THE ECOLOGY OF THE ALLIGATOR SNAPPING TURTLE, *Macrochelys temminckii*, IN OKLAHOMA

By

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Very little information exists on the biology of the alligator snapping turtle, *Macrochelys temminckii*. Pritchard (1989) and Ernst et al. (1994) suggested that *M. temminckii* populations have declined drastically throughout its range. Overharvesting and habitat alteration were listed as the primary causes (Pritchard, 1989). In 1984, *M. temminckii* was proposed for listing as a threatened species by the United States Fish and Wildlife Service. The request for listing was precluded due to a lack of ecological information about the species. The status of the species was reviewed again in 1991, but no further actions were taken (United States Fish and Wildlife Service, 1991). At the state level, *M. temminckii* is afforded some protection in all states in which it occurs, except Louisiana (Roman and Bowen, 2000). *M. temminckii* currently is listed as a species of special concern in Oklahoma (Ramus, 1998).

The first chapter of this thesis is designed to provide an overview of what is known about *M. temminckii*. Later chapters will attempt to build on the information provided in these previous studies. Hopefully, studies conducted in Oklahoma will serve as an important stepping-stone in understanding the biology of this very secretive creature.

Taxonomy

The family Chelydridae is a new world family containing two monotypic genera, *M. temminckii* and its closest living relative, the common snapping turtle, *Chelydra serpentina* (Ernst et al., 1994). *Macrochelys* fossils have been dated back to the Miocene

(23.7 mya). During the course of its geologic history, the genus *Macrochelys* may have included three species (Pritchard, 1989).

The nomenclatural history of *M. temminckii* is very complex and is outlined in Pritchard (1989). Recently, there has been some confusion concerning the valid generic name for this species. *Macroclemys* has long been considered the generic name for the North American alligator snapping turtle (Ernst and Barbour, 1989; Ernst et al., 1994). However, Webb (1995) suggested that *Macroclemys* is a junior synonym for *Macrochelys* according to the publication dates of the generic description. Based on this information, I chose to use *Macrochelys* throughout this manuscript.

Species Description

The alligator snapping turtle, *M. temminckii,* is the largest freshwater turtle in the New World, attaining a carapace length of 80 cm and a live mass of 113 kg. Adults exhibit sexual dimorphism; females reach a maximum size of only 35 kg (Pritchard, 1989). Precloacal tail length also is longer in males than females (Ernst et al., 1994).

A general description of the species is as listed in Powell et al. (1998) and Ernst et al. (1994). The rear edge of the carapace is strongly serrated, and a row of four supramarginal scales is present along the posterior rim. The plastron is reduced and cruciform in shape. The plastron is connected to the carapace by a narrow bridge that is longer than broad. The shell is grayish brown; the skin is dark gray to brown above and lighter below. The tail is about as long as the carapace and has three rows of tubercles above and many small scales below. It has a large, powerful, hooked jaw, lateral eyes and many dermal projections along the head, chin, and neck. A worm-like process is located anterior to the glottis and used to lure prey within biting range.

Distribution

Macrochelys temminckii is confined to river systems that drain into the Gulf of Mexico (Figure 1). It reaches as far north as Kansas and Illinois (Galbreath, 1961; Clarke, 1981), and ranges from the Florida Panhandle to eastern Texas and Oklahoma (Conant and Collins, 1991). In Oklahoma, *M. temminckii* is restricted primarily to the eastern one-third of the state (Webb, 1970).

Habitat

Macrochelys temminckii is found typically in deep water of major rivers and their main tributaries but also occurs in canals, lakes, oxbows, swamps, and bayous (Ernst et al., 1994). Juveniles are found occasionally in smaller feeder streams (Allen and Neil, 1950). The species also is known to enter brackish water (Dundee and Rossman, 1989). Jackson and Ross (1971) speculated that *M. temminckii* was capable of spending considerable time in brackish habitats based on presence of barnacles on shells of coastal specimens.

Little is known about microhabitat use by *M. temminckii*. Sloan and Taylor (1987) reported that turtles in Louisiana spent the majority of their time in open-water bayous and channels with a water depth of 1.8--2.9 m. Telemetry studies have found that *M. temminckii* chooses specific microhabitat sites as resting or core sites. Core sites had more structural cover and denser overhead canopy than generally available (Sloan and Taylor, 1987; Shipman, 1993; Harrel et al., 1996; Shipman and Neeley, 1998). The turtles occur in mud and gravel bottom streams (Ernst et al., 1994).

Thermoregulation in *M. temminckii* is poorly studied. It is not known to bask, and only the females leave the water (to lay eggs). Ewert (1976) reported one instance of basking in Texas by a 20-cm juvenile. Allen and Neil (1950) noted that captive individuals refused food at temperatures < 18^0 C. Captive individuals at the Tulsa Zoo and Living Museum became inactive in winter when water temperature reached 10^0 C (Grimpe, 1987), but individuals did surface to breathe during these periods. The critical thermal maximum for two Louisiana individuals was 38.5 and 40.7^0 C (Hutchison et al., 1966).

Home Ranges and Movements

Movement patterns of *M. temminckii* are relatively well-studied, although there is still a paucity of data even on that subject. Wickham (1922) tagged and released an individual in July 1918 in the Blue River, Bryan County, Oklahoma, originally captured in 1915 in the Washita River, Bryan County, Oklahoma. The individual was captured again in September 1918 and had moved 274 m. The last observation was made in July 1921, and the turtle had moved an additional 27-30 km upstream. No information is present on the sex or size of the turtle. A 24.7-kg female in Kansas moved upstream 7 km between 11 April 1986 and 31 May 1991 (Shipman et al., 1991). Prime activity times were between 0200 and 0700 and lasted for one to three hours. The turtle would remain inactive for up to eight days between movements.

Sloan and Taylor (1987) observed 11 individuals in a lake and adjacent bayou in Louisiana. Daily movements varied from 27.8 to 115.5 m/day. Home ranges were 18--27 ha. Shipman and Neeley (1998) studied movements of 10 turtles in the St. Francis River, Dunklin County, Missouri. The mean daily movement for all turtles was 57.9 m, and mean linear home range was 1,793.6 m.

Growth and Longevity

Hatchling data were collected for 18 individuals of *M. temminckii* at the Tulsa Zoo and Living Museum (Grimpe, 1987). Mean carapace length was 35.5 mm, and mean mass was 14.2 g. Allen and Neill (1950) observed three individuals from hatching to five years of age. At hatching, the three individuals had carapace lengths of 44 mm and an average mass of 23.2 g. At five years, carapace length ranged from 84 to 90 mm, and one individual had a mass of 141.3 g.

Dobie (1971) determined size of sexual maturity based on the dissection of 231 individuals at a commercial fish house in Louisiana. Males are thought to have a more rapid rate of growth. The smallest mature male was 37 cm in length and the smallest mature female 33 cm, sizes that correspond to an age of 11--13 years based on counts of scute annuli. Powders (1978) observed a nesting female with a carapace length of 38.5 cm. Apparent age based on scute annuli was 28--31 years. Growth curves for Louisiana turtles constructed by Tucker and Sloan (1997) agree with predictions of age to sexual maturity given by Dobie (1971).

Macrochelys temminckii is thought to be a long-lived species. Conant and Hudson (1949) reported on two individuals in captivity at the Philadelphia Zoo. One individual lived for 47 years and 7 months, while the second was still alive and could be traced back 58 years and 8 months. Snider and Bowler (1992) reported that a male lived for 70 years, 4 months, and 26 days at the Philadelphia Zoo.

Reproduction

Mating has been observed in captive specimens in Florida during February, March, and April (Allen and Neill, 1950; Harrel et al., 1996), and in October in captivity in Oklahoma (Grimpe, 1987). Mating is thought to be facilitated by posturing and olfactory cues between males and females. Aggressive interactions between males also occur during those displays (Harrel et al., 1996). Nesting was observed in Florida specimens between 1 and 11 May (Ewert, 1976). Captive specimens oviposited between 26 June and 11 July (Allen and Neill, 1950; Grimpe, 1987). Clutch sizes range from 9 (Powders, 1978) to 44 (Allen and Neill, 1950). Based on counts of corpora lutea, Dobie (1971) suggested possible clutch sizes of 52 eggs. During summer 2000, I visited two *M. temminckii* breeders. John Richards is a commercial breeder and owner of Loggerhead Acres Turtle Farm outside Strafford, Missouri. He currently maintains an outdoor colony of 200 breeders (sex ratio unknown). His turtles nest between the first week of June and the third week of July. Mean clutch size for his colony has been 26. Larry Andrews, a private breeder in Red Rock, Oklahoma, maintains a small colony of two males and four females. Nesting in his colony takes place in mid to late June and the mean clutch size for the four females has been 28 eggs.

Females generally nest in sandy substrates associated with some vegetation (Ewert, 1976). Captive females in the care of John Richards and Larry Andrews built nests either in artificial sandbars surrounded by dense vegetation or under clumps of vegetation. All nests observed by Ewert (1976) and myself had at least one side open to the sun.

Incubation period ranges from 79 to 107 days (Allen and Neill, 1950; Grimpe, 1987). Grimpe (1987) reported that juveniles are able to overwinter in the nest. I observed this phenomenon in the collection maintained by John Richards. We unearthed an individual who did not escape the nest the previous year. The hatchling was still alive and eating four months later when I contacted Mr. Richards. Gibbons and Nelson (1978) suggested that several species of turtles that may nest late in the season can exhibit delayed emergence.

Diet

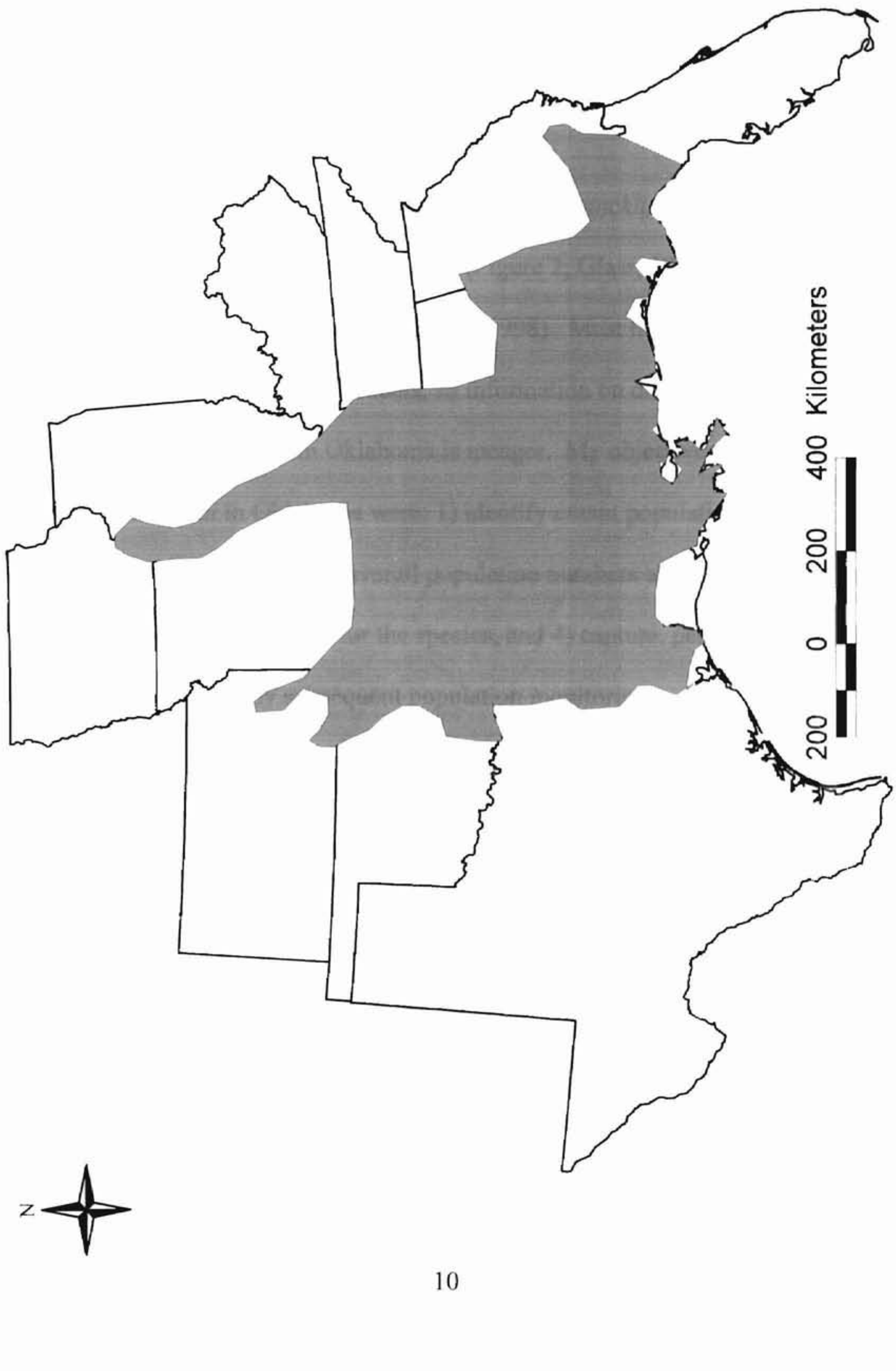
The primary foraging mode of *M. temminckii* is that of a sit-and-wait predator, only rarely foraging actively (Pritchard, 1989). Its diet is extremely catholic. Reports on stomach contents and fecal samples by Shipman et al. (1991), Ernst et al. (1994), and Sloan et al. (1996) include plant material (tubers, persimmons, acorns), invertebrates (crustaceans, gastropods, unionid mussels), fish (*Esox*, *Lepisosteus*, *Cyprinus*, *Amia*), frogs, salamanders (*Amphiuma*, *Siren*), alligator (*Alligator*), snakes, turtles (*Apalone, Graptemys, Trachemys, Pseudemys, Sternotherus, Macrochelys*), birds (passerines, wood duck), and mammals (*Procyon, Ondantra, Castor, Sylvilagus*).

Population Biology

Population size and demography may be the most poorly understood aspect of *M. temminckii* ecology. Few population studies have been conducted. Cagle and Chaney (1950) surveyed 14 sites in Louisiana in 1947. *M. temminckii* captures composed 4.2--12.5% of the samples. Shipman and Riedle (1994) and Shipman and Neeley (1998) captured 48 *M. temminckii* at two localities in southeastern Missouri. During the course of those studies, 20 individuals were captured at Wolf Bayou in Pemmiscot County, Missouri, in 1994. Turtles ranged between 6.2 and 24 kg and were represented by 10 males and 10 females. Seventeen individuals were captured in 1994 on the old channel of the St. Francis River in Dunklin County, Missouri. An additional 11 individuals were captured in 1997. Mass ranged between 2 and 17.3 kg for 27 individuals. Sex ratio was

11 males, 13 females, and 3 juveniles. Trauth et al. (1998) reported an adult sex ratio of 1:1 based on 86 individuals at two sites in Independence and Jackson County, Arkansas.

Figure1. The distribution of the alligator snapping turtle, *Macrochelys temminckii* in the United States, based on Conant and Collins (1998).



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CHAPTER II

HISTORIC AND CURRENT DISTRIBUTION OF THE ALLIGATOR SNAPPING TURTLE, *Macrochelys temminckii*, IN OKLAHOMA

Introduction

The Alligator Snapping Turtle, *Macrochelys temminckii,* once occurred throughout the eastern one-third of Oklahoma (Figure 2; Glass, 1949; Webb, 1970; Black, 1982; Carpenter and Krupa, 1989; Heck, 1998). Most historical accounts of *M. temminckii* are based on single individuals, so information on distribution and demography of *M. temminckii* in Oklahoma is meager. My objectives to determine the status of *M. temminckii* in Oklahoma were: 1) identify extant populations of *M. temminckii* in Oklahoma, 2) assess overall population numbers and viability, 3) identify and characterize important habitat for the species, and 4) capture, permanently mark, and release all specimens for any subsequent population monitoring.

Materials and Methods

I sampled sites throughout the eastern one-third of Oklahoma from May through August 1997-1999, with supplemental sampling of two sites in July 2000. Many of these sites were at or near historic sites of occurrence for the species in Oklahoma (Glass, 1949; Webb, 1970; Black, 1982; Carpenter and Krupa, 1989; Heck, 1998). I surveyed a variety of habitats to adequately sample all possible habitats in which *M. temminckii* might occur. The only area not sampled was the Arkansas River proper due to current channelization and impounding of the river, as well as lack of records for *M. temmincki* there; however, I did survey many tributaries of the Arkansas River.

Sites were sampled using commercial hoop nets that were 2.1 m in length and constructed of four 1.05-m diameter hoops covered with 2.5-cm square mesh. Nets were set upstream from submerged structures such as trees and log jams and were baited with fresh fish suspended by a piece of twine on the hoop furthest from the opening of the trap. Bait fish were procured with gill nets, or incidental capture in the turtle nets. Turtle nets were set in the late afternoon or evening and checked the following morning.

