1/07
4/18/07
7/25/06 to 9/29/06
5/30/07 to 9/13/07
DELORME
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MN (7.0° W)
m
0 60 120 180 240 300 360
Data Zoom 14-2

Figure 34: Graph of July nest temperatures for Nests 4 and 5 suggesting the effects of vegetation in 2006. On 4 July, corn around Nest 4 was approximately 2.1 meters (7 ft) tall while corn at Nest 5 was under 30 centimeters (1 ft); by 31 July, corn at Nest 4 was about 3.1 meters (10 ft) tall while corn at Nest 5 had reached approximately 1.1 meters (3.5 ft) tall.

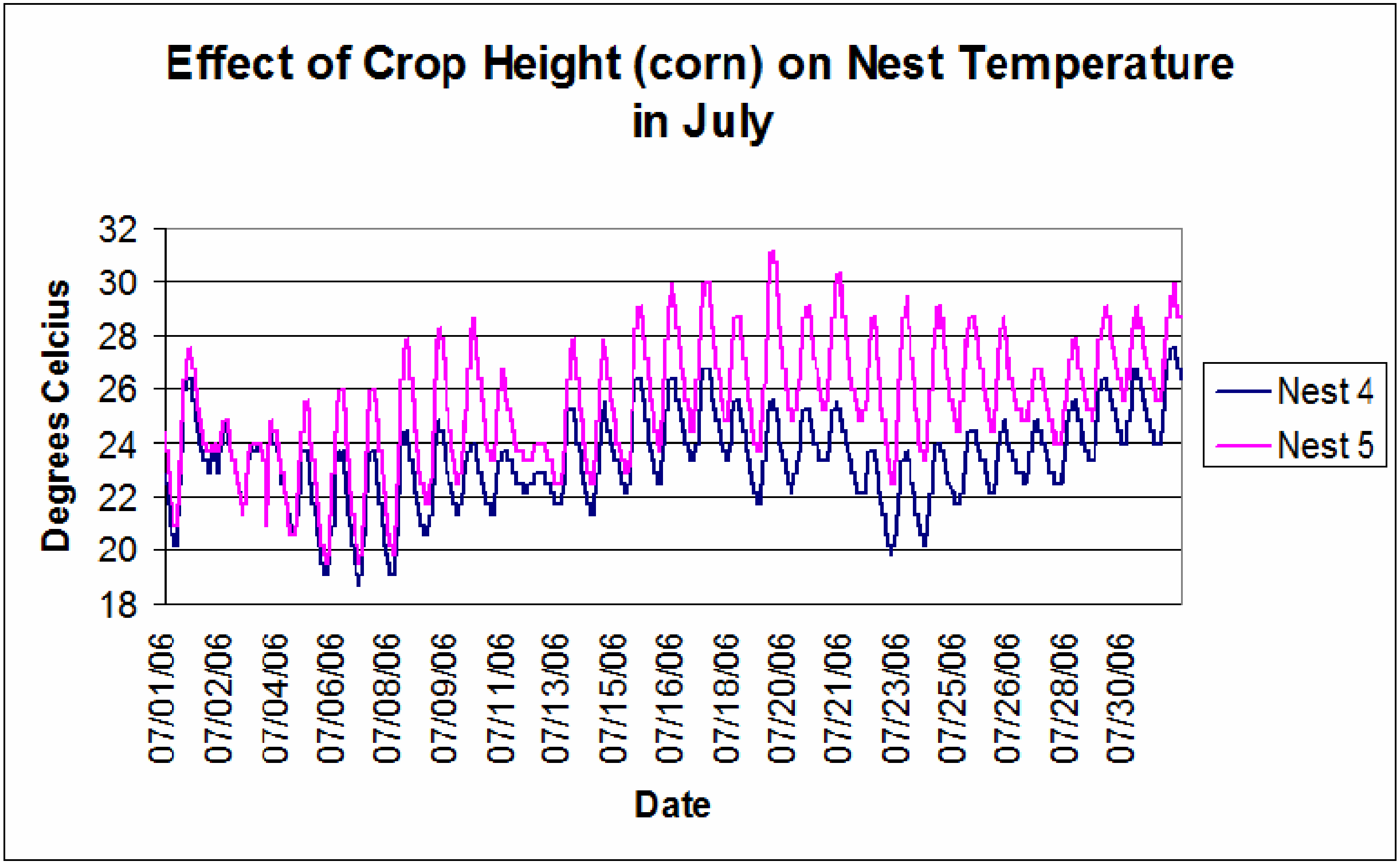
Effect of Crop Height (corn) on Nest Temperature in July
Degrees Celcius
32
30
28
26
24
22
20
18
07/01/06
07/02/06
07/04/06
07/06/06
07/08/06
07/09/06
07/11/06
07/13/06
07/15/06
07/16/06
07/18/06
07/20/06
07/21/06
07/23/06
07/25/06
07/26/06
07/28/06
07/30/06
Date
Nest 4
Nest 5

Figure 35: Graph of July nest temperatures for Nests 6 and 7 suggesting the effects of vegetation in 2007. On 12 July, corn around Nest 6 was approximately 2.4 meters (8 ft) tall while corn around Nest 7 was 1.8 meters (6 ft) tall and noticeably less dense than around Nest 6.

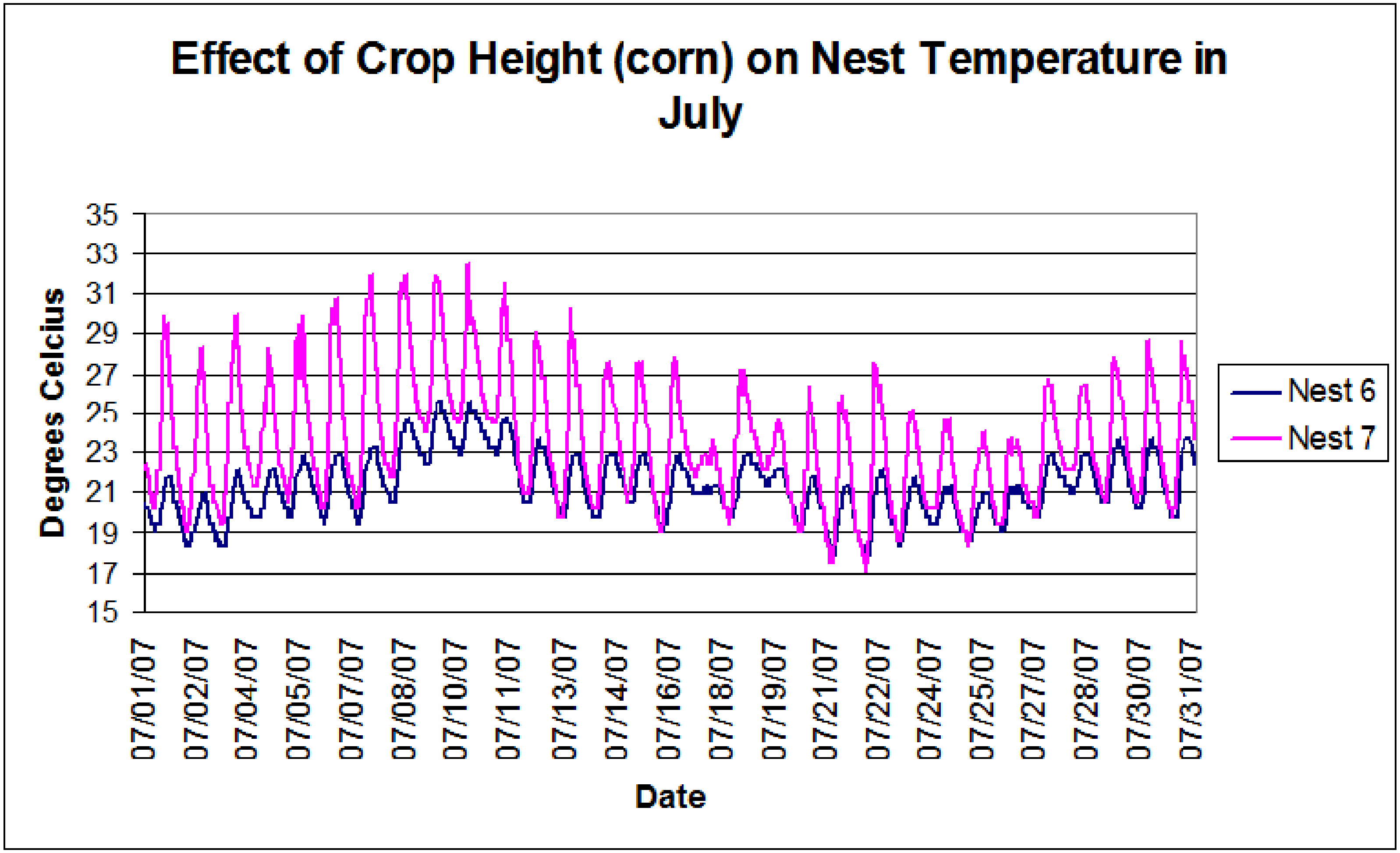
Effect of Crop Height (corn) on Nest Temperature in July
Degrees Celcius
35
33
31
29
27
25
23
21
19
17
15
07/01/07
07/02/07
07/04/07
07/05/07
07/07/07
07/08/07
07/10/07
07/11/07
07/13/07
07/14/07
07/16/07
07/18/07
07/19/07
07/21/07
07/22/07
07/24/07
07/25/07
07/27/07
07/28/07
07/30/07
07/31/07
Date
Nest 6
Nest 7

Figure 36: Map of all known nest sites, attempted nest sites, and mock nest sites for years 2005, 2006, and 2007. Female #73 displayed nest site fidelity, but Females #110 and #111 did not. Map created on DeLorme Topo USA 5.0.


Female #73
Female #111
Female #109
Female #119
Female #77
Female #110
Female #74
Female #94
S HYDE RD
2007 NEST 8
2006 MOCK NEST 5
2005 Nest Attempt
2007 NEST 6
2006 MOCK NEST 4
MARSH
Mackey Woods
S LATTIMORE RD
Gardiner
2007 NEST 7
Stubble Patc
2006 NEST 1
2006 NEST 2
2005 Nest Attempt
2005 Nest Attempt
S MULCAHY RD
S MABEL LN
53
Lattimore
North Lily Pond
Big Channel
Goosepond
2006 NEST 3
Lily Pond
Cooke's Inlet
Darr
Bunker Hill
Browns Pond
Durban's Bay
Kick-a-poo
Canvasback Point
2007 Nest Attempt
S LATTIMORE RD
Horseshoe Island
Winous Point
DELORME
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MN (7.0° W)
ft
0
1000
2000
Data Zoom 13-0

Figure 37: Graph of diel fluctuations in temperature of Nest 2 throughout incubation. The middle third of incubation when Temperature Sex Determination (TSD) is thought to occur is highlighted in red. Graph created by BoxCar Pro 4.3.

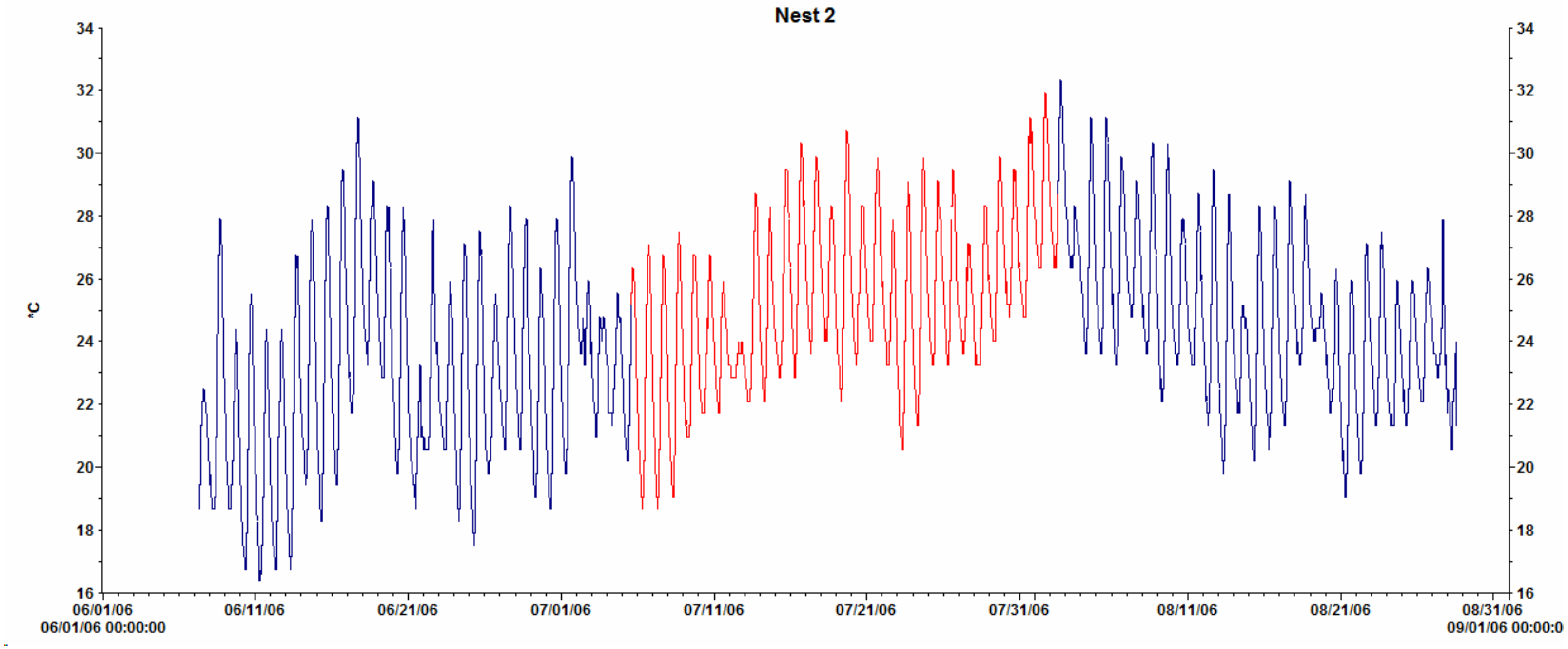
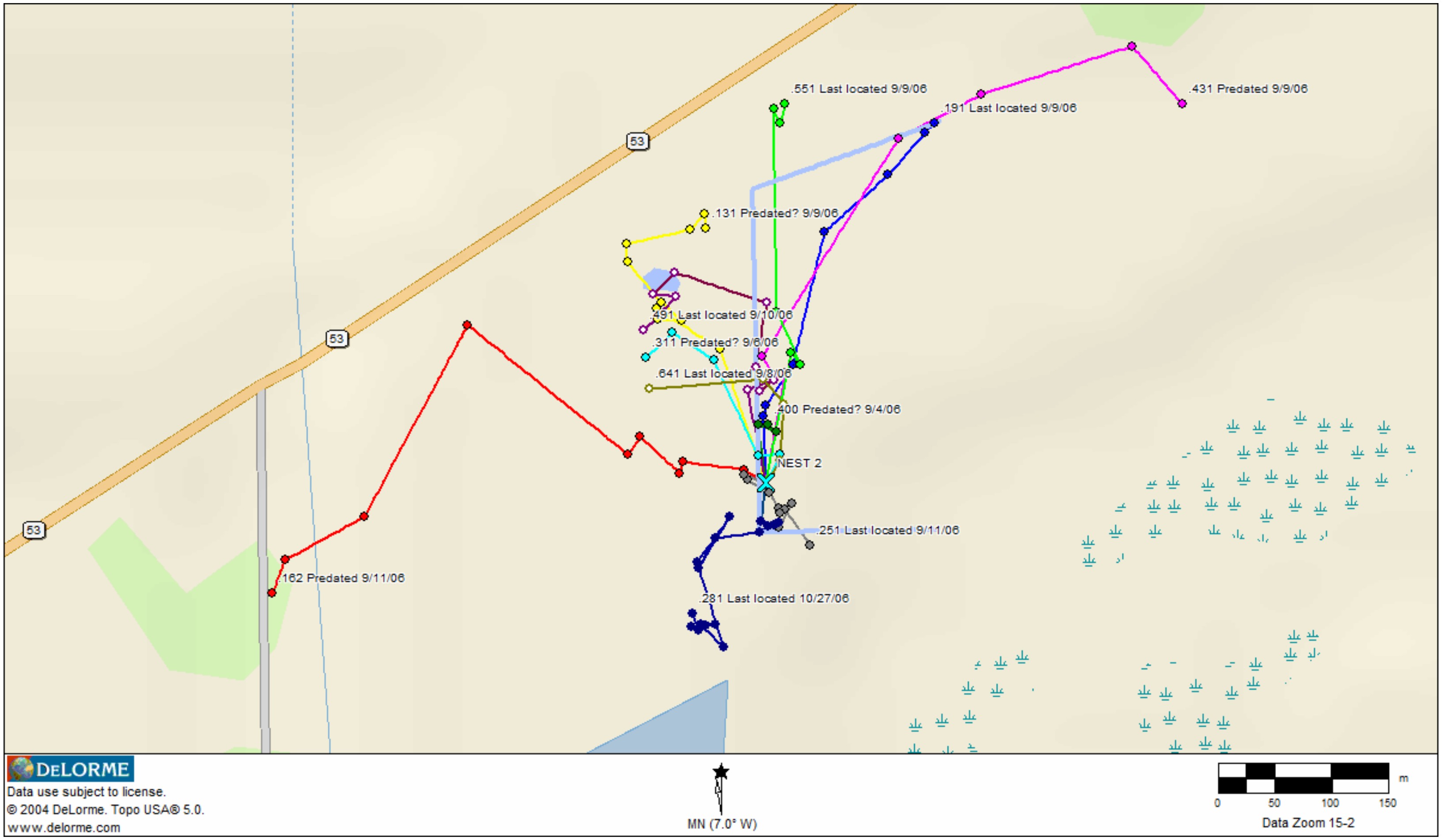