All individuals of all species of aquatic turtles were recorded. Basic habitat parameters also were collected at each site. Those data included aquatic regime (percent riffle, percent run, and percent pool); relative water current (0 = none, 1 = little, 2 = some, or 3 = much); stream morphology (0 = straight or channelized, 1 = slight bends in the stream, 2 = several bends within the stream, 3 = winding or braided stream); percent tree canopy covering the trap site; percentages of substrate types (clay, mud, sand, gravel, rock, and bedrock); amount of detritus (0 = none, 1 = little, 2 = some, or 3 = much); amount of beaver activity (0 = none, 1 = little, 2 = some, or 3 = much); mean site width; mean site depth; (1 = 0--1 m, 2 = 1.1--2 m, 3 = 2.1--3 m, or 4 = > 3 m); relative turbidity (0 = very clear, 1 = clear, 2 = slightly turbid, or 3 = very turbid); bank rise (0 = no rise, 1 = slight to 45^0 rise, 2 = 90^0 rise, or 3 = steep rise, bank overhanging the water); percentages of cover types (logs, log jams, trees, brush, and bank); relative amount of cover (0 = none, 1 = little, 2 = some, or 3 = much); number of feeder creeks present; amount of aquatic vegetation (0 = none, 1 = little, 2 = some, or 3 = much); and percent vegetative cover on the bank.

Canonical Correspondence Analysis (CCA) was used to determine site-by-species by-habitat associations (Palmer, 1993). CCA is a form of ordination analysis, in which raw data are a set of plots with measured abundance of species on each plot. Plots are ordered along a hypothetical or known environmental gradient according to similarity of species composition, or communities. Plots with similar communities are grouped together at one end of a continuum of some environmental gradient (e.g., moisture, elevation, etc.), and plots with dissimilar communities from those are grouped together at the other end of the gradient, with plots of intermediate communities located in between. CCA is a variant of Correspondence Analysis (CA), which is an iterative process that uses reciprocal averaging. In CA, (initially arbitrary) sample scores are used to compute species scores, which are weighted averages (sum of sample scores of each plot weighted by the frequency of each species present on each plot). Then, new sample scores are computed as the average of the species scores, again weighted by the abundance of each species in each sample. Scores are standardized at each step to prevent their approach to zero, and the process is repeated until scores stabilize. The result is the first CA axis solution. Subsequent ordination along further axes is performed in the same way after the effects of the first axis are factored out. Thus, axes are orthogonal.

In CCA, measured environmental variables that describe ecological gradients are included in the algorithm. Consequently, CCA is a form of "direct gradient" analysis. At each iteration, environmental variables are used as the independent variables in a multivariate linear least-squares regression to predict the new sample scores. Iteration is continued as before until scores stabilize. In CCA, species scores, sample scores, and independent variables can be plotted on the same triplot scatter diagram to see how plots with similar communities are related to measured environmental variables. Species that show similar habitat associations fall out together on such plots, and habitat associations are seen as the relative proximity of the species scores (represented by points) to the terminus of the habitat vectors. The relative importance and relationships of the habitat variables are based on the relative length and direction of vectors (Palmer, 1993). Very short vectors offer little explanatory power and are ignored. Axes of CCA are interpreted from multiple, long vectors that align closely with an axis and thus define an environmental gradient.

I collected basic morphometric data on each individual of *M. temminckii* captured. These data included mass, sex, and the following measurements: carapace length, carapace width, plastron length, plastron width, head length, head width, post-anal tail length, and total tail length. All individuals of *M. temminckii* captured were uniquely marked and fitted with a numbered tag. The identification marking was done using a hole drilled into specific marginal scutes along the carapace. The marks corresponded to a numbering system as detailed by Santhuff (1993). I placed short plastic cable ties in all numbered holes to ensure that the hole did not prematurely close. Numbered tags were plastic cattle ear tags attached to one of the numbered holes by a plastic cable tie.

Results

I surveyed 67 sites in 15 counties throughout eastern Oklahoma (Figure 3). Some sites were surveyed more than once due to the presence of *M. temminckii* or if seemingly good habitat was present. My total trapping effort was 1,085 net nights (one net per night = one net night), and I made 3,647 turtle captures of 13 species (Appendix A). From 1997-1999, I made 69 captures of 63 individuals of *M. temminckii* (plus 8 more captures added in July 2000 from Sequoyah National Wildlife Refuge) at 11 sites (Table I; Figure 4): one site each in the Little River, Horton Slough, Dirty Creek, Little Vian Creek, Hezekiah Creek, Mill Creek (McIntosh County), Mill Creek (Pushmataha County), Kiamichi River, and Dutchess Creek, and two sites on Big Vian Creek.

Canonical correspondence analysis indicated two principal environmental gradients along axes 1 and 2, respectively (Figure 5). Sites falling out to the left of axis 1 were turbid streams/rivers with riffles, mud, and detritus substrates, and substantial amounts of brush and trees in the water. Sites falling out to the right of axis 1 were faster-flowing streams/rivers with more pools and runs, logs and log jams, and sandier substrates. *Macrochelys temminckii* fell out in the middle of this first gradient, indicating its ecological generality with respect to these variables compared with the rest of the turtle species. The second environmental gradient (axis 2) was an upstream-downstream gradient, with upstream sites falling out low on this axis, and downstream sites falling out high on this axis (Figure 5). Downstream sites were deeper, more sinuous streams/rivers with mostly clay substrates and steeper banks; upstream sites were shallower streams/rivers with substrates of gravel and rock, more aquatic and bank vegetation with denser canopy, and more submerged cover. *M. temminckii* was also relatively generalized along this second axis, but was somewhat associated with upstream sites and their habitat characteristics (Figure 5). Considering the entire community of 13 aquatic turtle species I collected, red ear sliders (*Trachemys scripta*), common snapping turtles (*Chelydra serpentina*), common musk turtles (*Sternotherus odoratus*), and Mississippi mud turtles (*Kinosternon subrubrum*) were associated with approximately the same habitat as *M. temminckii* (Figure 5).

Net success (number of all turtles captured per net night) was plotted for each major river system sampled (Figure 6). Six of the 12 systems sampled exhibited low capture rates (<3 turtles/net night). The sites with the lowest estimated capture rates for *M. temminckii* (< 0.10 turtles/ per net night; Table I) were at rivers exhibiting low overall capture rates.

Discussion

Macrochelys temminckii was once distributed throughout all the major river systems in eastern Oklahoma (Figure 3). It probably inhabited a variety of habitats in these rivers. Canonical correspondence analysis indicated that *M. temminckii,* compared to the rest of the turtle species captured in my study, is still a habitat generalist, although it was associated with more upstream than downstream sites. In CCA, *M. temminckii* fell out with *Chelydra serpentina, Sternotherus odoratus,* and *Trachemys scripta,* which are likewise considered habitat generalists (Ernst et al., 1994).

Despite this generality of habitat preferences, *M. temminckii* was captured at only 11 of the 67 sites sampled within the historic range of this species in Oklahoma. These results indicate a dramatic decline in numbers of *M. temminckii* in the state. Current known populations seem to be restricted to a few locations in the southeastern corner of Oklahoma. Of those populations, only the Eufala and Kerr reservoirs yielded capture rates high enough to suggest possible healthy populations. *Macrochelys temminckii* appears to have been extirpated from the northeastern corner of the state. The possible reasons for this decline are habitat alteration and historical, incidental, and illegal harvest.

There are several forms of habitat alteration that may have a negative effect on *M. temminckii* in Oklahoma. The Verdigris River has been channelized for navigation throughout much of Oklahoma. This manipulation of the river channel turns a low-energy, meandering, aquatic system with high habitat diversity into a higher energy system with low habitat diversity that is vastly different from the habitat preferred by *M. temminckii* (Shipman, 1993, Moll and Moll, 2000).

Moll and Moll (2000) identified eight major negative effects of impoundments on riverine turtle populations: 1) changes in available food, 2) prevention of migration, 3) flooding of nesting beaches upstream, 4) destruction of downstream nesting beaches due to erosion, 5) alteration of flood cycles, 6) fragmentation of populations, 7) prevention of substrate transport within the channel to replace that lost by erosion, and 8) changes in water quality due to decomposition of drowned forests and pollution produced by construction of the impoundment. All of these factors may affect *M. temminckii* populations in Oklahoma.

Macrochelys temminckii is exclusively aquatic, except for females during egg laying (Pritchard, 1989). An impoundment such as a dam or a lock would block movement of individuals up or downstream of the structure. The Arkansas, Caney, Verdigris, and Neosho rivers seem to be the major dispersal pathways for *M. temminckii* throughout the central and northern parts of its range in Oklahoma. The series of locks and dams along the Arkansas, Caney, and Verdigris rivers may be the main impediment to the dispersal of individuals into the northern reaches of Oklahoma rivers and streams.

Macrochelys temminckii is thought to occur only sporadically in Kansas (Collins, 1993). Shipman et al. (1995) identified 12 historical sites for *M. temminckii* in Kansas. The majority of those records were from the late 1800's to the mid-1900s. They speculated that individuals wandered upstream from viable populations in Oklahoma. Due to the damming of all the major rivers entering Kansas, the apparent lack of source populations in northeastern Oklahoma (this study), and the documentation of only one individual during recent surveys, the occurrence of *M. temminckii* in Kansas may be sporadic at best.

Thermal alteration of aquatic environments such as hypolimnetic release of cold water also may be responsible for the decrease in *M. temminckii* abundance. The Mountain Fork River in McCurtain County, Oklahoma, is managed as a coldwater stream for trout fishing. Summer water temperatures taken during the study varied between 17^0 and 21^0 C. Little work has been done with the thermal requirements of *M. temminckii*, but Allen and Neill (1950) noted that individuals refused food at temperatures $<18^0$ C. Based on our observations, the thermal environment in rivers such as the Mountain Fork is not ideal for *M. temminckii* or other aquatic turtle species. A 36.4-kg *M. temminckii* was captured on the Mountain Fork River in 1993 by anglers (Shipman, pers. comm.). No individuals were captured on the Mountain Fork during our survey. Heck (1998) reported a decline in the number of *M. temminckii* observed on the Mountain Fork River since the construction of the Broken Bow Dam in 1969; his last *M. temminckii* reported from the Mountain Fork River was from 1995.

Water pollution also may affect aquatic turtle communities. Heck (1998) listed several sources of pollution on the Little River that may have contributed to the decline of *M. temmminckii* over the last 30 years. Sources include sewage discharge, runoff from chicken farms, waste-water discharge from chicken processing plants, chemical runoff, and soil erosion from commercial timber production.

The primary forms of harvest of *M. temminckii* include historical, incidental, and illegal capture. Most incidental captures are those on trot lines and limb lines set by fishermen for catfish. Shipman et al. (1991) reported a specimen caught on a limb line 32 km north of the Oklahoma border on a tributary of the Verdigris River. Heck (1998) listed several accounts of *M. temminckii* captures on limb lines and trot lines in McCurtain County, Oklahoma. Shipman and Riedle (1994) identified limb lines and trot lines as a primary threat to turtles on the Saint Francis River in southeastern Missouri. Several hundred lines were observed in a 4.8-km stretch, and one spiny softshell turtle, *Apolone spinifera*, was observed snagged on a limb line.

Due to its large adult size and ease of capture, *M. temminckii* has been harvested historically throughout its range as a source of meat for personal and commercial use (Pritchard, 1989). Sloan and Lovich (1995) reported 17,117 kg live-weight of *M. temminckii* purchased by a single buyer in Louisiana between 1984 and 1986. Turtles historically entered this market from Florida, Georgia, Mississippi, Arkansas, Texas, and possibly Oklahoma (Pritchard, 1989). Historical records for Oklahoma (Glass, 1949; Webb, 1970; Black, 1982; Carpenter and Krupa, 1989; Heck, 1998) are all based on individuals taken by fishermen, and all were kept by the fishermen themselves or donated to private or public collections. Commercial harvest in Louisiana is still ongoing (John Richards, pers. com.) even though *M. temminckii* is protected in surrounding states. Based on conversations with turtle trappers and dealers, many of the turtles at the Louisiana markets are still coming from out of state. Due to the protected status of *M. temminckii*, gaining reliable locality information on captures is difficult.

In addition to harvest for local consumption, there also is a large international demand for all turtles for the pet, food, and traditional medicine markets in Asia (Compton, 2000). Several North American turtle genera including *Trachemys*, *Chelydra* (Compton, 2000), *Graptemys* (Lau et al., 2000), *Macrochelys*, *Apalone*, *Malaclemmys*, *Sternotherus, Terrapene* (Chen et al., 2000), and *Pseudemys* (Ades et al., 2000) have been recorded in varying numbers in Asian markets.

In response to the international demands, commercial harvest and farming of turtles to supply the trade has become very common in the United States (Thorbjarnarson et al. 2000). The Oklahoma Department of Wildlife Conservation (ODWC) opened commercial turtle harvesting in Oklahoma in 1994. According to reports from ODWC, 370,466 turtles of 11 species were harvested and sold to Oklahoma licensed turtle buyers between 1994 and 1999 (Table II). During that 6-year period of time, turtle buyers in Oklahoma (Table III) exported 311,061 turtles. Those numbers likely represent minimal estimates of actual harvest.

Low rates of turtle captures during my survey may be due to harvesting pressure, although there is no documentation of localities from which turtles have been harvested. According to anecdotal information supplied by ODWC game wardens and local fishermen, the Arkansas, Deep Fork, and Little rivers are harvested fairly frequently. The Deep Fork River and Little River exhibited low rates of turtle capture during the survey. Although *M. temminckii* can be captured unintentionally while harvesting other species, it is exempt from harvest and legally should be released. No information is available on how many *M. temminckii* are accidentally harvested, where they are harvested, or their fate after harvest. Areas exhibiting low capture rates for *M. temminckii* coincide with those areas exhibiting low overall turtle capture rates. Areas where *M. temminckii* still occurs in appreciable numbers are areas where they are afforded some protection from harvest (e.g., Sequoyah National Wildlife Refuge).

TABLE I

ALLIGATOR SNAPPING TURTLE CAPTURE RATES BY SAMPLE SITE, 1997 - 1999

Site	County	Number of Captures	Net Nights	Capture Rate (# turtles/net night)
Little River	McCurtain	3	167	0.018
Kiamichi River*	Pushmataha	2	34	0.059
Dirty Creek**	Muskogee	7	37	0.120
Hezekiah Creek**	Sequoyah	3	17	0.180
Big Vian Creek***	Sequoyah	24	126	0.200
Little Vian Creek	Sequoyah	26	64	0.410
Dutchess Creek	McIntosh	4	9	0.444
Mill Creek	McIntosh	8	13	0.620

*Represents one site on the Kiamichi River and one site on its tributary, Mill Creek.
**Resampled July 2000 bringing total number of *M. temminckii* captures to 77.
***Represents two sites on Big Vian Creek and one site on Horton Slough.

TABLE II

NUMBER OF OKLAHOMA TURTLES BY SPECIES PURCHASED BY COMMERCIAL TURTLE BUYERS BETWEEN 1994 AND 1999, BASED ON REPORTS MADE TO THE OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION.

Species	1994	1995	1996	1997	1998	1999	Total
Trachemys scripta	6,165	8,623	37,253	84,206	41,996	49,035	227,278
Pseudemys concinna	3	0	49	207	50	163	472
Graptemys ouachitensis	10	1,013	196	586	624	593	3,022
Graptemys pseudogeographica	0	3	25	718	26	324	1,096
Chrysemys picta	0	15	0	8	0	50	73
Apalone spinifera	4,043	4,111	9,453	21,029	13,784	16,214	68,634
Apalone mutica	2,772	2,993	4,570	13,683	12,487	5,509	42,014
Chelydra serpentina	481	1,135	4,451	9,179	3,753	5,077	24,076
Sternotherus odoratus	1	67	251	209	464	950	1,942
Sternotherus carinatus	0	46	66	25	0	0	137
Kinosternon flavescens	46	83	76	245	196	212	858
Kinosternon subrubrum	2	857	0	5	0	0	864
Total	13,523	18,946	56,390	130,100	73,380	78,127	370,466

TABLE III
NUMBER OF TURTLES BY SPECIES, EXPORTED FROM OKLAHOMA,
BASED ON REPORTS FROM THE OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION

Species	1994	1995	1996	1997	1998	1999	Total
Trachemys scripta	2,003	7,834	36,866	57,042	46,727	29,624	180,096
Pseudemys concinna	3	0	8	2	22	0	35
Graptemys pseudogeographica	0	3	13	175	0	0	191
Graptemys ouachitensis	9	1,013	196	474	480	0	2,172
Chrysemys picta	0	15	0	0	0	0	15
Apalone spinifera	3,892	4,090	9,233	21,405	11,396	13,662	63,678
Apalone mutica	2,895	2,893	4,282	17,051	11,691	5,764	44,576
Chelydra serpentina	509	1,127	1,576	6,126	4,300	5,005	18,643
Sternotherus odoratus	1	67	304	35	165	36	608
Sternotherus carinatus	0	46	60	25	0	0	131
Kinosternon flavescens	46	81	66	94	40	0	327
Kinosternon subrubrum	4	857	0	0	0	0	861
Total	9,362	18,026	52,604	102,249	74,821	54,091	311,333

Figure 2. Historic distribution of the alligator snapping turtle *Macrochelys temminckii*, in Oklahoma.