Nest 2
°C
34
32
30
28
26
24
22
20
18
16
06/01/06
06/01/06 00:00:00
06/11/06
06/21/06
07/01/06
07/11/06
07/21/06
07/31/06
08/11/06
08/21/06
08/31/06
09/01/06 00:00:0

Figure 38: Map of all hatchling movements from release at Nest 2 on 28 August, 2006, to last known locations, excluding Hatchling .101 which was never located after its release. Hatchling .431, indicated by pink dots, was found predated by a small mammal and Hatchling .162, indicated by red dots, was swallowed by a bullfrog. Hatchling .281, indicated by dark blue dots (near the bottom of the map), apparently overwintered in the corner of a shallow flooded field and was often found buried in the organic substrate. Map created on DeLorme Topo USA 5.0.


53
53
53
.551 Last located 9/9/06
.431 Predated 9/9/06
.191 Last located 9/9/06
.131 Predated? 9/9/06
.491 Last located 9/10/06
.311 Predated? 9/6/06
.641 Last located 9/8/06
.400 Predated? 9/4/06
NEST 2
.251 Last located 9/11/06
.162 Predated 9/11/06
.281 Last located 10/27/06
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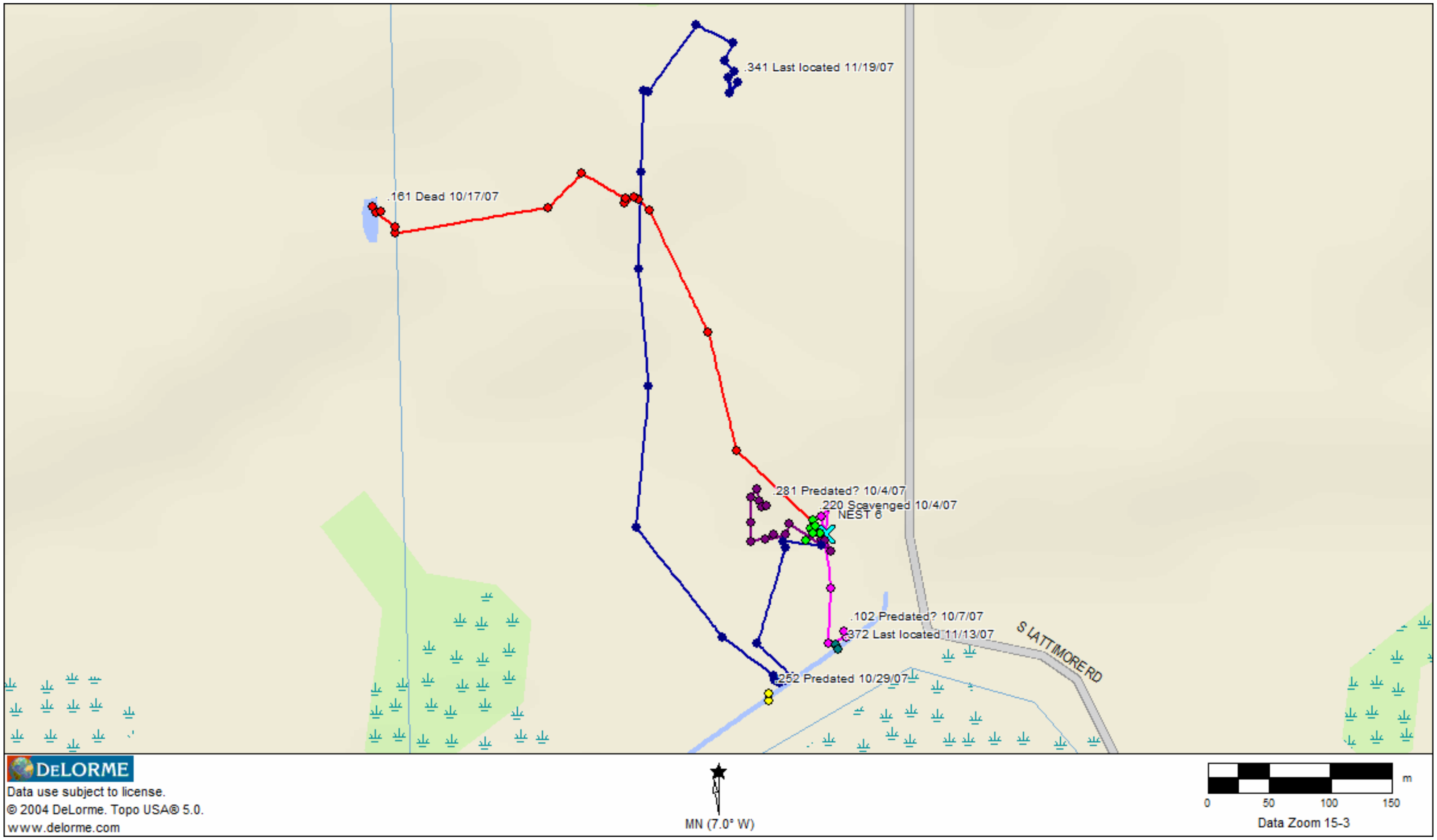
MN (7.0° W)
m
0
50
100
150
Data Zoom 15-2

Figure 39: Map of all hatchling movements from Nest 6 to last known locations. The yellow and dark green dots near the bottom of the map indicate the movements of Hatchlings .252 and .372 which were found when the nest was excavated on 15 October, 2007. The lime green dots near the nest indicate the limited movements of Hatchling .220 which was partially paralyzed in the front left limb and was eventually predated or scavenged. Food items were identified in the digestive tract of Hatchling .161 indicated in red. Hatchling .341, indicated by dark blue, made an extended movement from the ditch at the bottom of the map, back north into the cornfield where it presumably overwintered. Map created on DeLorme Topo USA 5.0.