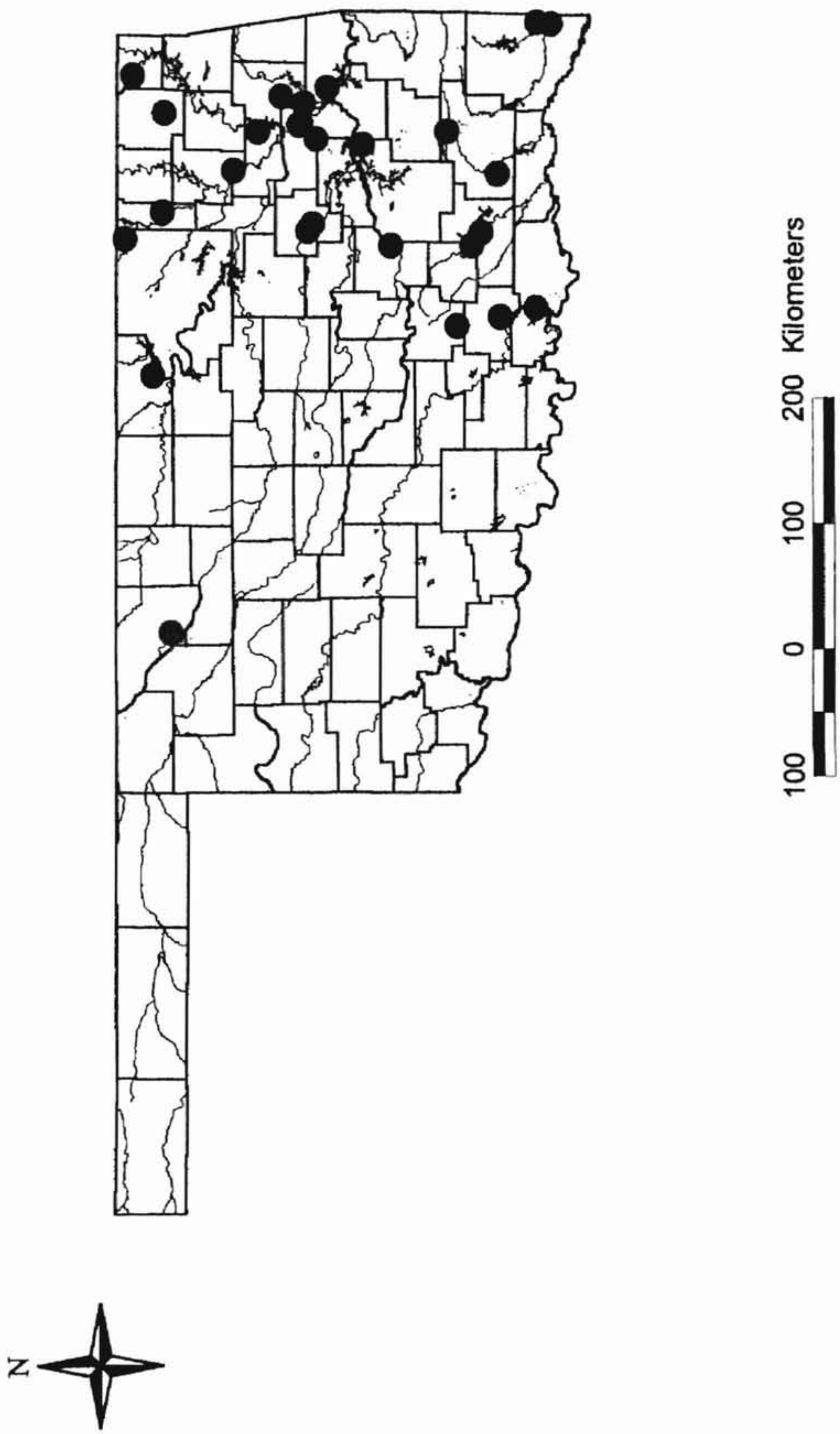

100 0 100 200 Kilometers
N

Figure 3. Sites sampled for *M. temminckii* in Oklahoma between 1997 and 1999. Points may represent more than one site, due to the close proximity of some sample sites.

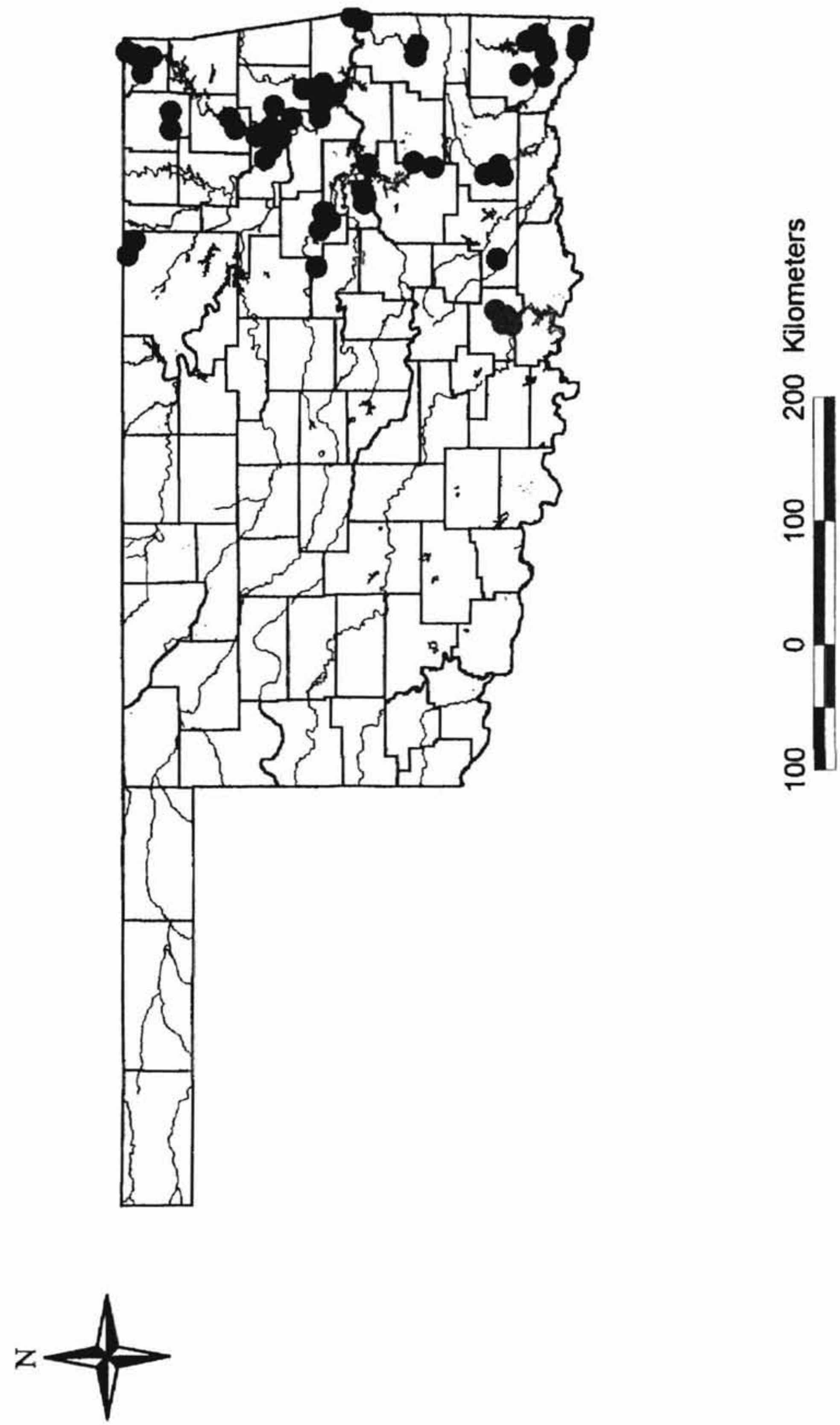

100
0
100
200 Kilometers
N

Figure 4. Current known distribution of *M. temminckii* in Oklahoma based on the 1997-1999 survey. Points may represent more than one site, due to the close proximity of some sample sites.

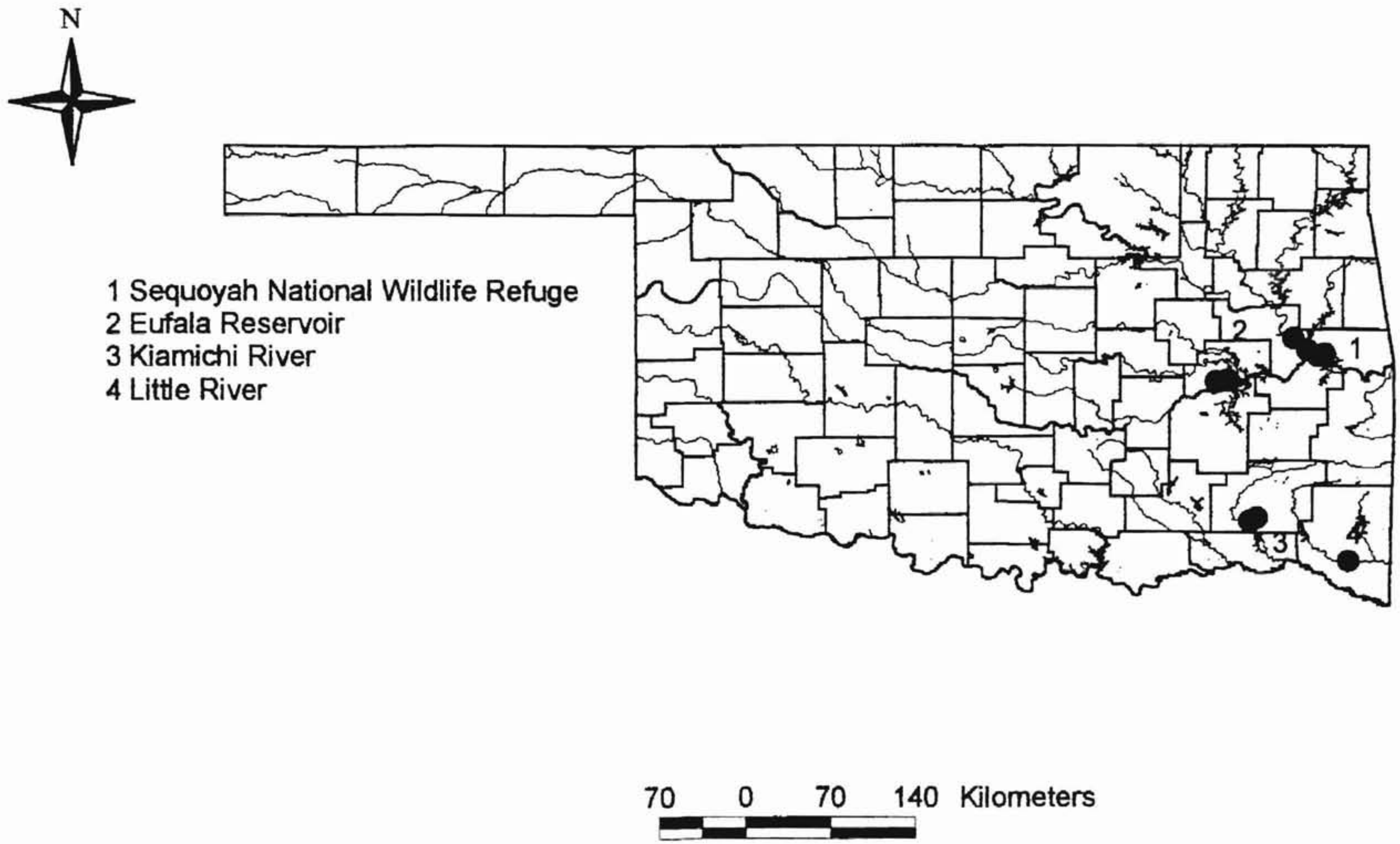

N
1 Sequoyah National Wildlife Refuge
2 Eufala Reservoir
3 Kiamichi River
4 Little River
1
2
3
4
70 0 70 140 Kilometers

Figure 5. Species-habitat associations as determined by canonical correspondence analysis. Species scores (shown as points): MATE=*Macrochelys temminckii*, CHSE=*Chelydra serpentina*, KISU=*Kinosternon subrubrum*, STCA=*Sternotherus carinatus*, STOD=*Sternotherus odoratus*, APSP=*Apalone spinifera*, GRKH=*Graptemys kohnii*, GRPS=*Graptemys psuedogeographica*, PSCO=*Pseudemys concinna*, and TRSC=*Trachemys scripta* (extremely rare species are excluded from analysis). Habitat vectors: 1=percent riffle, 2=relative amount of detritus, 3=water turbidity, 4=relative percent trees, 5=stream morphology, 6=mean stream depth, 7=bankrise, 8=percent clay substrate, 9=percent log cover, 10=percent log jam cover, 11=current speed, 12=percent sand substrate, 13= percent pool, 14=percent run, 15=percent gravel substrate, 16=percent rock substrate, 17=percent bedrock substrate, 18=number of feeder creeks, 19=relative amount of aquatic vegetation, 20=percent overhead canopy, 21=percent mud substrate, 22= percent brush, 23=percent bank cover, 24=relative amount of beaver activity, 25=mean stream width, 26=relative amount of total cover, 27=percent bank vegetation (refer to methods section for explanation of parameters).

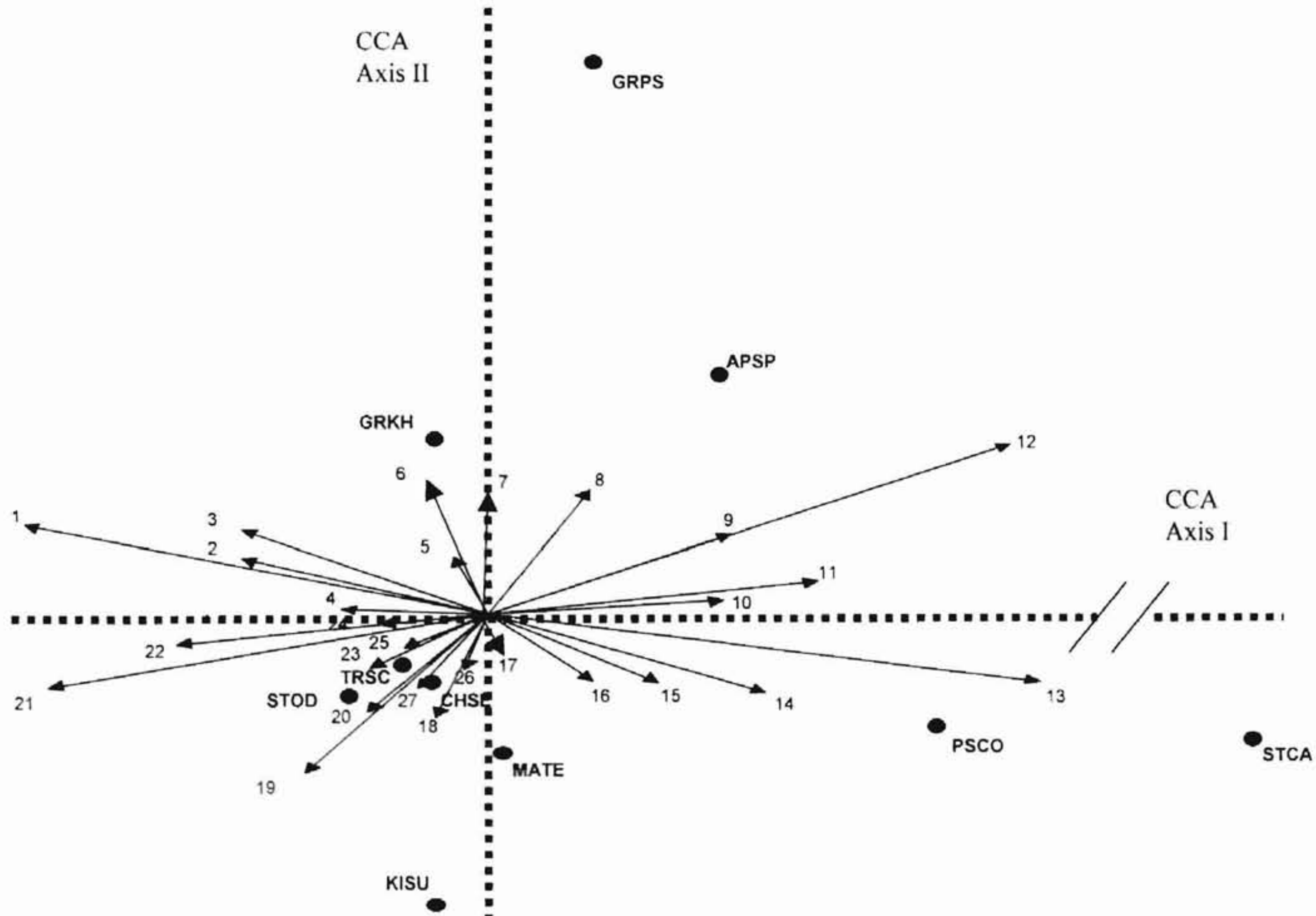
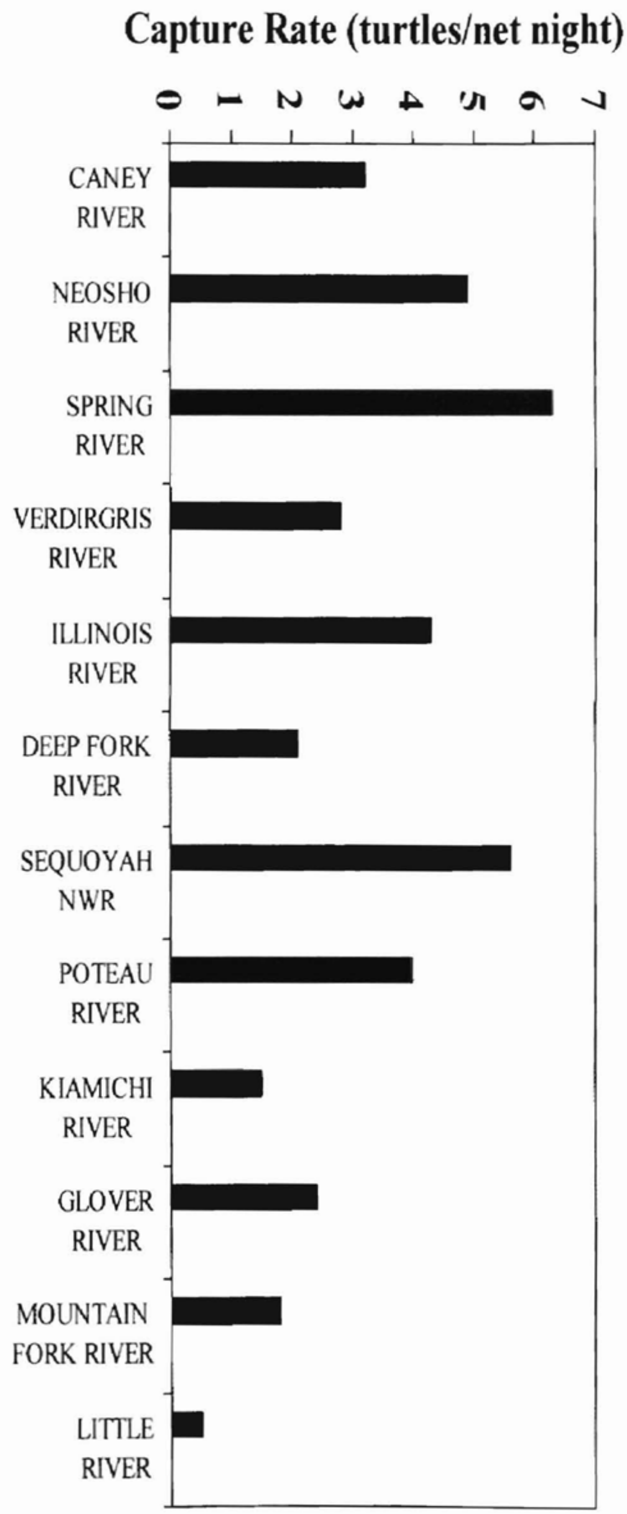

CCA
Axis II
CCA
Axis I
GRPS
APSP
GRKH
PSCO
STCA
MATE
KISU
STOD
TRSC
CHSE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
25
26
27

Figure 6. Capture rates for all turtle species in Oklahoma streams during the 1997-1999 survey. Streams are ordered from north to south. Sequoyah National Wildlife Refuge is a complex of streams that empty into Kerr Reservoir in Sequoyah County.


Capture Rate (turtles/net night)
0
1
2
3
4
5
6
7
CANEY RIVER
NEOSHO RIVER
SPRING RIVER
VERDIRGRIS RIVER
ILLINOIS RIVER
DEEP FORK RIVER
SEQUOYAH NWR
POTEAU RIVER
KIAMICHI RIVER
GLOVER RIVER
MOUNTAIN FORK RIVER
LITTLE RIVER

CHAPTER III

POPULATION DEMOGRAPHY OF THE ALLIGATOR SNAPPING TURTLE, *Macrochelys temminckii*, in SEQUOYAH COUNTY, OKLAHOMA

Introduction

Little is known about the population demography of *Macrochelys temminckii*. Shipman and Riedle (1994) and Shipman and Neeley (1998) sampled two populations in southeastern Missouri. In each, turtles ranged between 2 and 24 kg. Sex ratio for the two populations was 1 male:1.09 females. Trauth et al. (1998) sampled two sites in Arkansas and reported a sex ratio of 1:1. They also reported that males were significantly larger than females. Tucker and Sloan (1997) also found that males were significantly larger than females from examination of specimens at a commercial processing facility in Louisiana. Based on growth curves constructed by Dobie (1971) and Sloan and Tucker (1997), male *M. temminckii* reached sexual maturity at 37 cm, and females at 33 cm, straight carapace length.

Citing lack of information, *M. temminckii* was precluded for listing by the United States Fish and Wildlife Service in 1984 and 1991, but long-term population studies of this species should be undertaken. Due to the apparent decline of the species throughout its range (Pritchard, 1989; Ernst et al., 1994), large unimpacted populations may be hard to find. Information on ecology and demography of unimpacted populations obviously is necessary for the recommendation of practices to manage or restore impacted populations.

My overall goal was to elucidate the structure of a population of *M. temminckii*. My four primary objectives were: 1) determine population size and density at Sequoyah

National Wildlife Refuge (SNWR), 2) identify size classes, 3) determine sex ratios, and 4) test for sexual dimorphism.

Materials and Methods

During summer 1997, several *M. temminckii* was captured on the SNWR in east-central Oklahoma. The refuge was located in Sequoyah County, 4.8 km south of Vian, Oklahoma. It is 51,376 ha and encompasses the Canadian and Arkansas rivers and their confluence. Primary habitat is bottomland flood plain with many small tributaries that drain into both rivers. Following the discovery of this sizeable population at SNWR, I initiated a more intensive study of *M. temminckii* there.

I sampled SNWR sporadically in 1997 and 1998 and more intensively in 1999 and 2000. Several small streams were sampled including Dirty Creek, Hezekiah Creek, Big Vian Creek, Little Vian Creek, and Negro Creek. Sally Jones Lake, a shallow lake connected to Big Vian Creek, also was sampled (Figure 7). Big Vian Creek and Little Vian Creek were sampled more intensively due to their easy access and were used for estimates of population size and density. Both streams are tributaries of the Arkansas River and the mouths of both streams are about 0.8 km apart. The entire navigable stretches of both streams were sampled. The navigable stretch of Little Vian Creek was 2 km in length, reaching from its mouth until the stream became shallow and predominated by riffles. Big Vian Creek was 4.5 km in length from the mouth to where the stream became very shallow and clogged with fallen logs.

All streams were sampled using commercial hoop nets that were 2.1 m in length and constructed of four 1.05-m hoops covered with 2.5-cm square mesh. Nets were set upstream from submerged structures such as fallen trees. Nets were baited with fresh fish suspended by a piece of twine on the hoop furthest from the opening of the net. Bait fish were procured with gill nets or incidental capture in the turtle nets. Turtle nets were set late in the afternoon or evening and checked the following morning.

I recorded basic morphometric data on each individual of *M. temminckii* captured. Those data included mass, sex, and the following measurements: carapace length, carapace width, plastron length, plastron width, head length, head width, preanal tail length, post-anal tail length, and total tail length. All individuals of *M. temminckii* captured were uniquely marked and fitted with numbered tags. The identification marking was done using a hole drilled into specific marginal scutes along the carapace. Marks corresponded to a numbering system as detailed by Santhuff (1993). I placed short plastic cable ties in all numbered holes to ensure that the hole did not prematurely close. Numbered plastic cattle ear tags were also attached to one of the numbered holes by a plastic cable tie.

All individuals of *M. temminckii* were assigned to three primary classes based on sex and size. Sex was determined from two characters: relative tail length and presence/absence of a penis. Males typically have longer preanal tail lengths than females (Ernst et al. 1994) and the penis, if present, can be felt by inserting a finger into the turtle's cloaca. Turtles that were too small to display differences in preanal tail length or to examine for a penis were classified as juveniles. Morphological measurements between males and females were compared using two-group *t*-tests.

Results

Population size and density

I sampled a total of 565 net nights (1 net night = 1 net/night) between 1997 and 2000 on Dirty Creek, Hezekiah Creek, Big Vian Creek, Little Vian Creek, Sally Jones Lake, and Negro Creek. I captured 2,759 turtles of nine species, which included 197 captures of *M. temminckii*. *Macrochelys temminckii* was not captured in Sally Jones Lake or Negro Creek. Of all the turtles, red ear sliders, *Trachemys scripta,* were the most abundant, representing 83% of all captures. *Macrochelys temminckii* was the second most abundant, representing 7% of all captures. One hundred fifty-seven individuals of *M. temminckii* were marked and released (Appendix B). The recapture rate for *M. temminckii* was 21%.

Eighty-four individuals of *M. temminckii* were captured on Big Vian Creek and 64 were captured on Little Vian Creek. Because I could not test for emigration or immigration, I used a Lincoln-Peterson estimator of population size based on capture-mark-recapture data. Lincoln-Peterson estimates assume no emigration or immigration. The estimated population size for Big Vian Creek was 127.5 (SE = 24.5) individuals with a density of 28.3 turtles/km and, for Little Vian Creek, was 68.4 (SE = 18.2) individuals with a density of 34.2 turtles/km.

Size Distribution

Mean sizes for SNWR turtles were 8.71 kg (range = 0.22--46.4 kg), 330 mm carapace length (110--614 mm), and 240 mm plastron length (72--470 mm). I captured few small juveniles and large adults (Figure 8). There also was a cohort of turtles between 340 and 400 mm carapace length that was noticeably underrepresented.

Sex Ratio and Sexual Size Dimorphism

I captured 34 males, 42 females, and 81 juveniles, and the male-to-female ratio (1:1.23) did not differ from 1:1 ($X^2 = 1.263$, 1 df, $p = 0.25$). I was able to determine sex of males ≥240-mm carapace length and females with ≥260 mm carapace length, but not in all cases. I was able to determine sex of all individuals (except one) at carapace lengths >340 mm (Figure 8).

A lack of significant sexual size dimorphism was noted in the SNWR population (Table 4). Males were slightly larger than females, but there was no significant difference in any measurement between males and females, although all but one individual >500 mm carapace length were males. A Chi-square analysis of sexes by size class was used to compare number of males to females in two different size classes: medium (361-480 mm) and large (481-620 mm). The number of males and females differed in these two size classes ($X^2 = 4.76$, 1 df, $p = 0.029$); males represented the large adult cohort (Figure 8).

Discussion

Macrochelys temminckii was the second most abundant species captured at Sequoyah National Wildlife Refuge, occurring in high densities. There may have been some sampling bias toward that species with respect to type of bait and net size, but *M. temminckii* was still a commonly encountered species at SNWR. Because the Lincoln-Peterson estimate assumes no emigration or immigration, it may have overestimated population size on SNWR. Still, *M. temminckii* was captured fairly frequently and exhibited a low recapture rate. Unfortunately, there are currently no other published data on population densities of *M. temminckii* to compare with SNWR densities. I feel that the estimates made on SNWR are fairly accurate and may imply stable populations, especially because estimates for both Big Vian Creek and Little Vian Creek were fairly similar and most size classes were represented (see below). Based on survey data (Chapter 2), this may be one of the last large populations left in Oklahoma. The refuge came under federal stewardship in 1970, and many of the smaller feeder creeks are now accessible only by boat. Even so, boat travel is very difficult due to numerous fallen trees and stumps. One can suppose that harvest of *M. temminckii* is low to nonexistent at SNWR.

A wide range of size classes was captured, providing evidence for a stable population with good recruitment (Figure 8). The primary cohorts missing from the sample were hatchling-size turtles and large adults. The size of the mesh and throats of the nets used for sampling were large enough to capture adults but too large to contain small turtles.

The population was slightly female-biased with an adult sex ratio of 1:1.23. This ratio is similar to values from populations in Missouri and Arkansas (Shipman and Riedle, 1994; Shipman and Neeley, 1998; Trauth et al., 1998). Although I was able to sex some individuals at relatively small sizes, my ability to sex small turtles was inconsistent. The primary factor was the inability to insert my finger far enough into the cloaca to feel for the presence or absence of a penis. I also was not able to determine minimal size of sexual maturity, because I did no internal analysis of follicular or testicular maturation. I was able to accurately sex all individuals (except one) with $\geq$340 mm carapace length. That was within the size range for sexually mature turtles in Louisiana (Tucker and Sloan, 1997). Populations of *M. temminckii* in Louisiana reached sexual maturity at 13-21 yrs for females and 11-21 yrs for males. These estimates of age to maturity may not be entirely accurate for Oklahoma populations, but because the sexed turtles that I captured were comparable in size, they provide the best estimate until more precise data can be gathered.

Although the population of *M. temminckii* at SNWR appeared healthy, there was evidence for possible perturbations in the past. The lack of significant sexual size dimorphism could be attributed to a couple of factors. Because the population at SNWR is a more northerly population of *M. temminckii*, it may be that a shorter growing season is the reason for lack of size dimorphism. In contrast, Trauth et al. (1998) found significant differences in size between males and females in a population in northeastern Arkansas. Many large individuals (25 to 55 kg) have been captured throughout eastern Oklahoma in the past (Webb, 1970; Black, 1982; Carpenter and Krupa, 1989). I captured six large males (25, 34.5, 36.3, 41.8, 42.3, 46.4 kg) and one large female (26.8 kg) while sampling at SNWR. A second possibility concerns the harvest of large turtles. Shipman and Riedle (1994) and Trauth et al. (1998) reported differences in body size between harvested and unharvested populations, with the absence of larger turtles from exploited populations. There is some evidence for historical take of *M. temminckii* in Oklahoma (Black, 1982; Carpenter and Krupa, 1989; Pritchard, 1989). It may be that before SNWR was established in 1970 there was significant take of *M. temminckii,* especially large ones from that area, and not enough time has elapsed to allow for the current adult cohort to reach its full growth potential. The few large individuals captured may represent the remaining cohort left before the refuge came under federal jurisdiction.

Individuals within the 340--400-mm range of carapace length are clearly under-represented in my sample. This phenomenon may be attributed to subadult dispersal, previous habitat alteration on the refuge, or previous heavy harvest of adults. Juvenile common snapping turtles, *Chelydra serpentina*, occupy small streams after hatching and disperse from those streams as they reach sexual maturity (Graves and Anderson, 1987). This phenomenon also may be occurring within the populations of *M. temminckii* at SNWR. Perhaps these subadults leave the larger streams, which I trapped, and are found only in the smaller (unsampled) streams.

The missing cohort apparently is representative of the whole refuge. Although sample sizes on Hezekiah Creek and Dirty Creek were small, those size classes were still underrepresented in the captures. But if those 340--400-mm subadults used some different habitat, one has to wonder why even smaller individuals did not. I captured many juveniles < 340-mm carapace length in the same habitat as the larger turtles. Intuitively, those smaller turtles should be the ones using smaller streams because their smaller body size would make them more susceptible to predation by fish and larger turtles. So if the 340--400-mm turtles are using some different habitat that I did not sample, it is unknown what that habitat is and why only that size class used it.

An alternative hypothesis may be that the refuge population experienced some past disturbance that may have had a negative impact on nest success and that underrepresented size-age class is the lingering "footprint" of such nest failure. I propose that such a past disturbance was the flooding of upstream areas after construction of the dam to make Robert S. Kerr Reservoir (RSKR). SNWR lies on the immediate upstream side of RSKR. Construction of the dam began in April 1964 and closure occurred in

October 1970. Subsequently, stream levels rose significantly based on information from SNWR personnel and remnant hardwood structure present in the current streambed. This dramatic rise in water level may have temporarily destroyed nest sites along the streams. The closure of the dam corresponds roughly with the potential age of the cohort affected. One negative impact of dams listed by Moll and Moll (2000) is flooding of nest sites upstream from the impoundment.

During June 2000, I found three possible nest sites of *M. temminckii* on SNWR. These were identified by large claw marks, large drag marks, and digging activity. Evidence of predation on several nests was observed, but no active nest could be found. Identification of eggshell remnants was based on comparison with eggs from captive *Macrochelys, Chelydra,* and *Trachemys*. Nests were found in either sandy soil or depositional mounds of mud, leaves and sticks. All nests were < 1 m from the water's edge, so similar nest locations could have been flooded when water levels rose dramatically in the early 1970s.

One problem with this theory is that the underrepresented cohort appears to be younger than the flooding event. Rise in water level also should have affected nesting success of the turtles for only one nesting season. After one season, the water level should have more-or-less stabilized, and the subsequent risk of flooding of nesting sites would no longer exist. Perhaps, though, after a permanent rise in water levels, more than one year would show reduced nesting success. It must take some period of time for the deposition of new nesting beaches.

Given these considerations, I conclude that past harvest probably had a greater effect on populations of *M. temminckii* at SNWR than did previous changes in stream morphology due to construction of the RSKR dam. The current paucity of large adults and lack of significant sexual size dimorphism supports this conclusion. If breeding adults were seriously depleted before the refuge was established, there would have been very little recruitment of turtles (now represented by the missing size-age class). However, small prereproductive turtles would have been commercially unimportant and left unharvested. These turtles have now grown into the small adult age class at SNWR (Figure 8). Their offspring are the current prereproductives. A few turtles big enough to be commercially important before the refuge was established somehow escaped harvest and currently represent the largest size-age class at SNWR (Figure 8).

Gibbs and Amato (2000) characterize turtle demography as low egg and hatchling survival, high rates of juvenile and adult survival, long lifespan, delayed reproductive maturation, and pronounced iteroparity after maturity has been reached. Population stability is strongly influenced by changes in adult and juvenile survival and less influenced by fecundity and hatchling survival (Congdon et al., 1993; Congdon et al., 1994). Although the type and severity of historical impacts on populations of *M. temminckii* at SNWR are not entirely known, there is some evidence that total protection of the adult cohorts will allow populations *M. temminckii* to recover over time. Figure 8 shows a large number of adults reaching sexual maturity and even more prereproductive age turtles. This age structure implies the ability of the species to recover after historic disturbances.