.341 Last located 11/19/07
.161 Dead 10/17/07
.281 Predated? 10/4/07
.220 Scavenged 10/4/07
NEST 6
.102 Predated? 10/7/07
.372 Last located 11/13/07
.252 Predated 10/29/07
S LATTIMORE RD
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MN (7.0° W)
m
0
50
100
150
Data Zoom 15-3

Table 1: Measurements for 22 individuals included in dietary study. Mean measurements for all individuals and for males versus females.

Measurements for Study Individuals

Notch Code	Sex	Carapace Length (cm)	Plastron Length (cm)	Head/Jaw Width (mm)	Mean Mass (g)
59	M	21.8	20.1	33.6	1603
63	M	21.6	20.8	34.9	1549
72	M	21.2	20.0	35.9	1437
73	F	21.1	20.6	32.7	1548
92	M	23.1	21.2	34.9	1694
95	M	20.3	18.8	32.9	1242
109	F	22.4	21.2	33.1	1640
110	F	22.4	22.2	32.3	1656
111	F	21.6	20.4	31.8	1395
112	M	21.9	20.5	35.5	1565
113	F	20.6	19.7	30.9	1474
114	M	20.9	19.2	34.3	1379
115	F	18.0	17.0	28.6	931
116	M	21.4	19.3	33.0	1418
117	M	20.7	19.1	31.2	1210
118	M	20.6	19.5	33.6	1462
120	M	21.5	20.0	34.0	1508
121	M	22.0	20.2	33.8	1510
122	M	21.8	20.1	32.2	1504
123	M	22.3	20.3	32.0	1469
124	M	23.2	21.0	34.4	1756
119	F	22.2	21.8	31.3	1618
Range		18.0–23.2	17.0–22.2	28.6–35.9	931–1756
Total Mean		21.5	20.1	33.0	1480.4
Males		21.6	20.0	33.7	1487
Females		21.2	20.4	31.5	1466

Table 2: List of 22 individuals included in the dietary study by stomach flushing. An additional 2 female individuals not listed here were found dead on the road, and dissection of their stomachs is included in stomach sample results.

Dietary Study Individuals

Notch Code	Sex	Flushings Attempts	Successful Flushes	Fecal Samples	Date Captured	Capture Method	Remarks
59	M	9	1		5/24/2006	radio telemetry	originally captured in trap on 8/18/04; w/ 110 on 8/23/07, displayed hibernacula site fidelity
63	M	10	7		5/11/2007	by hand w/ 111	originally captured in trap on 8/25/04
72	M	11	5		7/5/2006	Trap #18 w/116	originally captured in trap on 9/24/04
92	M	11	6		4/13/2007	by hand in Lattimore	originally captured in trap on 5/9/05
95	M	10	4		4/13/2007	by hand w/ 73	originally captured in trap on 5/31/05
112	M	9	2	1	6/7/2006	Trap #16 w/ 111	potentially in pursuit of female 111
114	M	17	5		6/15/2006	by hand w/ 73	potentially mating w/ 73 when captured
116	M	6	1	1	7/5/2006	Trap #18 w/ 72	
117	M	15	5		7/6/2006	Trap # 9	
118	M	10	3		5/11/2007	by hand in Lattimore	
120	M	6	1		6/22/2007	trapped by WPM staff	captured w/ male 121
121	M	1	0	1	6/22/2007	trapped by WPM staff	in muskrat burrow under dike 7/18–8/1 (aestivating)
122	M	6	2	1	6/25/2007	by hand on dike	resident of Horseshoe Marsh (was open bay till 1990's); crooked jaw (old injury)
123	M	4	2		6/26/2007	by hand on tussock	located on land 7/26–8/28 (aestivating)
124	M	1	1		8/23/2007	by hand in Lattimore	not equipped with radio transmitter
73	F	11	4	3	5/31/2006	by hand on dike	originally captured by hand on 10/28/2004 (w/ a male); displayed nest site fidelity
109	F	6	3	1	5/31/2006	Trap # 7	nested in 2006 (in pile of burned automobile tires)
110	F	12	4		6/2/2006	by hand on dike	successfully nested in 2006 and 2007
111	F	14	6		6/7/2006	Trap #16 w/ 112	nested in 2006 (morning) and 2007 (evening)
113	F	1	0		6/14/2006	Trap #17	radio signal never picked up after release
115	F	5	1		6/20/2006	Trap # 7	small, heavily scarred individual; shell found 10/4/07 (died of uncertain causes)
119	F	7	2		6/8/2007	by hand while nesting	growth rings indicate this to be the youngest individual at ~12 years

Table 3: Analysis of contents in stomach samples (N = 67) collected from 22 individual *Emydoidea blandingii* (including 2 D.O.R. females) with the top six dietary groups (by IRI) highlighted. %N = percent of total items, %V = percent of total volume, %F = frequency of occurrence, and IRI = index of relative importance. Calculations are based on the pooling of stomach samples collected in 2006 (n = 20) and 2007 (n = 47).

Food Items		%N	%V	%F	IRI
GASTROPODA		**82.0**	**75.6**	**67.2**	**10582.7**
	Lymnaeidae (*Stagnicola elodes*)	69.1	71.8	59.7	8415.5
	Planorbidae	3.6	2.7	10.5	65.1
	Viviparidae	0.3	0.1	1.5	0.6
	Physidae	9.0	1.0	1.5	14.9
INSECTA		**7.3**	**7.8**	**37.3**	**561.3**
	Anisoptera	1.7	3.7	13.4	71.8
	Dytiscidae	0.2	1.1	4.5	5.9
	Hydrophilidae	0.7	0.6	6.0	7.7
	Belostomatidae	0.8	1.2	9.0	18.2
	Naucoridae	0.7	0.6	9.0	11.9
	Nepidae	0.1	0.1	1.5	0.3
	Notonectidae	0.1	0.0	1.5	0.2
	Corixidae	0.2	0.0	1.5	0.3
	Chironomidae	2.2	0.3	7.5	18.9
	Stratiomyidae	0.3	0.2	4.5	2.2
	Syrphidae	0.1	0.1	1.5	0.3
HIRUDINAE	Hirudinidae	**2.6**	**4.2**	**16.4**	**111.6**
CRUSTACEA	Decapoda (*Procambarus sp.*)	**0.6**	**6.3**	**6.0**	**41.5**
	Cladocera	0.1	0.0	1.5	0.2
	Amphipoda	1.8	0.1	6.0	11.2
VERTEBRATA	Fish	**1.3**	**3.3**	**10.5**	**47.6**
	Anuran	0.2	0.5	3.0	2.0
	Avian	0.1	0.3	1.5	0.6
PLANT MATTER		**3.3**	**1.4**	**37.3**	**174.8**
Unknown Egg Mass		0.3	0.4	4.5	3.3
Unidentified Matter		0.4	0.2	7.5	4.9

Table 4: Seasonal variation in the diet of 22 individual *Emydoidea blandingii* according to index of relative importance (IRI) with the top six dietary groups highlighted. Due to small sample sizes, calculations are based on pooling of stomach samples from 2006 and 2007: May (n = 13), June (n = 16), July (n = 22), and August (n = 14).