Future work on SNWR needs to center on some of the ideas set forth in this paper. Mark-recapture studies should be continued to test for possible dispersal between creeks, especially by subadults. Long-term, mark-recapture studies also could be used to determine if the underrepresented, mid-sized cohort is due to past disturbance or to juvenile dispersal to distinct habitat. If the size of the underrepresented cohort were to increase over time, then the lack of individuals would be due to past disturbance. More effort should be afforded to developing aging techniques and determining age at sexual maturity in populations of *Macrochelys temminckii* at SNWR. Long-term studies also should focus on nest success and developing possible methodologies of capturing and monitoring hatchling *M. temminckii*.

TABLE IV

SIZE COMPARISON BETWEEN MALE AND FEMALE *Macrochelys temminckii* AT SEQUOYAH NATIONAL WILDLIFE REFUGE

	Male		Female			
Measurement	Mean ± 1SD	*n*	Mean ± 1SD	*n*	*t*	*p*
Carapace Length (mm)	409.65 ± 91.41	34	403.79 ± 56.15	43	0.328	0.744
Carapace Width (mm)	321.32 ± 78.22	34	317.72 ± 51.48	43	0.232	0.818
Plastron Length (mm)	299.18 ± 67.36	34	295.14 ± 55.17	43	0.282	0.778
Plastron Width (mm)	277.91 ± 53.42	34	272.14 ± 48.65	43	0.490	0.626
Head Length (mm)	143.84 ± 35.39	32	142.24 ± 21.33	37	0.223	0.824
Head Width (mm)	126.88 ± 30.98	32	122.14 ± 15.16	37	0.788	0.435
Post-Anal Tail Length (mm)	304.47 ± 45.44	32	301.30 ± 63.67	37	0.240	0.811
Pre-Anal Tail Length (mm)	81.38 ± 39.81	32	76.72 ± 30.99	36	0.533	0.596
Total Tail Length (mm)	385.84 ± 67.54	32	376.08 ± 70.79	37	0.586	0.560
Mass (kg)	15.89 ± 11.67	34	13.45 ± 4.96	42	1.138	0.262

Figure 7. Map of Sequoyah National Wildlife Refuge.

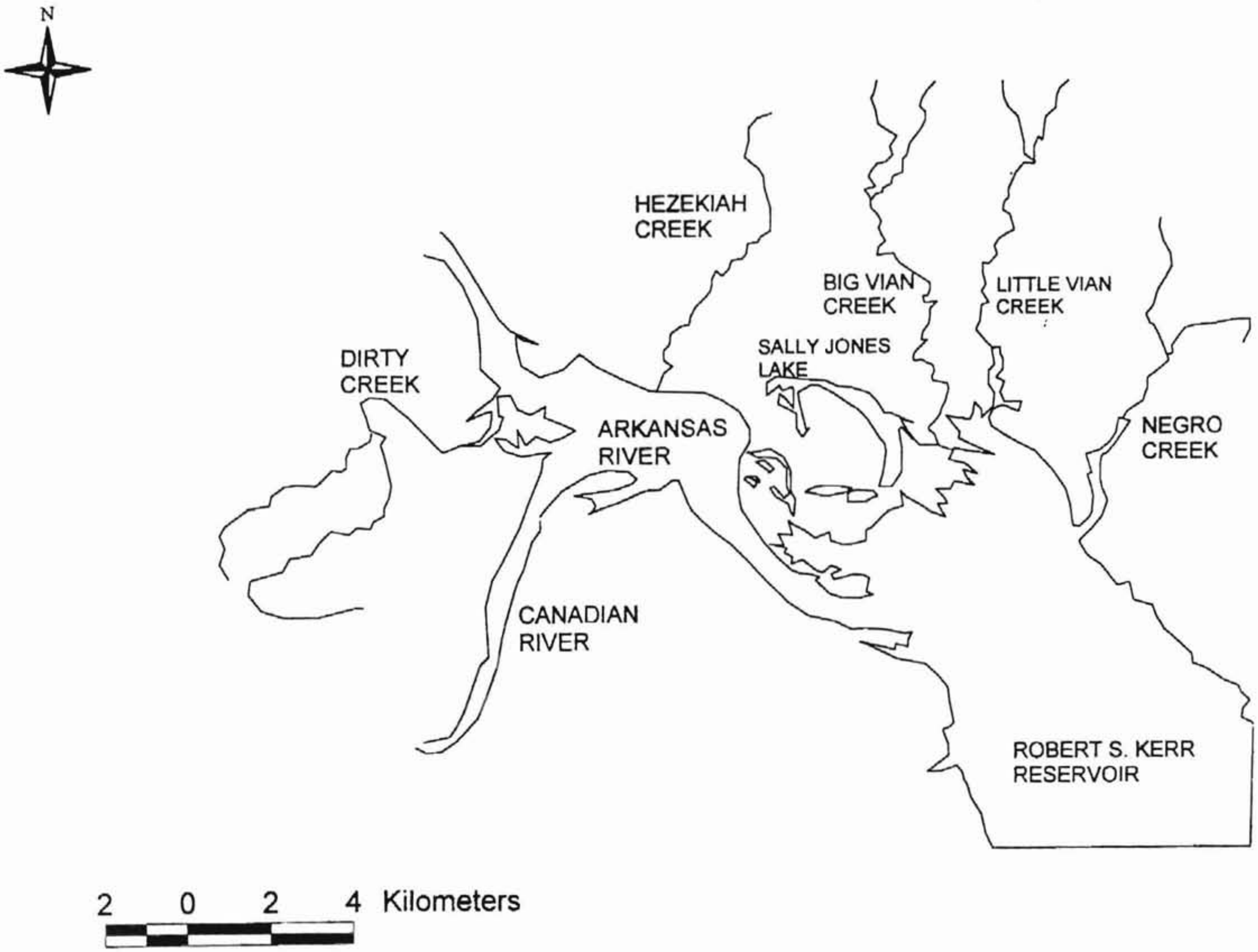
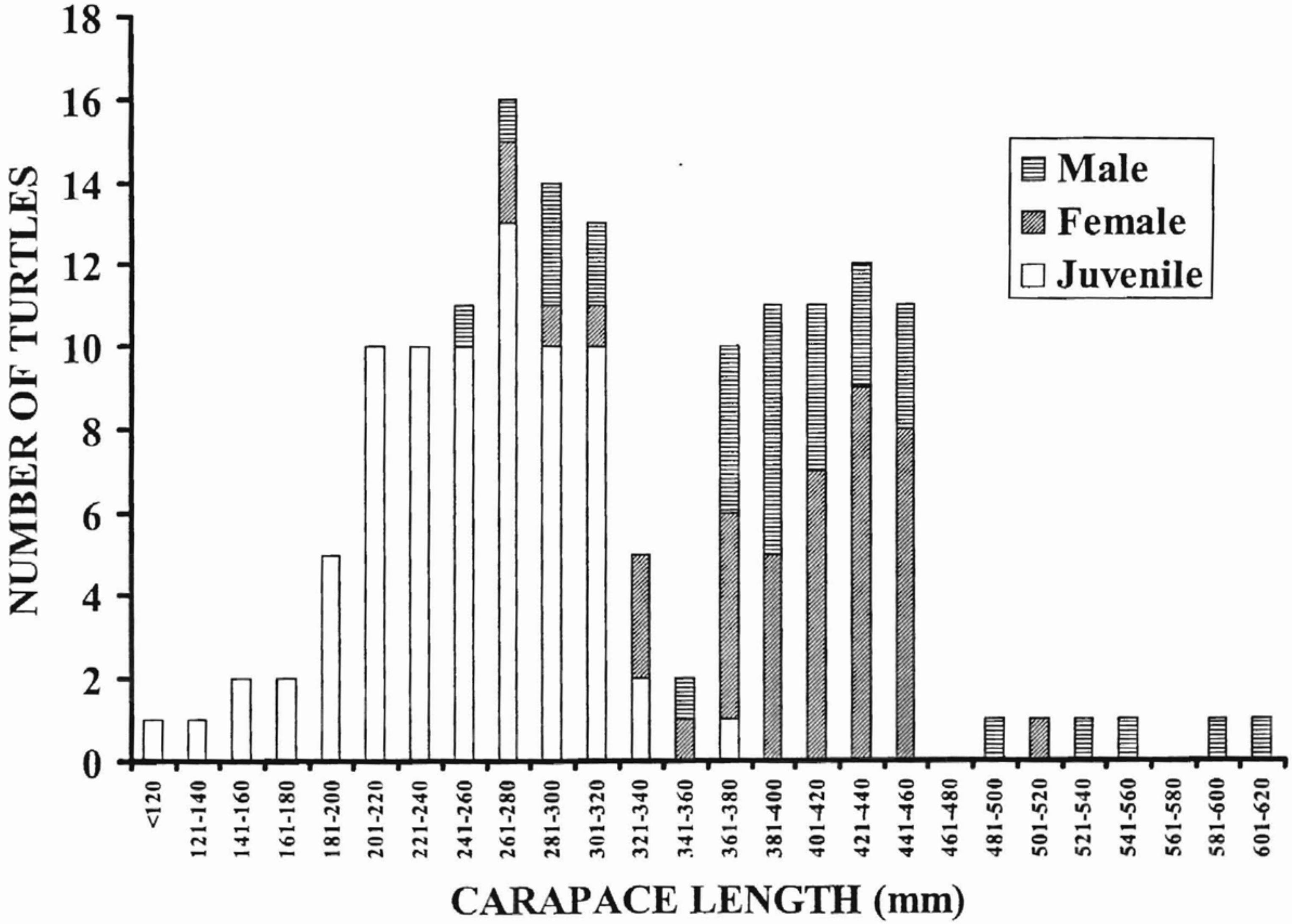

N
HEZEKIAH CREEK
BIG VIAN CREEK
LITTLE VIAN CREEK
SALLY JONES LAKE
DIRTY CREEK
ARKANSAS RIVER
NEGRO CREEK
CANADIAN RIVER
ROBERT S. KERR RESERVOIR
2 0 2 4 Kilometers

Figure 8. Histogram of size classes, based on carapace length in millimeters, of *Macrochelys temminckii* captured at Sequoyah National Wildlife Refuge.


NUMBER OF TURTLES
18
16
14
12
10
8
6
4
2
0
Male
Female
Juvenile
<120
121-140
141-160
161-180
181-200
201-220
221-240
241-260
261-280
281-300
301-320
321-340
341-360
361-380
381-400
401-420
421-440
441-460
461-480
481-500
501-520
521-540
541-560
561-580
581-600
601-620
CARAPACE LENGTH (mm)

CHAPTER IV

MICROHABITAT USE, HOME RANGE, AND MOVEMENTS OF *Macrochelys temminckii* IN SEQUOYAH COUNTY OKLAHOMA

One of the earliest records of movement of *Macrochelys temminckii* was a 23-kg individual captured in the Washita River in Bryan County, Oklahoma, in 1915 (Wickham, 1922). The turtle was re-released in the Blue River, Bryan County, Oklahoma, in 1918, then recaptured in 1921 some 27-30 km upstream from the release site. More thorough studies (Sloan and Taylor, 1987; Shipman et al., 1991; Harrel et al., 1996; Shipman and Neeley, 1998) have been conducted in Kansas, Louisiana, and Missouri. Results from those studies showed that *M. temminckii* moved extensively throughout its aquatic environment, although individuals chose specific microhabitat sites as resting or core sites. The core sites had more structural cover and denser overhead canopy than other available habitats. *M. temminckii* is typically thought to be fairly sedentary (Ernst et al., 1994). Shipman et al. (1991) observed that individuals would remain inactive for up to eight days at a time.

I conducted a mark-recapture study of *M. temminckii* at Sequoyah National Wildlife Refuge (SNWR), Sequoyah County, Oklahoma, outfitting individuals with telemetry tags. The primary goal was to quantify microhabitat use and possible core site selection. Movement data also were collected to determine movement patterns and home range use by *M. temminckii*. Previous studies had been conducted in more open, lentic environments (Sloan and Taylor, 1987) and a larger river (Shipman and Neeley, 1998). The site at SNWR consisted of two small creeks that emptied into the Arkansas River.

The only other study conducted in this type of smaller, lotic habitat was completed by Shipman (1993) in Kansas. The sample size for the Kansas study was only one individual, a 24.7-kg female. The study on SNWR provides more complete data on the species and also provides a comparison to populations in a variety of habitats.

Materials and Methods

Between June 1999 and August 2000, 18 individuals (Appendix C) of *M. temminckii* were outfitted with ultrasonic tags. Tags were temperature-sensitive ultrasonic tags that were 65 mm in length and had a mass of 8 g. Tags were attached to the rear margin of the carapace by drilling 0.63-cm holes in the carapace and looping heavy gauge monofilament fishing line and plastic cable ties through the holes and transmitters. Turtles were tracked using a Sonotronics USR-5W digital receiver and a directional hydrophone (Sonotronics, Tucson, AZ). Turtle locations were pinpointed using triangulation.

The study area was divided into sub-areas, Big Vian Creek and Little Vian Creek. Big Vian Creek was navigable from the mouth to 4 km upstream, while Little Vian Creek was navigable from the mouth to 2 km upstream. The mouths of the two streams were separated by 0.5-km straight distance.

At each turtle location, a set of microhabitat variables was taken. Data included depth of the stream, canopy cover, temperature at the bottom of the stream, substrate, and cover type. Canopy cover was estimated with a concave forestry densiometer (Lemmon, 1957). Temperature data taken at turtle locations were recorded from the telemetry tag.

Microhabitat used by the turtles was compared against microhabitat taken at random points. To this end, a grid was first laid over the study area. The grid was composed of a numbered flag placed every 50 m from the mouth of each stream to the point at which the stream became unnavigable. Random points could then be chosen along the stream by using x-y coordinates along the grid. The x-coordinate corresponded to points at or between numbered flags, while the y-coordinate represented distance from the bank. Random coordinates were chosen by selecting a set of numbers from a random number table. The same set of microhabitat data was recorded at a random point paired with each turtle point the same day.

Turtles were checked two to three times weekly from June through the first part of August. They also were checked sporadically throughout fall (September-October) and winter (November-February). A linear home range was determined by measuring the distance between the two farthest points along the stream at which a turtle was located. Movement patterns were analyzed only for the period of time between June and August when regular location checks were made. The only movements included in the analysis were those between core sites, or from a core site to a baited net. A core site was any location occupied by a turtle for more than one day.

Results

I was able to obtain at least two months of data on 16 individuals (7 males, 3 females, 6 juveniles). One hundred and forty-seven locations were recorded, and 109 locations were used for microhabitat analysis. Paired *t*-tests were used to compare microhabitat data collected at each turtle location to those collected at random locations. Seasonal differences in microhabitat use also were analyzed.

There was no difference in temperature between turtle locations and random locations. Turtles did select for sites that exhibited higher percentage of canopy cover ($p < 0.001$). Turtles were always associated with some sort of structure, including overhanging trees and shrubs, dead submerged trees, and beaver dens. The only exceptions were when individuals were in water too deep to discern any submerged cover. There was no difference between depths used by turtles and random depths although seasonal differences in depth use were observed (Figure 9). Turtles used deeper water during extreme times of the year. The depths were significantly deeper in the hottest months (July, August; $t = -4.27$, df = 75, $p = <0.001$) and the coldest months (January, February; $t = -4.94$, df = 33, $p = <0.001$) than during early summer months (May, June). Seasonal differences in temperatures of turtles were also observed but followed natural fluctuations in water temperature (Figure 10).

The mean linear home range for all turtles was 777.8 m. Females had significantly larger linear home ranges than males, and, although not significant, juveniles had larger linear home ranges than adults (Table V). The average distance moved between core sites was 431.2 m for juveniles and 219.3 m for adults. Again, females tended to make longer movements than males, and juveniles made longer movements than adults, but the distances were not significantly different (Table V). Turtles made nearly twice as many movements in June than in July. During the summer field season when regular location points were taken (June--August), all turtles remained at core sites for an average of 12.3 days before moving to new core sites. The range of time a turtle remained at a core site during summer varied from 1 to 38 days. All turtles remained each at a single core site throughout winter (November--February).

There were three instances of movement between creeks based on mark-recapture data. Two turtles, a 5.4-kg juvenile and 9.5-kg male, moved from Big Vian Creek to

Little Vian Creek. The original captures and recaptures occurred one year apart. The third instance was a 11.8-kg female recaptured in Hezekiah Creek two months after its first capture in Big Vian Creek. Hezekiah Creek also is a tributary of the Arkansas River and is located 16 km upstream from Big Vian Creek.

Macrochelys temminckii was observed active on only one occasion. An individual estimated at 5 kg was observed surfacing to breathe in about 3 m of water. The incident occurred at 1945 hours on 12 July 2000. The water was fairly clear and visibility was roughly 2 m in depth.

Discussion

Throughout the course of the study, individuals of *M. temminckii* moved throughout the whole study area, but chose specific microhabitat sites as resting or core sites. Females moved somewhat longer distances and occupied significantly larger home ranges than males. There were slight differences in movement patterns between adults and juveniles; juveniles had larger home ranges and made longer movements.

Shipman and Neeley (1998) found that *M. temminckii* in the St. Francis River of Missouri had a mean linear home range of 1,793.6 m. This was considerably larger than what I found in my study. There were major differences between the study sites; the Missouri study took place in a large river and the Oklahoma sites in my study were smaller streams. The major constraint on home-range size in *M. temminckii* may be availability of suitable habitat, such as appropriate water depths and submerged shelter.

Movement was primarily restricted to distances between core sites. Turtles occupied core sites for several days to several months. The types and duration of movements from a core site are poorly known. Shipman et al. (1991) observed a 24.7-kg female in Kansas and recorded movements between 0200 and 0700 hours lasting for 1-3 hours. On three occasions at SNWR, nocturnal checks were made on several turtles at 2 hr intervals. An 11.8-kg male was observed making an inter-core site movement between 2000 and 2200 hours. The individual was moving when he was located and proceeded to move another 200 m upstream within a two-hour period before settling underneath a fallen tree. No other movements were recorded during those nocturnal observations.

Movements out of a local study area also may occur. Several tagged individuals disappeared from the study area, suggesting possible dispersal. A mark-recapture study taking place concurrently on the refuge provided evidence for three cases of inter-creek dispersal. One instance involved an individual moving 16 km in a two-month time period. *Macrochelys temminckii* is known to make long movements. The 24.7-kg female studied by Shipman et al. (1991) moved 7 km in five years. An Oklahoma specimen moved between 27-30 km in three years (Wickham, 1922). Dispersal along rivers may be a common phenomenon for *M. temminckii*. Specimens reach the northern extent of the species range upstream along the Mississippi River in Illinois and Iowa (Pritchard, 1989) and into Kansas upstream along the Arkansas, Verdigris, and Neosho rivers (Shipman et al., 1995).

Two kilometers up Little Vian Creek, stream morphology changed from deeper water runs with a mud-sand-detritus substrate to a gravel-bottom, riffle-pool habitat. Riffles were generally < 25 cm in depth, with some pools reaching 2-3 m in depth. This riffle-pool habitat is not generally thought to be ideal *M. temminckii* habitat. During summer 1999, a 16.8-kg female outfitted with an ultrasonic tag occupied core sites near the transition between deeper runs and shallower riffles. After a high water event in late summer 1999, the female disappeared. She was not located again until June 2000, again near this stream morphology transition zone. One hypothesis is that during the high water event, the turtle was able to move upstream into some of the deeper pools, and then moved back downstream when water levels subsided.

Core sites used by *M. temminckii* were all similar in that they consisted of some type of submerged structure with dense overhead canopy cover. Cover types were generally submerged logs, but turtles also used overhanging shrubs and beaver dens. *Macrochelys temminckii* may use beaver dens as diurnal refugia due to the cover they offer and air pockets that they contain. Beaver dens at SNWR are composed of a tunnel leading under the bank into a partially submerged chamber. A 34.5-kg male was observed on several occasions occupying such a den. Based on the sporadic signal given off by the ultrasonic telemetry tag, the turtle was resting at or near the surface of the water. Ultrasonic signals can be received only through a liquid medium, and the signal cut out in such a pattern as to suggest that the carapace was bobbing in and out of the water.

A very intriguing set of data is the variation in seasonal depth use by *M. temminckii* at SNWR. Very little is known about thermoregulation in *M. temminckii*. It does not bask, and only females leave the water (to lay eggs). Captive individuals refuse food at 18^0 C, become inactive at 10^0 C, and have a critical thermal maxima between 38.5 and 40.7^0 C (Allen and Neil, 1950; Hutchison et al., 1966; Grimpe, 1987).

Based on seasonal depth use (Figure 9), I suggest that *M. temminckii* may thermoregulate by altering their depth in the water column. Temperature data (Figure 10) do not seem to support this theory because there was no difference in temperature between random points and turtle locations. There are, however, several factors that may have influenced this discrepancy in the data sets. One factor may be that the ultrasonic tags were placed externally on the turtles, and because the tags were relatively small, fluctuations in temperature would be greater for the telemetry tag than for the turtle. However, one must also consider that *M. temminckii* is extremely sedentary, remaining in the same place for several days to weeks. This should have been ample time to allow for the tag and turtle to adjust to the current water temperature.

Another factor may be the thermal characteristics of the water body itself. Slow-moving streams will generally stratify at different times of the year, with deeper depths being cooler in summer and warmer in winter (Allen, 1995). The study site at SNWR remained stratified through June but became isothermal in August (Figure 11). Differences in temperatures at varying depths in the early part of the summer support the theory of seasonal depth use for thermoregulation, because turtles are using the shallower, warmer water, but why did they go deeper in August if there was no difference in water temperature between depths?

One flaw in the methodology was that surface temperatures were not taken at either turtle locations or random points. Because *M. temminckii* is a bottom-dwelling turtle, temperature was taken at the bottom, or as close to the bottom of the stream as possible. Because water is a thermally stable medium, fluctuations in temperature would be greater near the surface as opposed to deeper in the water column. Impromptu checks of surface temperature at about 10-20 cm in depth showed readings as high as 34-35^0 C in late July and August and 3^0 C in February. When the February reading was taken, there was a 2-3-cm layer of ice cover the surface. The water at SNWR also was very turbid, which did not allow solar radiation to penetrate very deeply. Even if the water were isothermal in August, turtles could potentially avoid exposure to solar radiation and extreme fluctuations in surface temperature by remaining in deep water.

Macrochelys temminckii seems to be a generalist as far as habitat is concerned (Chapter 2). Limiting factors to its distribution may be availability of cover and adequate water depth. *Macrochelys temminckii* is a very secretive species, and it is still not understood why it moves from one core site to another and what determines duration of the stays at each core site. *Macrochelys temminckii* did occur in fairly high densities on SNWR (33 individuals/km stretch of stream) and competition for food and space may be one factor that stimulates movement from one core site to another. Regardless, *M. temminckii* does disperse over considerable distances, and this may be a mechanism for colonization of new sites. From a conservation standpoint, river impoundments may be the major factor affecting dispersal between healthy and depleted populations in Oklahoma and elsewhere.

TABLE V

SEASONAL COMPARISONS OF DEPTH USE BY *Macrochelys temminckii*, AT SEQUOYAH NATIONAL WILDLIFE REFUGE

EARLY SUMMER MEAN ± 1 SD	LATE SUMMER MEAN ± 1 SD	WINTER MEAN ± 1 SD	*t*	*p*
1.21 m ± 0.70	1.85 m ± 0.76	--	-4.274	<0.001
1.21 m ± 0.70	--	2.14 m ± 0.78	-4.941	<0.001
--	1.85 m ± 0.76	2.14 m ± 0.78	-0.313	0.755

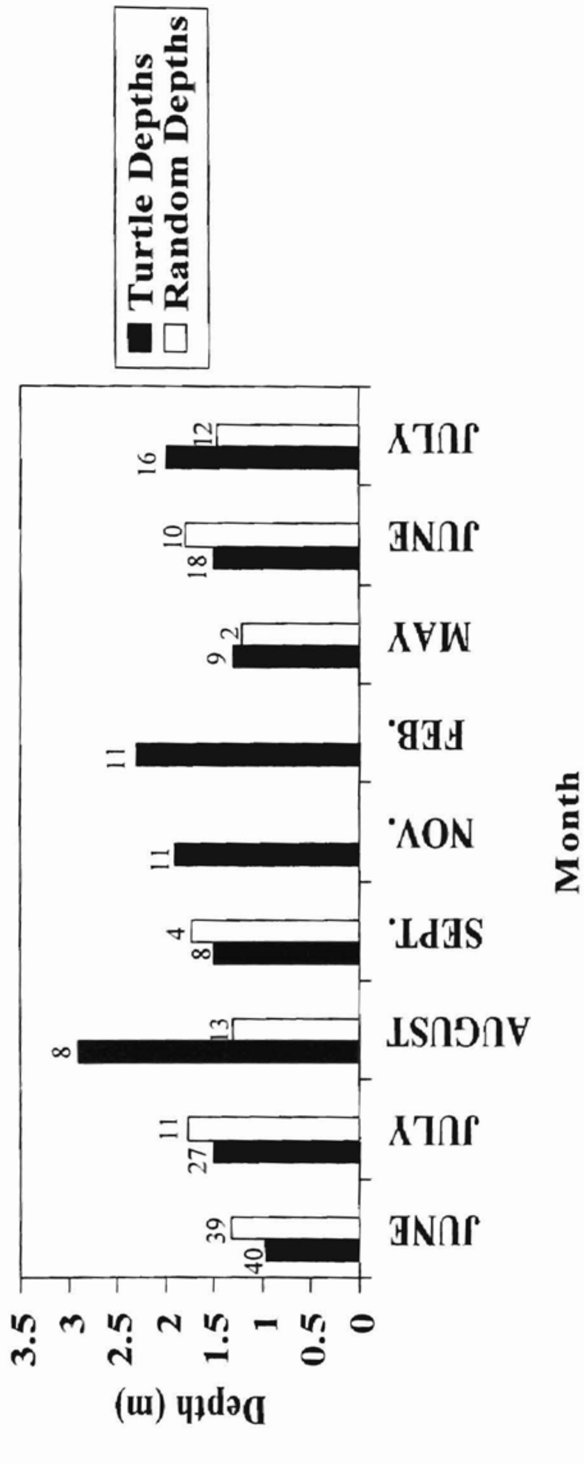
TABLE VI

MEAN HOME RANGE SIZE (± 1 SD), MEAN DISTANCE MOVED BETWEEN CORE SITES (± 1 SD), AND TOTAL NUMBER OF SUMMER MOVEMENTS MADE BY MALE, FEMALE, AND JUVENILE *Macrochelys temminckii*

SEX	n	MEAN HOME RANGE SIZE (m)	MEAN DISTANCE MOVED BETWEEN CORE SITES (m)	NUMBER OF MOVEMENTS	
				JUNE	JULY
MALE	7	481.4 ± 227.7[1,2]	168.2 ± 137.1[3,4]	16	13
FEMALE	3	878.3 ± 298.4[1,2]	249.2 ± 218.6[3,4]	13	6
JUVENILE	6	1073.3 ± 1015.4[2]	431.2 ± 542.2[4]	17	10

[1]Males vs. Females: *t*-test, $t = -2.32$, $p = 0.048$
[2]Adults vs. Juveniles: *t*-test, $t = -1.40$, $p = 0.18$
[3]Males vs. Females: *t*-test, $t = -1.29$, $p = 0.21$
[4]Adults vs. Juveniles: *t*-test, $t = -1.73$, $p = 0.097$

Figure 9. Mean depths by month taken at *Macrochelys temminckii* locations and random points at Sequoyah National Wildlife Refuge. Numbers above bars represent sample size.



Turtle Depths
Random Depths
Depth (m)
3.5
3
2.5
2
1.5
1
0.5
0
JUNE
JULY
AUGUST
SEPT.
NOV.
FEB.
MAY
JUNE
JULY
Month

Figure 10. Mean temperatures by month taken at *Macrochelys temminckii* locations and random points at Sequoyah National Wildlife Refuge.

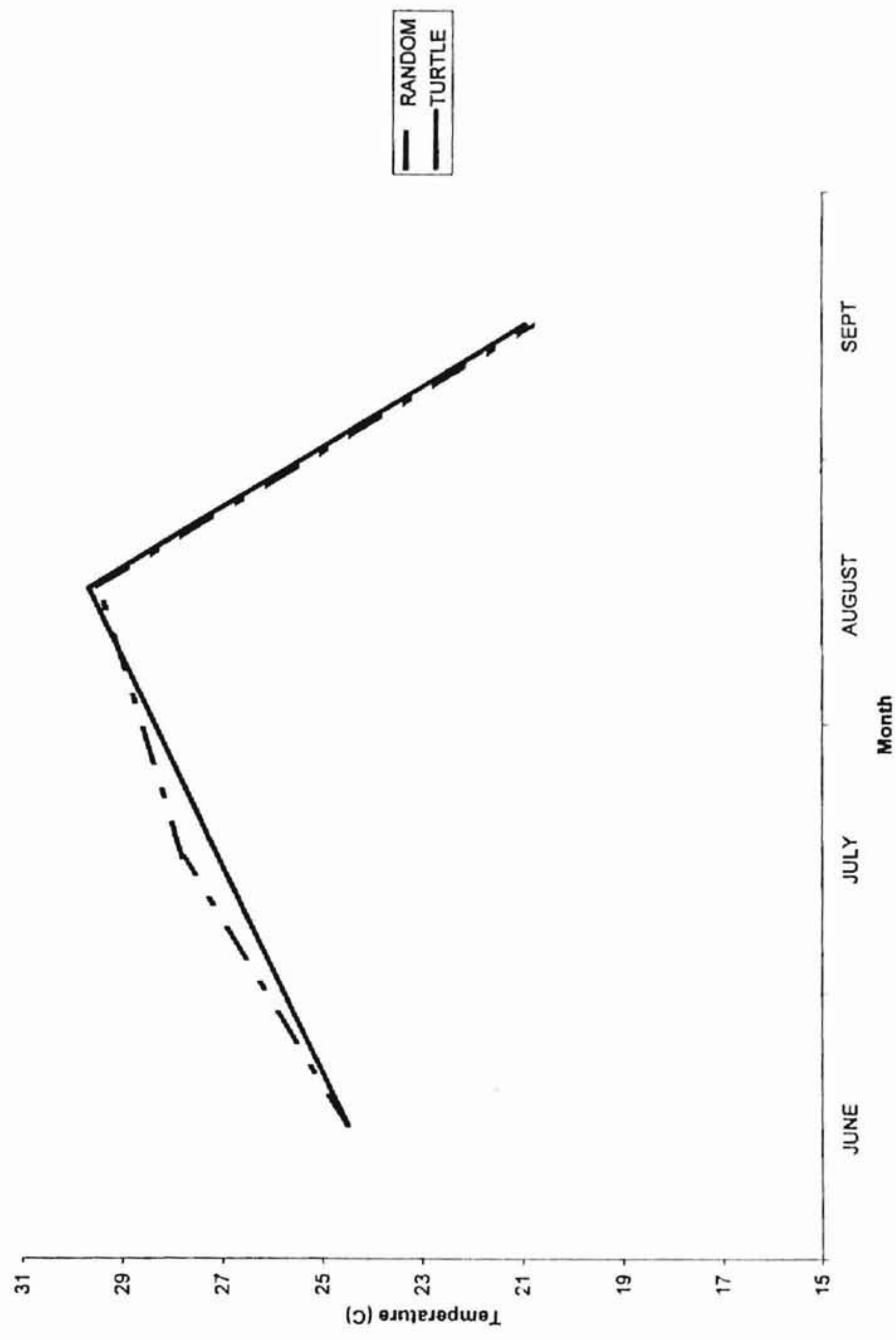
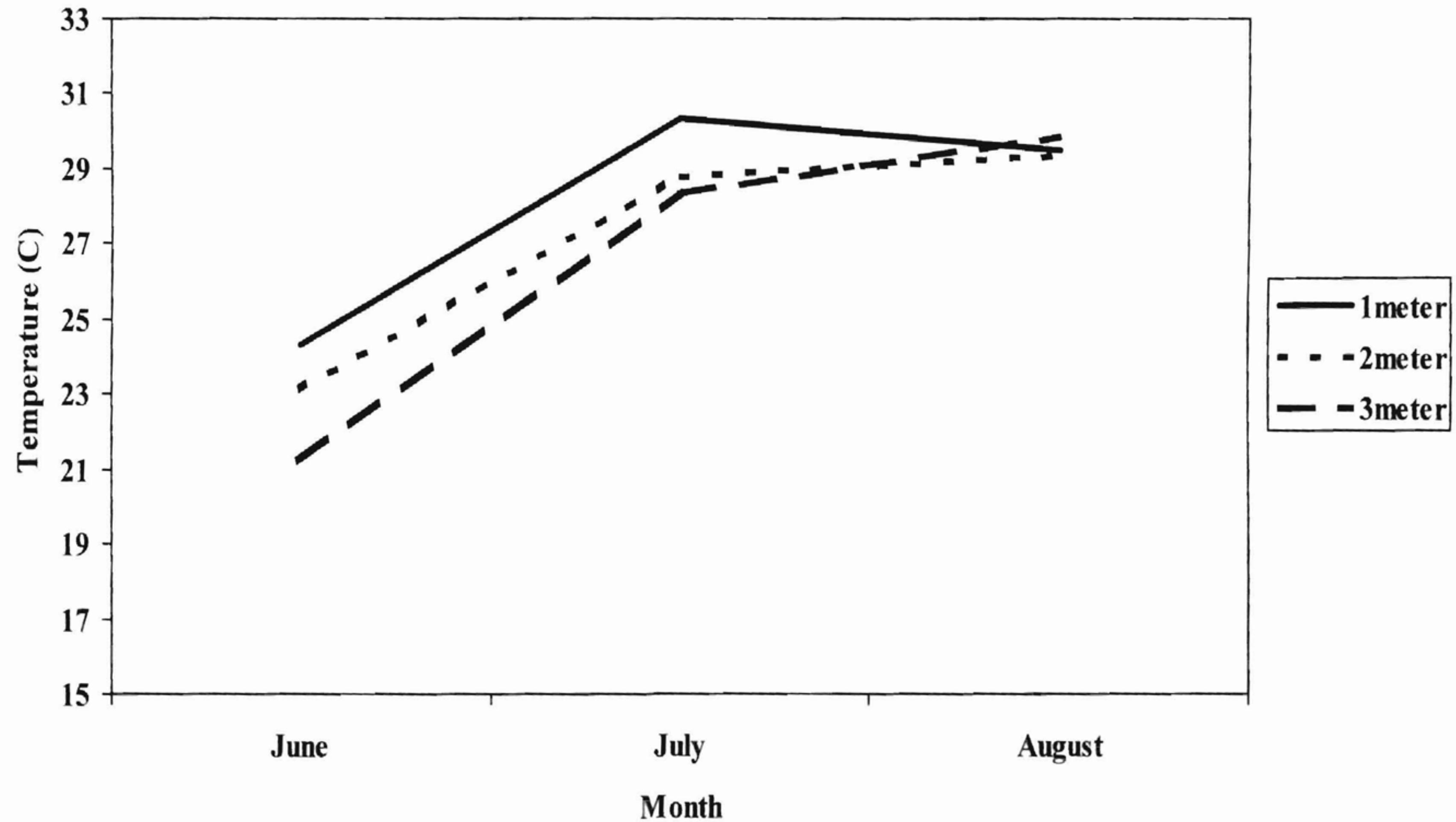

RANDOM
TURTLE
Temperature (C)
31
29
27
25
23
21
19
17
15
JUNE
JULY
AUGUST
SEPT
Month

Figure 11. Mean random water temperatures taken by month at varying depths at Sequoyah National Wildlife Refuge.