Food Items		May IRI	June IRI	July IRI	August IRI
GASTROPODA		**12244.0**	**5527.8**	**12512.7**	**11266.7**
	Lymnaeidae (*Stagnicola elodes*)	12088.9	1160.1	10762.9	11266.7
	Planorbidae	0.0	432.8	110.6	0.0
	Viviparidae	0.0	0.0	6.7	0.0
	Physidae	0.0	316.4	0.0	0.0
INSECTA		**91.9**	**871.1**	**1272.5**	**353.0**
	Anisoptera	23.4	75.4	137.3	78.2
	Dytiscidae	0.0	0.0	58.8	0.0
	Hydrophilidae	3.8	45.1	6.3	0.0
	Belostomatidae	0.0	0.0	189.8	0.0
	Naucoridae	23.1	0.0	2.5	52.6
	Nepidae	0.0	0.0	0.0	13.1
	Notonectidae	0.0	3.3	0.0	0.0
	Corixidae	0.0	6.6	0.0	0.0
	Chironomidae	0.0	203.5	12.1	0.0
	Stratiomyidae	0.0	3.3	12.5	0.0
	Syrphidae	0.0	0.0	3.1	0.0
HIRUDINAE	Hirudinidae	**667.3**	**8.2**	**3.1**	**170.6**
CRUSTACEA	Decapoda (*Procambarus sp.*)	**0.0**	**659.4**	**5.8**	**0.0**
	Cladocera	1.8	0.0	0.0	0.0
	Amphipoda	27.4	13.3	1.8	0.0
VERTEBRATA	Fish	**3.8**	**62.5**	**142.9**	**17.4**
	Anuran	0.0	0.0	20.5	0.0
	Avian	0.0	0.0	5.8	0.0
PLANT MATTER		**125.5**	**333.4**	**116.4**	**264.0**
Unknown Egg Mass		2.8	9.5	4.5	0.0
Unidentified Matter		0.0	6.4	0.0	43.9

Table 5: Shannon's Index of diversity (H) and evenness (E_H) for stomach (pooling stomach samples collected in 2006 and 2007) and dip net items (collected 2006 only) over the peak months of feeding activity. Also, overall stomach samples from April–September (N = 67), and male (n = 45) versus female (n = 22) stomach samples are compared. Years were pooled due to small sample sizes for months per year (2006: May n = 0; June n = 3; July n = 11; August n = 5) (2007: May n = 13; June n = 13; July n = 11; August n = 9). Comparison of diversity and evenness between 2006 and 2007 are shown for peak months of feeding activity and overall. Only dip net items ≥1 cm are included in these analyses.

Samples		**May**	**June**	**July**	**August**	**Overall**	**Males**	**Females**
Stomach	H	0.58	1.76	1.33	1.04	1.38	1.33	1.11
	E_H	0.24	0.63	0.45	0.50	0.43	0.42	0.42
Dip Net	H	1.63	2.44	2.03	1.58	2.25		
	E_H	0.59	0.75	0.70	0.55	0.63		
Stomach 2006	H		0.25	0.46	0.48	0.51		
	E_H		0.37	0.21	0.35	0.20		
Stomach 2007	H	0.58	1.64	1.86	1.27	1.53		
	E_H	0.24	0.59	0.67	0.65	0.49		

Table 6: A comparison of the diets gleaned from male (n = 45) versus female (n = 22) stomach samples. The top six dietary groups are highlighted. Results derived from 22 individual *Emydoidea blandingii* (14 males and 8 females).

Food Items		**% N**		**% V**		**% F**		**IRI**	
		Males	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
GASTROPODA		**81.8**	**82.6**	**77.2**	**72.2**	**66.7**	**68.2**	**10600.5**	**10554.3**
	Lymnaeidae (*Stagnicola elodes*)	67.9	73.0	74.2	66.9	60.0	59.1	8526.6	8266.1
	Planorbidae	1.7	9.6	1.4	5.3	11.1	9.1	33.7	135.5
	Viviparidae	0.4	0.0	0.1	0.0	2.2	0.0	1.2	0.0
	Physidae	11.8	0.0	1.5	0.0	2.2	0.0	29.5	0.0
INSECTA		**8.8**	**2.6**	**9.9**	**3.4**	**44.4**	**22.7**	**829.3**	**135.9**
	Anisoptera	2.1	0.4	5.3	0.3	17.8	4.6	131.2	3.2
	Dytiscidae	0.3	0.0	1.6	0.0	4.4	4.6	8.5	0.0
	Hydrophilidae	0.8	0.4	0.7	0.3	8.9	0.0	13.4	0.0
	Belostomatidae	0.7	1.3	0.5	2.5	6.7	13.6	8.3	52.2
	Naucoridae	0.8	0.4	0.8	0.3	11.1	4.6	17.6	3.2
	Nepidae	0.1	0.0	0.1	0.0	2.2	0.0	0.6	0.0
	Notonectidae	0.1	0.0	0.0	0.0	2.2	0.0	0.3	0.0
	Corixidae	0.3	0.0	0.0	0.0	2.2	0.0	0.6	0.0
	Chironomidae	2.9	0.0	0.5	0.0	11.1	0.0	37.7	0.0
	Stratiomyidae	0.4	0.0	0.3	0.0	6.7	0.0	4.6	0.0
	Syrphidae	0.1	0.0	0.1	0.0	2.2	0.0	0.6	0.0
HIRUDINAE	Hirudinidae	**3.2**	**0.9**	**5.9**	**0.6**	**20.0**	**9.1**	**182.0**	**13.0**
CRUSTACEA	Decapoda (*Procambarus sp.*)	**0.3**	**1.7**	**1.4**	**16.6**	**2.2**	**13.6**	**3.6**	**249.7**
	Cladocera	0.0	0.4	0.0	0.0	0.0	4.6	0.0	2.0
	Amphipoda	0.4	6.1	0.0	0.3	6.7	4.6	2.8	29.0
VERTEBRATA	Fish	**1.0**	**2.2**	**2.6**	**4.8**	**13.3**	**4.6**	**47.3**	**31.6**
	Anuran	0.1	0.4	0.1	1.1	2.2	4.6	0.6	7.1
	Avian	0.1	0.0	0.4	0.0	2.2	0.0	1.2	0.0
PLANT MATTER		**3.5**	**2.6**	**1.8**	**0.6**	**44.4**	**22.7**	**236.0**	**72.1**
Unknown Egg Mass		0.3	0.4	0.3	0.6	4.4	4.6	2.8	4.5
Unidentified Matter		0.6	0.0	0.3	0.0	11.1	0.0	10.0	0.0

Table 7: The diversity and evenness in the diets of 14 males are compared and the index of relative importance (IRI) is provided for the top five dietary items. Measures highlighted represent the most important dietary item for each individual. Physid snail was the most important food item in the diet of Male #95, but was present in just one stomach sample (in large numbers). The most important food item in the diet of Male #117 was plant matter, but this is largely based on its conspicuous presence in a single stomach sample. Individuals represented by less than two stomach samples are of limited interest in this analysis.