33
31
29
27
25
23
21
19
17
15
Temperature (C)
June
July
August
Month
1meter
2meter
3meter

CHAPTER V

CONCLUSIONS

The alligator snapping turtle, *Macrochelys temminckii*, is a large freshwater turtle that was probably once common throughout most of eastern Oklahoma. Current trends show a very dramatic decline in *M. temminckii* numbers throughout the state. Reasons for these declines are most likely habitat alteration and overharvest. Harvest of *M. temminckii* is the primary suspect in the species decline. Habitat alteration in the form of impoundment of waterways may have had a secondary effect by barring dispersal of individuals from unimpacted to impacted populations.

The demand for *M. temminckii* meat seems to have reached its peak in popularity in the 1960s and 1970s when the turtle was harvested heavily throughout most of its range (Pritchard, 1989; Sloan and Lovich, 1995). Currently, Louisiana is the only state that still allows harvest of *M. temminckii*; it is currently protected throughout the rest of its range. A recent study of meat markets in Florida and Louisiana showed that *M. temminckii* is only rarely offered and seems to have been replaced by the more common, widespread, and unregulated common snapping turtle, *Chelydra serpentina* (Roman and Bowen, 2000). It has been suggested that wild populations of *M. temminckii* have been depleted to the point where the capture of marketable-sized specimens is cost ineffective.

The same trend that has been observed in *M. temminckii* has now being seen in other species of aquatic turtles in Oklahoma. Since legalization of commercial turtle harvesting in Oklahoma in 1994, large numbers of several species of aquatic turtles in Oklahoma have been harvested and exported. These turtles are used in meat and pet markets in the United States and in ever-growing foreign markets (Compton, 2000). Some aquatic turtle communities in Oklahoma seem to have been seriously depleted. Measures need to be taken to prevent further harm to Oklahoma turtle species.

Recovery of *M. temminckii* and other aquatic turtle species may be as simple as cessation of harvest, at least in most lotic habitats and their associated impoundments. Commercialization should at least be more strictly regulated. Currently, there is no accurate count of the number of species harvested or the location of the harvests. The only numbers recorded by the Oklahoma Department of Conservation are numbers of turtles bought and exported by turtle buyers licensed in Oklahoma.

Studies conducted on *M. temminckii* in Oklahoma and elsewhere show it to be fairly abundant along rivers. That is, it is abundant if left alone. Population data from the Sequoyah National Wildlife Refuge show that if populations are afforded complete protection, they stand a good chance of recovery. This protection is what is needed in Oklahoma and throughout the range of *M. temminckii.*

Macrochelys temminckii is totally aquatic and never leaves the water except to lay eggs (Ernst et al., 1994). Thus, impoundments of rivers impede gene flow. Consequently, some human intervention may be needed in aiding dispersal of both adults and hatchlings. Care should be taken in this endeavor, however, given the population ecology of *M. temminckii.*

Roman et al. (1999) examined mitochondrial DNA of individuals from 12 different river drainages and discovered eight river specific genetic haplotypes. No genetic work has been conducted in Oklahoma but should be considered before specimens are released haphazardly throughout the state. There could possibly be two genetically-distinct populations: those of the Arkansas River and Red River drainages.

There is obviously still a chance to restore *M. temminckii* populations in Oklahoma. It will require the proper resources and strict protection over a long period of time. Alfred Sherwood Romer (1933:p176) in his book *Vertebrate Paleontology* stated that "Because they are still living, turtles are commonplace objects to us; were they entirely extinct, their shells -- the most remarkable defensive armor ever assumed by a tetrapod -- would be cause for wonder." Hopefully we can manage and protect what we have before it is gone.

Literature Cited

Ades, G., C. B. Banks, K. A. Buhlmann, B. Chan, H. C. Chang, T. H. Chen, P. Crow, H. Haupt, R. Kan, J. Y. Lai, M. Lau, H. C. Lin, and S. Haitao. 2000. Turtle trade in northeast Asia: regional summary (China, Hong Kong, and Taiwan). Pp. 52-54 In: P. P. van Dijk, B. L. Stuart, and A. G. J. Rhodin editors. Asian Turtle Trade. Chelonian Research Foundation Chelonian Research Monograph number 2:164 pp.

Allen, E. R. and W. T. Neill. 1950. The Alligator Snapping Turtle, *Macroclemys temminckii,* in Florida. Special Publication No. 4, Ross Allen's Reptile Institute.

Allen, J. D. 1995. Stream Ecology: Structure and Function of Running Waters. Kluwer Academic Publishers, Boston. 388 pp.

Black, J. H. 1982. An annotated bibliography to articles, notes and photographs on reptiles and amphibians appearing in Oklahoma Game And Fish News, Oklahoma Wildlife, and Outdoor Oklahoma. Oklahoma Herpetological Society Special Publication Number 2.

Cagle, F. R., and A. H. Chaney. 1950. Turtle populations in Louisiana. American Midland Naturalist 43:383-388.

Carpenter, C. C., and J. J. Krupa. 1989. Oklahoma Herpetology: An Annotated Bibliography. University of Oklahoma Press, Norman. 258 pp.

Chen, T. H., H. C. Lin., and H. C. Chang. 2000. Current status of and utilization of chelonians in Taiwan. Pp. 45-51 In: P. P. van Dijk, B. L. Stuart, and A. G. J. Rhodin editors. Asian Turtle Trade. Chelonian Research Foundation Chelonian Research Monograph number 2:164 pp.

Clarke, R. F. 1981. A record of the alligator snapping turtle, *Macroclemys temminckii*, (Testudines: Chelydridae), in Kansas. Transactions of the Kansas Academy of Science 84:59-60.

Collins, J. T. 1993. Amphibians and Reptiles in Kansas. 3rd edition. University Press of Kansas, Lawrence. 397 pp.

Compton, J. 2000. An overview of Asian turtle trade. Pp 24-29 In: P. P. van Dijk, B. L. Stuart, and A. G. J. Rhodin editors. Asian Turtle Trade. Chelonian Research Foundation Chelonian Research Monograph number 2:164 pp.

Conant, R., and J. T. Collins. 1998. A Field Guide to Reptiles and Amphibians: Eastern And Central North America. 3rd edition. Houghton Mifflin Company, Boston. 616 pp.

Conant, R. and R. G. Hudson. 1949. Longevity records for reptiles and amphibians in the Philadelphia Zoological Garden. Herpetologica 5:1-8.

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

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

Dobie, J. L. 1971. Reproduction and growth in the alligator snapping turtle, *Macroclemys temminckii* (Troost). Copeia 1971:645-658.

Dundee, H. A., and D. A. Rossman. 1989. The Amphibians and Reptiles of Louisiana. Louisiana State University Press, Baton Rouge. 300 pp.

Ernst, C. H., and R. W. Barbour. 1989. Turtles of the World. Smithsonian Institution Press, Washington D. C. 313 pp.

Ernst, C. H., J. E. Lovich, and R. W. Barbour. 1994. Turtles of the United States and Canada. Smithsonian Institute Press, Washington, D. C. 313 pp.

Ewert, M. A. 1976. Nests, nesting and aerial basking of *Macroclemys* under natural conditions, and comparisons with *Chelydra* (Testudines: Chelydridae). Herpetologica 32:150-156.

Galbreath, E. C. 1961. Two alligator snappers, *Macroclemys temminckii*, from southern Illinois. Transactions of the Illinois State Academy of Science 54:134-135.

Gibbs, J. P., and G. D. Amato. 2000. Genetics and demography in turtle conservation. Pp. 207-217 In: M. W. Klemens editor. Turtle Conservation. Smithsonian Institution Press, Washington D. C. 334 pp.

Gibbons, J. W., and D. H. Nelson. 1978. The evolutionary significance of delayed emergence from the nest by hatchling turtles. Evolution 32:297-303.

Glass, P. B. 1949. *Macroclemys temminckii* in Oklahoma. Copeia 1949(2):138-141.

Graves, B. M., and S. H. Anderson. 1987. Habitat suitability index models: snapping turtle. United States Fish and Wildlife Service Biological Report 82(10.141). 18 pp.

Grimpe, R. 1987. Maintainence, behavior, and reproduction of the alligator snapping turtle, *Macroclemys temminckii*, at the Tulsa Zoological Park. Bulletin of the Oklahoma Herpetological Society 12:1-6.

Harrel, J. B., C. M. Allen, and S. J. Herbert. 1996. Movements and habitat use of subadult alligator snapping turtles, *Macroclemys temminckii*, in Louisiana. American Midland Naturalist 135:60-67.

Heck, B. A. 1998. The alligator snapping turtle (*Macroclemys temminckii)* in southeast Oklahoma. Proceedings of the Oklahoma Academy of Science 78:53-58.

Hutchison, V. H., A. Vinegar, and R. J. Kosh. 1966. Critical thermal maxima in turtles. Herpetologica 22:32-41.

Jackson, C. G., Jr., and A. Ross. 1971. The occurrence of barnacles on the alligator snapping turtle, *Macroclemys temminckii* (Troost). Journal of Herpetology 5:188-189.

Lau, M., B. Chan, P. Crow, and G. Ades. 2000. Trade and conservation of turtles and tortoises in the Hong Kong Special Administrative Region, People's Republic of China. Pp. 39-44 In: P. P. van Dijk, B. L. Stuart, and A. G. J. Rhodin editors. Asian Turtle Trade. Chelonian Research Foundation Chelonian Research Monograph number 2:164 pp.

Lemmon, P. E. 1957. A new instrument for measuring forest overstory density. Journal of Forestry 55:667-668.

Moll, E. O. and D. Moll. 2000. Conservation of river turtles. Pp 126-155 In: M. W. Klemens editor. Turtle Conservation. Smithsonian Institution Press, Washington D. C. 334 pp.

Palmer, M. W. 1993. Putting things in even better order: the advantages of canonical correspondance analysis. Ecology 74:2215-30.

Powders, V. N. 1978. Observations of oviposition and natural incubation of eggs of the alligator snapping turtle, *Macroclemys temminckii*, in Georgia. Copeia 1978:154-156.

Powell, R., J. T. Collins, and E. D. Hooper, Jr. 1998. A Key to Amphibians and Reptiles of the Continental United States and Canada. University Press of Kansas, Lawrence. 131 pp.

Pritchard, P. C. H. 1989. The Alligator Snapping Turtle: Biology and Conservation. Milwaukee Public Museum, Wisconsin. 104 pp.

Ramus, E. 1998. The Herpetology Source Book. Ramus Publishing, Inc. Pottsville, Pennsylvania. 254 pp.

Roman, J., S. D. Santhuff, P. E. Moler, and B. W. Bowen. 1999. Population structure and cryptic evolutionary units in the alligator snapping turtle. Conservation Biology 13:135-142.

Roman. J., and B. W. Bowen. 2000. The mock turtle syndrome: genetic identification of turtle meat purchased in the south-eastern United States of America. Animal Conservation 3:61-65.

Romer, A. S. 1933. Vertebrate Paleontology. The University of Chicago Press. 687 pp.

Santhuff, S. D. 1993. Alligator snapping turtle, *Macroclemys temminckii*, trap, mark, and release project 1993. Final Report to the Missouri Department of Conservation, Jefferson City, Missouri. 17 pp.

Shipman, P. A. 1993. Alligator Snapping Turtle, habitat selection, movements, and natural history in southeast Kansas. Unpubl. M.S. Thesis. Emporia State University, Emporia, Kansas. 90 pp.

Shipman, P. A., D. R. Edds, and D. Blex. 1991. Report on the recapture of an alligator snapping turtle (*Macroclemys temminckii*) in Kansas. Kansas Herpetological Society Newsletter 85:8-9.

Shipman, P. A., and D. Riedle. 1994. Alligator snapping turtle, *Macrclemys temminckii*, trap, mark and release project 1994. Final Report to the Missouri Department of Conservation, Jefferson City, Misouri. 29 pp.

Shipman, P. A., D. R. Edds, and L. E. Shipman. 1995. Distribution of the alligator snapping turtle (*Macroclemys temminckii*) in Kansas. Transactions of the Kansas Academy of Science 98(3-4):83-91.

Shipman, P. A., and A. Neeley. 1998. Alligator snapping turtle trap, mark, and telemetry project. Final Report to the Missouri Department of Conservation, Jefferson City, Missouri. 35 pp.

Sloan, K. N., and D. Taylor. 1987. Habitats and movements of adult alligator snapping turtles in northeast Louisiana. Proceedings of the annual conference of Southeastern Association of Fish and Wildlife Agencies 41:343-348.

Sloan, K. N., K. A. Buhlmann, and J. E. Lovich. Stomach contents of commercially harvested adult alligator snapping turtles, *Macroclemys temminckii*. Chelonian Conservation and Biology 2:96-99.

Snider, A. T., and J. K. Bowler. 1992. Longevity of reptiles and amphibians in North American collections, second edition. Society for the Study of Amphibians and Reptiles Herpetological Circular (21):1-40.

Thorbjarnarson, J., C. J. Lageux, D. Bolze, M. W. Klemens, and A. B. Meylan. 2000. Human use of turtles:a worldwide perspective. Pp 33-84 In: M. W. Klemens editor. Turtle Conservation. Smithsonian Institution Press, Washington D. C. 334 pp.

Trauth, S. E., J. D. Wilhide, and A. Holt. Population structure and movement patterns of alligator snapping turtles (*Macroclemys temminckii*) in northeastern Arkansas. Chelonian Conservation and Biology 3:64-70.

Tucker, A. D., and K. N. Sloan. Growth and reproductive estimates from alligator snapping turtles, *Macroclemys temminckii*, taken by commercial harvest in Louisiana. Chelonian Conservation and Biology 2:587-592.

United States Fish and Wildlife Service. 1991. 1991 status review of the alligator snapping turtle (*Macroclemmys temminckii*). Endangered Species Office, Jackson, Mississippi. 26 pp.

Webb, R. G. 1970. Reptiles of Oklahoma. University of Oklahoma Press, Norman. 370pp.

Webb, R. G. 1995. The date of publication of Gray's catalogue of shield reptiles. Chelonian Conservation and Biology 1:322-323.

Wickham, M. M. 1922. Notes on the migration of *Macrochelys lacertina*. Proceedings of the Oklahoma Academy of Science 2:20-22.

Appendix A. Sample dates, location by county (CK=Cherokee, CG=Craig, JO=Johnston, LT=Latimer, LF=LeFlore, MA=Mayes, MC=McCurtain, MT=McIntosh, OK=Okmulgee, OG=Osage, OT=Ottawa, PT=Pittsburgh, PM=Pushmataha, SQ=Sequoyah, WG=Wagoner), net nights and number of turtles captured by species (MATE=*Macrochelys temminckii*, CHSE=*Chelydra serpentina*, KISU=*Kinosternon subrubrum*, STCA=*Sternotherus carinatus*, STOD=*Sternotherus odoratus*, APSP=*Apalone spinifera*, APMU=*Apalone mutica*, CHPI=*Chrysemys picta*, GRGE=*Graptemys geographica*, GRKH=*Graptemys kohnii*, GRPS=*Graptemys pseudogeographica*, PSCO=*Psuedemys concinna*, TRSC=*Trachemys scripta*).