	Male Individuals													
	59	**63**	**72**	**92**	**95**	**112**	**114**	**116**	**117**	**118**	**120**	**122**	**123**	**124**
Diversity (H)	0.33	1.29	0.70	0.45	0.93	0.41	1.91	0.00	1.66	0.48	1.98	1.04	1.63	0.95
Evenness (E_H)	0.47	0.56	0.36	0.20	0.40	0.59	0.92	NA	0.85	0.44	0.95	0.95	0.91	0.86
IRI for *Stagnicola elodes*	**15667.0**	**11097.4**	**12732.0**	**11921.3**	190.0	**18571.0**	1696.4	**20000.0**	1584.0	**18521.0**	833.0	0.0	**4230.5**	**13692.0**
IRI for Insecta	0.0	2294.3	619.2	431.3	2394.0	0.0	**3267.6**	0.0	526.4	0.0	**8453.0**	3333.5	1346.0	3538.0
IRI for Hirudinidae	0.0	187.1	891.6	661.0	0.0	0.0	0.0	0.0	295.6	0.0	4047.0	2083.5	0.0	0.0
IRI for Decapoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2692.0	0.0
IRI for Fish	0.0	52.3	0.0	0.0	106.5	0.0	455.4	0.0	0.0	0.0	6667.0	**4583.5**	577.0	0.0
Number of Stomach Samples	1	7	5	5	4	2	5	1	5	3	1	2	2	1

Table 8: The diversity and evenness in the diets of eight females are compared and the index of relative importance (IRI) is provided for the top five dietary items. Measures highlighted represent the most important dietary item for each individual. The dissected stomach samples from two individuals found dead on the road (D.O.R.) are included, but consisted solely of *Procambarus* crayfish remains. Individuals represented by less than two stomach samples are of limited interest in this analysis.

	Female Individuals							
	D.O.R	**D.O.R.**	**73**	**109**	**110**	**111**	**115**	**119**
Diversity (H)	0.00	0.00	0.64	0.33	0.90	0.77	0.00	1.35
Evenness (E_H)	NA	NA	0.58	0.30	0.46	0.43	NA	0.84
IRI for *Stagnicola elodes*	0.0	0.0	**8473.5**	**12546.0**	**11537.3**	**10239.3**	**20000.0**	2592.5
IRI for Insecta	0.0	0.0	381.5	0.0	741.0	81.8	0.0	601.5
IRI for Hirudinidae	0.0	0.0	381.5	0.0	85.3	0.0	0.0	0.0
IRI for Decapoda	**20000.0**	**20000.0**	0.0	0.0	0.0	0.0	0.0	972.0
IRI for Fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**5231.5**
Number of Stomach Samples	1	1	4	3	4	6	1	2

Table 9: Dietary results for stomach samples (N = 65) based on wetland class microhabitat individuals were found in. Results exclude stomach contents for two individuals found dead on the road (D.O.R.). The top six dietary groups are highlighted. Calculations based PEM n = 50, PAB n = 9, PUB n = 2, and PFO n = 4.

	Food Items	PEM IRI	PAB IRI	PUB IRI	PFO IRI
GASTROPODA		**12313.4**	**9072.5**	**1666.5**	**5105.5**
	Lymnaeidae (*Stagnicola elodes*)	10808.8	3881.8	1666.5	5105.5
	Planorbidae	86.9	50.4	0.0	0.0
	Viviparidae	0.0	20.8	0.0	0.0
	Physidae	0.0	470.1	0.0	0.0
INSECTA		**486.0**	**448.0**	**6666.5**	**4158.0**
	Anisoptera	72.8	55.3	2083.5	0.0
	Dytiscidae	0.0	31.9	4583.5	0.0
	Hydrophilidae	3.2	55.3	0.0	0.0
	Belostomatidae	10.0	32.2	0.0	513.3
	Naucoridae	15.2	0.0	0.0	0.0
	Nepidae	0.5	0.0	0.0	0.0
	Notonectidae	0.0	4.7	0.0	0.0
	Corixidae	0.0	9.3	0.0	0.0
	Chironomidae	19.8	0.0	0.0	658.0
	Stratiomyidae	4.1	0.0	0.0	0.0
	Syrphidae	0.5	0.0	0.0	0.0
HIRUDINAE	Hirudinidae	**115.8**	**159.9**	**0.0**	**0.0**
CRUSTACEA	Decapoda (*Procambarus sp.*)	**3.0**	**25.1**	**0.0**	**0.0**
	Cladocera	0.3	0.0	0.0	0.0
	Amphipoda	2.6	71.9	0.0	0.0
VERTEBRATA	Fish	**9.8**	**392.2**	**1666.5**	**214.8**
	Anuran	0.5	31.9	0.0	0.0
	Avian	1.0	0.0	0.0	0.0
PLANT MATTER		**141.7**	**230.6**	**0.0**	**1693.0**
Unknown Egg Mass		1.2	36.7	0.0	0.0
Unidentified Matter		8.8	0.0	0.0	0.0

Table 10: Shannon's Index of diversity (H) and evenness (E_H) for stomach contents and dip net items ≥1 cm across different habitat types and wetland classes. Stomach content results exclude two stomach samples for females found dead on the road (D.O.R.), and calculations are based on N = 65 (PEM n = 50, PAB n = 9, PUB n = 2, PFO n = 4). Calculations for dip net results are based on N = 72 (PEM n = 24, PAB n = 20, PUB n = 20, PFO n = 8).

Samples		PEM	PAB	PUB	PFO
Stomach	H	0.92	1.75	1.39	1.50
	E_H	0.31	0.58	1.00	0.84
Dip Net	H	2.18	1.72	1.72	2.14
	E_H	0.66	0.58	0.59	0.79

		Shallow Marsh	Intermediate Marsh	Deep Marsh	Trench	Canal	Wet Woods
Dip Net	H	2.20	1.34	1.17	1.87	1.04	1.30
	E_H	0.69	0.52	0.53	0.66	0.54	0.79

Table 11: Percentage of total items and frequency of occurrence for items in dip net samples (N = 72). Items highlighted are those of greatest interest for comparison to stomach samples, and also those believed to be more accurately estimated by dip net sampling.

Items found in Dip Net		**Items ≥1cm**		**Items <1cm**	
		% N	**% F**	**% N**	**% F**
GASTROPODA		**18.2**	**38.9**	**13.8**	**83.3**
	Lymnaeidae (*Stagnicola elodes*)	**13.3**	**22.2**	**0.4**	**9.3**
	Planorbidae	2.7	15.3	8.1	64.8
	Viviparidae	0.4	4.2	0.0	1.9
	Physidae	1.8	11.1	4.5	74.1
INSECTA		**71.9**	**86.1**	**39.9**	**96.3**
***INSECTA** (excluding non-food items)		**20.0**	**54.2**	**15.4**	**92.6**
	Anisoptera	2.3	13.9	0.6	31.5
	Dytiscidae	0.1	1.4	0.3	27.8
	Hydrophilidae	0.4	4.2	0.1	9.3
	Belostomatidae	0.5	5.6	0.0	3.7
	Naucoridae	5.9	23.6	0.2	13.0
	Nepidae	0.3	2.8	0.0	1.9
	Notonectidae	2.3	18.1	0.1	11.1
	Corixidae	2.7	6.9	4.5	18.5
	Chironomidae	1.7	4.2	9.6	88.9
	Stratiomyidae	3.6	15.3	0.1	11.1
	Syrphidae	0.3	1.4	0.0	0.0
	*Zygoptera (not observed in diet)	43.6	70.8	2.6	68.5
	*Caenidae (not observed in diet)	0.0	0.0	18.3	87.0
HIRUDINAE	Hirudinidae	1.0	9.7	0.3	31.5
CRUSTACEA	Cladocera	0.0	0.0	21.9	61.1
	Amphipoda	0.0	0.0	14.8	81.5
VERTEBRATA	Fish	2.3	9.7	0.0	0.0
	Anuran	1.5	5.6	0.0	0.0
Unknown Egg Mass		0.5	5.6	0.4	27.8

Table 12: Percentage of total items and frequency of occurrence for items in dip net samples (N = 72) by month (n = 18) for items ≥1 cm. Items highlighted are those of greatest interest for comparison to stomach samples, and also those believed to be more accurately estimated by dip net sampling.

		% N				**% F**			
Food Items ≥1cm in Dip Net		**May**	**June**	**July**	**August**	**May**	**June**	**July**	**August**
GASTROPODA		**14.7**	**27.6**	**21.0**	**7.7**	**16.7**	**50.0**	**50.0**	**38.9**
	Lymnaeidae (*Stagnicola elodes*)	**10.1**	**20.7**	**17.1**	**3.9**	**11.1**	**22.2**	**38.9**	**16.7**
	Planorbidae	0.0	3.3	3.4	3.0	0.0	22.2	16.7	22.2
	Viviparidae	0.0	0.4	0.5	0.4	0.0	5.6	5.6	5.6
	Physidae	4.7	3.3	0.0	0.4	16.7	22.2	0.0	5.6
INSECTA		**79.8**	**58.5**	**62.4**	**89.7**	**77.8**	**83.3**	**88.9**	**94.4**
***INSECTA** (excluding non-food items)		**20.9**	**25.2**	**16.1**	**17.5**	**38.9**	**55.6**	**44.4**	**77.8**
	Anisoptera	0.8	4.1	0.0	3.4	5.6	22.2	0.0	27.8
	Dytiscidae	0.0	0.4	0.0	0.0	0.0	5.6	0.0	0.0
	Hydrophilidae	0.0	0.4	1.0	0.0	0.0	5.6	11.1	0.0
	Belostomatidae	0.0	0.0	0.0	1.7	0.0	0.0	0.0	22.2
	Naucoridae	2.3	0.8	10.2	9.4	11.1	5.6	27.8	50.0
	Nepidae	0.0	0.0	0.5	0.4	0.0	0.0	5.6	5.6
	Notonectidae	3.1	4.1	2.0	0.4	16.7	33.3	16.7	5.6
	Corixidae	0.8	6.5	0.0	2.1	5.6	5.6	0.0	16.7
	Chironomidae	10.9	0.0	0.0	0.0	16.7	0.0	0.0	0.0
	Stratiomyidae	3.1	8.9	1.5	0.0	16.7	38.9	5.6	0.0
	Syrphidae	0.0	0.0	1.0	0.0	0.0	0.0	5.6	0.0
	*Zygoptera (not observed in diet)	57.4	27.6	36.1	59.4	77.8	55.6	77.8	72.2
HIRUDINAE	Hirudinidae	1.6	1.2	0.5	0.9	5.6	16.7	5.6	11.1
CRUSTACEA	Amphipoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VERTEBRATA	Fish	0.8	5.7	2.0	0.0	5.6	22.2	11.1	0.0
	Anuran	0.0	4.1	2.0	0.9	0.0	5.6	5.6	11.1
Unknown Egg Mass		0.0	1.2	0.0	0.4	0.0	16.7	0.0	5.6

Figure 13: Dip net results for microhabitat type at hoop-net trap sites (N = 72; n = 12). Shallow marsh produced the greatest number of items at 34%; followed by deep marsh-channel (20%), deep marsh (15%), intermediate marsh (13%), wet woods (13%), and canal (5%). Items highlighted are those of greatest interest for comparison to stomach samples, and also those believed to be more accurately estimated by dip net sampling.

Food Items ≥1cm in Dip Net		**% N**						**% F**					
		Shallow Marsh	Interm. Marsh	Deep Marsh	Wet Woods	Deep Marsh-Channel	Canal	Shallow Marsh	Interm. Marsh	Deep Marsh	Wet Woods	Deep Marsh-Channel	Canal
GASTROPODA		**26.3**	**0.0**	**3.4**	**22.3**	**29.1**	**2.3**	**66.7**	**0.0**	**33.3**	**58.3**	**66.7**	**8.3**
	Lymnaeidae (*Stagnicola elodes*)	**19.0**	**0.0**	**0.0**	**20.4**	**21.2**	**0.0**	**41.7**	**0.0**	**0.0**	**41.7**	**50.0**	**0.0**
	Planorbidae	3.7	0.0	2.5	0.0	5.5	0.0	25.0	0.0	25.0	0.0	41.7	0.0
	Viviparidae	0.4	0.0	0.8	0.0	0.0	2.3	8.3	0.0	8.3	0.0	0.0	8.3
	Physidae	3.3	0.0	0.0	1.9	2.4	0.0	25.0	0.0	0.0	16.7	25.0	0.0
INSECTA		**69.7**	**80.7**	**89.9**	**49.5**	**68.5**	**79.6**	**91.7**	**91.7**	**91.7**	**91.7**	**83.3**	**66.7**
***INSECTA** (excluding non-food items)		**21.2**	**8.3**	**20.2**	**27.2**	**25.5**	**4.6**	**83.3**	**50.0**	**58.3**	**58.3**	**75.0**	**25.0**
	Anisoptera	0.0	0.9	7.6	1.9	4.2	0.0	0.0	8.3	66.7	8.3	33.3	0.0
	Dytiscidae	0.4	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0
	Hydrophilidae	0.4	0.0	0.0	1.0	0.6	0.0	8.3	0.0	0.0	8.3	8.3	0.0
	Belostomatidae	0.7	0.9	0.0	0.0	0.6	0.0	16.7	8.3	0.0	0.0	8.3	0.0
	Naucoridae	1.8	0.9	8.4	10.7	12.7	0.0	25.0	8.3	66.7	16.7	58.3	0.0
	Nepidae	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	16.7	0.0
	Notonectidae	1.8	4.6	3.4	1.0	1.2	4.6	25.0	16.7	50.0	8.3	16.7	33.3
	Corixidae	7.3	0.0	0.8	0.0	0.6	0.0	25.0	0.0	16.7	0.0	8.3	0.0
	Chironomidae	2.6	0.0	0.0	6.8	0.0	0.0	8.3	0.0	0.0	16.7	0.0	0.0
	Stratiomyidae	5.5	0.9	0.0	5.8	4.2	0.0	33.3	8.3	0.0	16.7	33.3	0.0
	Syrphidae	0.7	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0
	*Zygoptera (not observed in diet)	31.8	67.9	68.9	11.7	41.2	72.7	58.3	83.3	83.3	58.3	75.0	66.7
HIRUDINAE	Hirudinidae	1.1	1.8	0.0	1.0	1.2	0.0	25.0	16.7	0.0	8.3	8.3	0.0
CRUSTACEA	Amphipoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VERTEBRATA	Fish	0.4	7.3	6.7	0.0	0.0	4.6	8.3	25.0	16.7	0.0	0.0	8.3
	Anuran	0.4	9.2	0.0	0.0	0.6	9.1	8.3	8.3	0.0	0.0	8.3	8.3
Unknown Egg Mass		0.0	0.0	0.0	2.9	0.6	0.0	0.0	0.0	0.0	25.0	8.3	0.0

Table 14: Percentage of total items and frequency of occurrence for items in dip net samples ≥1 cm for each Cowardin wetland class sampled from. Calculations based on N = 72 (PEM n = 24, PAB n = 20, PUB n = 20, PFO n = 8). Items highlighted are those of greatest interest for comparison to stomach samples, and also those believed to be more accurately estimated by dip net sampling.

Food Items ≥1cm in Dip Net		% N				% F			
		PEM	**PAB**	**PUB**	**PFO**	**PEM**	**PAB**	**PUB**	**PFO**
GASTROPODA		**18.8**	**13.2**	**19.8**	**22.8**	**33.3**	**55.0**	**20.0**	**62.5**
	Lymnaeidae *(Stagnicola elodes)*	**13.6**	**7.1**	**14.7**	**21.7**	**20.8**	**20.0**	**15.0**	**50.0**
	Planorbidae	2.6	4.4	2.6	0.0	12.5	30.0	10.0	0.0
	Viviparidae	0.3	0.6	0.6	0.0	4.2	5.0	5.0	0.0
	Physidae	2.4	1.1	1.9	1.1	12.5	10.0	10.0	12.5
INSECTA		**72.9**	**85.2**	**68.8**	**46.7**	**91.7**	**90.0**	**70.0**	**100.0**
***INSECTA** (excluding non-food items)		**17.5**	**28.0**	**11.5**	**29.4**	**62.5**	**60.0**	**30.0**	**75.0**
	Anisoptera	0.3	7.1	1.9	2.2	4.2	30.0	10.0	12.5
	Dytiscidae	0.3	0.0	0.0	0.0	4.2	0.0	0.0	0.0
	Hydrophilidae	0.3	1.1	0.0	0.0	4.2	10.0	0.0	0.0
	Belostomatidae	0.8	0.6	0.0	0.0	12.5	5.0	0.0	0.0
	Naucoridae	1.6	15.4	1.9	12.0	16.7	45.0	10.0	25.0
	Nepidae	0.0	1.1	0.0	0.0	0.0	10.0	0.0	0.0
	Notonectidae	2.6	2.2	2.6	1.1	20.8	15.0	20.0	12.5
	Corixidae	5.2	0.6	0.6	0.0	12.5	5.0	5.0	0.0
	Chironomidae	1.8	0.0	0.0	7.6	4.2	0.0	0.0	25.0
	Stratiomyidae	4.2	0.0	4.5	6.5	20.8	0.0	20.0	25.0
	Syrphidae	0.5	0.0	0.0	0.0	4.2	0.0	0.0	0.0
	*Zygoptera (not observed in diet)	42.0	53.3	56.1	9.8	70.8	75.0	70.0	62.5
HIRUDINAE	Hirudinidae	1.3	0.0	1.3	1.1	20.8	0.0	5.0	12.5
CRUSTACEA	Amphipoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VERTEBRATA	Fish	2.4	0.6	5.7	0.0	16.7	5.0	10.0	0.0
	Anuran	2.9	0.6	2.6	0.0	8.3	5.0	5.0	0.0
Unknown Egg Mass		0.0	0.6	0.6	2.2	0.0	5.0	5.0	25.0

Table 15: The number of items ≥1 cm identified in dip net samples from each wetland class and the mean number of items found in each sample. ANOVA was unable to detect a significant difference between any of the means for the number of items found in each wetland class (p = 0.164).

Distribution of Dip Net Items

Wetland Class	Dip net samples	Total Number of Items	Mean Number of Items Per Sample
PAB	20	182	9
PEM	24	383	16
PUB	20	157	8
PFO	8	92	12
Total	72	814	11

Table 16: A list of the eight individuals included in the reproductive study. *Indicates nesting occurrences which were not fully observed and are thus unconfirmed.

Reproductive Study Individuals

Notch Code	Carapace Length (cm)	Year	Nest Number	Clutch Size	Number Hatched	Nest Date	Nest Site
73	21.1	2005	–	?	?	9 June	*soybean field
		2006	1	17	0	3 June	soybean field
74	20.4	2005	–	?	?	20 June	*corn
77	19.6	2005	–	?	?	13 June	*wheat field
94	20.2	2005	–	?	?	9 June	*soybean field
109	22.4	2006	3	17	0	15 June	burned tire pile at edge of corn field
110	22.4	2006	2	13	12	6 June	buckwheat field
		2007	6	13	8	8 June	corn field
111	21.6	2006	4	?	?	9 June	*corn field
		2007	8	11	0	24 June	edge of lawn and fallow field
119	22.2	2007	7	13	0	10 June	corn field

Table 17: An analysis of soil composition at 2006 nest sites irrespective of any compaction that would have been present. The soil sample collected from the marsh hummock included more organic debris, such that the sample was notably less compacted and crumbled easily.

Nest Soil Analysis

Site	% Sand	% Silt	%Clay
Nest 1	4	56	40
Nest 2	21	54	25
Nest 3	10	50	40
Mock Nest 4	6	54	40
Marsh Hummock	0	50	50

Table 18: Nest temperature data showing maximum, minimum, mean, median, and mode temperatures for each month of incubation. The month of July loosely corresponds to the middle third of development in which sex of the hatchling is determined by incubation temperature. (temps in blue signify figures based on incomplete months, temps in red signify extremes due to exposure of the temperature probe to the surface or recorder anomalies). On 4 July, approximately 12 hours (3am to 3pm) were inexplicably lost from Nest 4, but this time frame was eliminated from the other nests during later direct comparison between nests.

		June					July					August				
	Nest	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
2006	Max	31.12	31.12	33.59	26.73	27.52	30.71	31.12	35.27	27.52	31.12	31.93	32.34	33.17	28.31	30.71
	Min	16.38	16.38	18.28	19.81	19.81	19.42	18.66	18.66	18.66	19.42	17.52	19.04	17.90	11.77	19.42
	Mean	22.80	22.70	23.66	23.03	23.39	25.05	24.89	25.64	23.31	25.37	25.16	24.97	23.26	22.71	24.96
	Median	22.48	22.48	22.86	22.86	23.24	25.17	24.79	25.17	23.24	25.17	25.17	24.79	22.86	22.86	24.79
	Mode	22.09	20.57	22.09	22.09	21.71	25.56	24.01	23.24	23.63	24.01	25.17	23.63	22.09	23.24	23.63

		June			July			August			September		
	Nest	6	7	8	6	7	8	6	7	8	6	7	8
2007	Max	27.12	34.43	29.90	25.56	32.34	31.12	41.05	30.71	30.71	25.56	28.31	26.73
	Min	17.52	16.38	20.19	17.52	17.14	19.42	17.90	12.93	18.66	12.16	10.99	14.09
	Mean	22.31	25.04	25.23	21.29	23.59	24.63	22.34	23.54	24.74	19.73	19.70	20.84
	Median	22.48	24.79	25.17	21.33	23.24	24.40	22.48	23.63	24.79	20.19	19.81	20.95
	Mode	22.09	25.17	23.63	21.33	22.09	23.63	22.09	23.24	25.17	21.71	20.19	20.19

Table 19: Mean measurements in millimeters for Nest 2 (n = 12), Nest 6 (n = 8), and all hatchlings combined (N = 20). The range of measurements is included for all hatchlings. All hatchlings were offspring of Female #110.

Hatchling Measurements

Nest	Mass	Carapace Length	Carapace Width	Plastron Length	Head Width	Tail Length
Nest 2	10.9	38.2	33.7	34.0	10.0	21.5
Nest 6	9.9	35.1	29.2	29.7	9.8	18.1
Total	10.5	37.0	31.9	32.2	9.9	20.2
Range	9.1–11.8	33.4–39.2	26.6–34.3	27.8–35.2	9.5–10.5	16.0–22.9