LOCATION	DATE	NET NIGHTS	COUNTY	SPECIES												
				MATE	CHSE	KISU	STCA	STOD	APSP	APMU	CHPI	GRGE	GRKH	GRPS	PSCO	TRSC
BIG CABIN CREEK	5/29/97	5	CG	0	1	0	0	0	1	0	0	0	0	0	1	12
BIG CABIN CREEK	5/29/97	10	CG	0	3	0	0	0	2	0	0	0	2	0	1	15
MOUNTAIN FORK RIVER	6/9/97	14	MC	0	0	0	5	0	4	0	0	0	1	0	4	13
LITTLE RIVER	6/10/97	2	MC	0	0	0	0	0	0	0	0	0	0	0	0	4
LITTLE RIVER	6/10/97	13	MC	0	0	0	13	0	0	0	0	0	0	0	1	12
MOUNTAIN FORK	6/11/97	5	MC	0	0	0	5	0	0	0	0	0	0	0	0	1
LITTLE RIVER	6/11/97	5	MC	0	0	0	1	0	0	0	0	0	0	0	1	0
LITTLE RIVER	6/11/97	14	MC	0	0	0	12	0	0	0	0	0	0	0	0	14
CANEY RIVER	6/18/97	10	OG	0	0	0	0	1	5	0	0	0	2	15	2	16
CANEY RIVER	6/18/97	10	OG	0	1	0	0	0	6	0	0	0	3	12	0	18
CANEY RIVER	6/19/97	10	OG	0	0	0	0	0	6	0	0	0	2	2	0	12
CANEY RIVER	6/19/97	10	OG	0	0	0	0	0	4	0	0	0	4	17	1	29
EUFALA LAKE	6/29/97	4	MT	0	0	0	0	0	0	0	0	0	0	6	0	2
GROVE CREEK	6/30/97	9	OK	0	0	0	0	2	2	0	0	0	2	0	0	2
GROVE CREEK	6/30/97	9	OK	0	0	0	0	0	0	0	0	0	0	0	0	1
GROVE CREEK	6/30/97	2	OK	0	1	0	0	2	0	0	0	0	3	1	0	10
DEEP FORK RIVER	7/1/97	10	OK	0	0	0	0	0	5	0	0	0	0	7	0	3
DEEP FORK RIVER	7/1/97	10	OK	0	0	0	0	0	3	0	0	0	1	32	0	3
DEEP FORK RIVER	7/2/97	10	OK	0	0	0	0	0	3	1	0	0	0	6	0	6
DEEP FORK RIVER	7/2/97	10	OK	0	0	0	0	0	2	0	0	0	1	26	0	2
LITTLE RIVER	7/10/97	20	MC	1	0	0	7	0	1	0	0	0	0	0	0	1
HORTON SLOUGH	7/10/97	8	SQ	1	0	0	0	0	0	0	0	0	0	11	1	33
LITTLE RIVER	7/11/97	19	MC	0	0	0	3	0	3	0	0	0	0	1	1	1
HORTON SLOUGH	7/11/97	4	SQ	2	0	0	0	1	0	0	0	0	0	1	0	27
HORTON SLOUGH	7/11/97	8	SQ	2	0	0	0	0	2	0	0	0	0	0	1	32
LITTLE RIVER	7/12/97	19	MC	0	0	0	16	0	0	0	0	0	0	0	0	1
BIG VIAN CREEK	7/12/97	4	SQ	5	4	0	0	0	0	0	0	0	0	0	0	23
HORTON SLOUGH	7/12/97	4	SQ	1	0	0	0	1	0	0	0	0	1	1	0	46

Appendix A cont.

LOCATION	DATE	NETS	COUNTY	MATE	CHSE	KISU	STCA	STOD	APSP	APMU	CHPI	GRGE	GRKH	GRPS	PSCO	TRSC
HORTON SLOUGH	7/12/97	7	SQ	0	1	0	0	0	4	0	0	0	0	0	0	53
LITTLE RIVER	7/13/97	19	MC	1	0	0	3	0	3	0	0	0	0	0	2	1
LITTLE RIVER	7/14/97	19	MC	1	0	0	3	0	0	0	0	0	0	0	0	4
LITTLE RIVER	7/15/97	19	MC	0	0	0	2	0	3	0	0	0	0	0	0	6
GLOVER RIVER	7/15/97	8	MC	0	0	0	13	0	0	0	0	0	0	2	4	1
KIAMICHI RIVER	7/16/97	6	PM	1	0	0	6	0	1	0	0	0	0	1	0	0
MILL CREEK[1]	7/16/97	4	PM	1	0	0	2	0	0	0	0	0	0	0	1	3
KIAMICHI RIVER	7/16/97	15	PM	0	0	0	9	0	0	0	0	0	0	0	0	5
BIG VIAN CREEK	7/29/97	10	SQ	0	0	0	0	1	1	0	0	0	0	1	0	5
BIG VIAN CREEK	7/30/97	10	SQ	0	0	0	0	0	0	0	0	0	0	0	0	18
BIG VIAN CREEK	7/30/97	10	SQ	4	0	0	0	0	1	0	0	0	0	1	1	30
BIG VIAN CREEK	7/31/97	10	SQ	1	0	0	0	0	0	0	0	0	0	0	0	38
HORTON SLOUGH	7/31/97	10	SQ	1	0	0	0	0	1	0	0	0	0	2	0	47
DIRTY CREEK	7/31/97	6	SQ	1	1	0	0	0	0	0	0	0	0	3	1	22
DIRTY CREEK	7/31/97	8	SQ	0	2	0	0	0	2	0	0	0	2	2	1	47
DIRTY CREEK	8/1/97	8	SQ	0	3	0	0	0	4	0	0	0	0	0	0	61
DIRTY CREEK	8/1/97	6	SQ	0	1	0	0	1	1	0	0	0	0	5	0	64
VERDIGRIS RIVER	8/6/97	5	WG	0	1	0	0	0	1	0	0	0	0	2	0	17
VERDIGRIS RIVER	8/6/97	8	WG	0	1	0	0	0	2	0	0	0	0	4	0	19
FT. GIBSON LAKE	8/7/97	10	WG	0	0	0	0	1	1	0	0	0	0	0	0	12
GREEN LEAF LAKE	8/8/97	15	CK	0	0	0	0	3	0	0	0	0	1	0	1	12
SPRING RIVER	5/20/98	9	OT	0	4	0	0	1	0	0	0	0	1	6	0	13
SPRING RIVER	5/21/98	10	OT	0	6	0	0	0	1	0	0	0	0	1	0	35
CANEY RIVER	6/6/98	5	OG	0	0	0	0	0	0	0	0	0	1	7	0	15
CANEY RIVER	6/7/98	10	OG	0	0	0	0	0	1	0	0	0	0	6	0	11
CANEY RIVER	6/8/98	10	OG	0	0	0	0	0	1	0	0	0	0	3	0	5
SPRING RIVER	6/12/98	10	OT	0	11	0	0	0	1	0	0	0	0	0	0	147
NEOSHO RIVER	6/13/98	10	OT	0	1	0	0	0	0	0	0	0	1	2	1	31
NEOSHO RIVER	6/14/98	10	OT	0	1	0	0	0	0	0	0	0	1	4	0	55
ILLINOIS RIVER	6/30/98	11	SQ	0	3	0	0	2	0	0	0	0	0	8	0	38
ILLINOIS RIVER	7/2/98	5	SQ	0	0	0	0	3	0	0	0	0	0	0	1	12

Appendix A cont.

LOCATION	DATE	NETS	COUNTY	MATE	CHSE	KISU	STCA	STOD	APSP	APMU	CHPI	GRGE	GRKH	GRPS	PSCO	TRSC
SALLYJONESLAKE	7/2/98	3	SQ	0	0	0	0	0	0	0	0	0	0	0	0	33
BIG VIAN CREEK	7/2/98	7	SQ	0	0	0	0	0	0	0	0	0	0	0	0	24
BIG VIAN CREEK	7/3/98	10	SQ	5	2	0	0	0	0	0	0	0	0	0	0	52
HORTON SLOUGH	7/3/98	8	SQ	0	1	0	0	0	2	0	0	0	0	8	4	95
BIG VIAN CREEK	7/9/98	18	SQ	0	0	0	0	4	2	0	0	0	0	15	6	81
BIG VIAN CREEK	7/10/98	18	SQ	2	0	0	0	0	0	0	0	0	0	9	6	47
SPRING CREEK	7/13/98	12	MA	0	0	0	0	8	1	0	0	0	0	5	1	33
SPRING CREEK	7/14/98	8	MA	0	0	0	0	7	0	0	0	1	0	3	0	40
NEOSHO RIVER	7/14/98	10	MA	0	1	0	0	0	0	0	0	0	0	12	0	31
VERDEGRIS RIVER	15-Jul	15	WG	0	1	1	0	0	1	0	0	0	0	2	0	35
VERDEGRIS RIVER	7/16/98	10	WG	0	0	0	0	0	0	0	0	0	0	7	0	14
LITTLE VIAN CREEK	7/21/98	8	SQ	1	0	0	0	0	1	0	0	0	0	0	0	18
LITTLE VIAN CREEK	7/22/98	8	SQ	1	0	0	0	1	1	0	0	0	0	1	0	41
LITTLE VIAN CREEK	7/23/98	8	SQ	6	0	0	0	3	3	0	0	0	0	4	0	30
LITTLE VIAN CREEK	7/24/98	8	SQ	0	0	0	0	0	2	0	0	0	0	0	0	19
LITTLE RIVER	7/23/98	6	MC	0	0	0	8	0	0	0	0	0	0	0	0	3
MTN FORK RIVER	7/23/98	4	MC	0	0	0	0	0	0	0	0	0	0	0	1	0
LITTLE RIVER	7/24/98	9	MC	0	0	0	5	0	0	0	0	0	0	0	0	2
LITTLE RIVER	7/25/98	9	MC	0	0	0	2	0	0	0	0	0	0	0	0	0
MTN FORK RIVER	7/26/98	9	MC	0	0	0	5	0	0	0	0	0	0	0	0	15
KIAMICHI RIVER	7/27/98	9	PM	0	0	0	20	0	0	0	0	0	0	0	0	0
LITTLE VIAN CREEK	7/28/98	8	SQ	9	0	0	0	0	1	0	0	0	0	0	0	20
LITTLE VIAN CREEK	7/29/98	8	SQ	4	1	0	0	0	0	0	0	0	0	0	0	18
HEZEKIAH CREEK	7/30/98	9	SQ	1	2	0	0	1	0	0	0	0	0	5	0	75
LITTLE VIAN CREEK	7/30/98	8	SQ	5	0	0	0	0	1	0	0	0	0	0	0	11
LITTLE VIAN CREEK	7/31/98	8	SQ	0	0	0	0	0	0	0	0	0	0	0	0	10
NEGRO CREEK	7/28/98	9	SQ	0	0	0	0	0	1	0	0	0	0	0	0	39
POTEAU RIVER	8/4/98	12	LF	0	0	0	0	0	0	0	0	0	0	1	0	5
POTEAU RIVER	8/10/98	10	LF	0	0	0	0	0	0	0	0	0	0	2	0	14
POTEAU RIVER	8/11/98	12	LF	0	0	0	0	2	0	0	0	0	0	0	2	18
POTEAU RIVER	8/10/98	7	LF	0	0	0	0	8	1	0	0	0	1	2	2	42

Appendix A cont.

LOCATION	DATE	NETS	COUNTY	MATE	CHSE	KISU	STCA	STOD	APSP	APMU	CHPI	GRGE	GRKH	GRPS	PSCO	TRSC
POTEAU RIVER	8/10/98	5	LF	0	0	0	0	2	0	0	0	0	0	0	0	19
POTEAU RIVER	8/11/98	6	LF	0	0	0	0	6	1	0	0	0	0	6	1	50
POTEAU RIVER	8/11/98	5	LF	0	0	0	0	0	0	0	0	0	1	4	0	32
14 MILE CREEK	5/25/99	15	CK	0	1	0	0	0	0	0	0	0	0	0	0	0
BIG CABIN CREEK	5/27/99	10	CG	0	4	0	0	0	7	0	0	0	0	7	0	23
FORT GIBSON LAKE	5/28/99	9	WG	0	0	0	0	0	0	0	0	0	0	0	0	0
WALNUT CREEK	6/7/99	10	OK	0	0	0	0	0	0	0	0	0	0	0	0	0
PENNINGTON CREEK	6/10/99	9	JO	0	6	0	1	1	0	0	0	0	0	0	1	24
SANDY CREEK	6/15/99	14	OK	0	0	0	0	0	0	0	0	0	0	1	0	43
DICKS POND	6/16/99	14	JO	0	3	0	0	1	0	0	0	0	0	0	0	76
DICKS POND	6/17/99	11	JO	0	1	0	0	0	0	0	0	0	0	0	0	26
GOOSE PEN POND	6/18/99	14	JO	0	1	0	0	1	0	0	0	0	0	1	1	42
RED LAKE	6/30/99	10	MC	0	0	0	0	0	0	0	0	0	0	0	0	78
41 CUTOFF OXBOW	7/1/99	13	MC	0	1	0	1	8	1	0	1	0	0	0	0	20
41 CUTOFF OXBOW	7/2/99	13	MC	0	2	0	0	16	0	0	0	0	0	0	0	18
LAKE EUFALA TRIB.	7/20/99	13	OK	0	0	1	0	1	2	0	0	0	0	2	1	16
MILL CREEK[2]	7/22/99	13	MT	8	2	1	0	0	4	0	0	0	0	1	0	5
DUTCHESS CREEK	7/23/99	9	MT	4	2	0	0	0	1	0	0	0	0	0	0	115
GAINES CREEK	7/23/99	13	LT	0	1	0	0	0	0	0	0	0	0	0	0	10
TWIN LAKES	7/27/99	8	JO	0	1	0	0	0	0	0	0	0	0	0	0	77
BELL CREEK	7/28/99	9	JO	0	1	0	0	0	0	0	0	0	0	0	0	55
BUFFALO CREEK	7/30/99	13	PT	0	0	0	10	0	0	0	0	0	0	0	0	0

[1] = Mill Creek, Pushmataha County
[2] = Mill Creek, McIntosh County

Appendix B. Capture dates, id number, tag number, sex (M=male, F=female, JV=juvenile), mass (kg), and body measurements (mm) (CL=carapace length, CW=carapace width, PL=plastron length, PW=plastron width, HL=head length, HW=head width, PA=post anal tail length, and TL=total tail length), for individuals of *Macrocheys temminckii* captured at Sequoyah National Wildlife Refuge

APPENDIX B

DATE	ID#	TAG	SEX	MASS	CL	CW	PL	PW	HL	HW	PA	TL
7/10/1997	10	10	M	3.6	267	212	189	187	NA	NA	NA	NA
7/11/1997	1	1	F	4.25	283	234	207	197	NA	NA	NA	NA
7/11/1997	2	2	F	10.25	370	305	262	262	NA	NA	NA	NA
7/11/1997	3	3	JV	1	179	145	126	124	NA	NA	NA	NA
7/11/1997	4	4	JV	1.5	202	155	143	130	NA	NA	NA	NA
7/12/1997	5	5	F	3.25	269	201	73	75	NA	NA	NA	NA
7/12/1997	6	6	JV	1.8	220	161	160	146	NA	NA	NA	NA
7/12/1997	7	7	F	6.25	332	254	225	220	NA	NA	NA	NA
7/12/1997	8	8	JV	2.75	257	184	174	164	NA	NA	NA	NA
7/12/1997	9	9	F	4.25	303	210	200	190	NA	NA	NA	NA
7/12/1997	11	11	JV	1.9	220	165	144	137	NA	NA	NA	NA
7/30/1997	14	14	M	2.75	259	199	180	180	NA	NA	NA	NA
7/30/1997	15	15	JV	1.5	223	165	149	165	NA	NA	NA	NA
7/30/1997	16	16	JV	1.5	219	150	145	142	NA	NA	NA	NA
7/31/1997	17	19	JV	2.25	222	183	156	160	NA	NA	NA	NA
7/31/1997	18	NA	F	NA	364	282	274	262	NA	NA	NA	NA
7/3/1998	24	24	M	4.5	287	205	209	209	100	82	224	263
7/3/1998	25	NA	JV	2	209	178	150	150	66	61	141	171
7/3/1998	26	NA	JV	2.7	222	175	157	150	75	61	200	250
7/3/1998	27	17	F	11	370	281	288	261	128	105	300	365
7/3/1998	28	NA	JV	2.5	230	150	161	147	79	67	185	220
7/9/1998	17	19	JV	2.25	222	183	156	160	80	68	197	267
7/9/1998	29	29	JV	2.75	245	180	163	167	80	65	191	231

Appendix B cont.

DATE	ID#	TAG	SEX	MASS	CL	CW	PL	PW	HL	HW	PA	TL
7/21/1998	30	NA	JV	2	240	170	165	165	75	70	175	202
7/23/1998	31	NA	JV	1.75	210	157	147	150	65	55	169	204
7/23/1998	32	NA	JV	0.5	140	115	100	100	40	40	120	145
7/23/1998	33	NA	JV	1	195	145	138	138	58	55	161	197
7/23/1998	34	3	JV	2.5	230	165	165	160	73	70	183	232
7/23/1998	35	23	M	5	295	235	210	210	100	90	240	295
7/23/1998	36	????	F	4	280	230	194	180	95	85	245	300
7/28/1998	37	36	JV	3.5	268	195	190	190	99	85	210	266
7/28/1998	38	38	F	17	433	360	340	295	135	130	323	420
7/28/1998	39	NA	JV	2.5	225	200	163	165	79	70	191	232
7/28/1998	40	43	M	14	390	300	285	265	130	100	355	385
7/28/1998	41	44	M	9.5	380	290	277	255	125	105	311	365
7/28/1998	42	47	F	19	450	360	340	305	142	130	310	370
7/28/1998	43	48	F	7	330	270	234	230	110	100	264	331
7/28/1998	44	50	M	41.8	595	442	415	360	206	180	303	515
7/28/1998	45	49	F	10.2	380	310	275	255	118	115	302	380
7/29/1998	46	65	JV	2.25	259	186	178	170	90	203	205	252
7/29/1998	47	61	F	12.25	392	317	294	263	129	113	305	366
7/29/1998	48	71	F	12.25	415	320	305	269	125	120	310	377
7/29/1998	49	74	M	16.25	460	327	347	332	165	135	332	398
7/30/1998	50	55	M	7.5	380	290	285	265	115	115	291	362
7/30/1998	51	70	M	22	495	392	345	315	156	160	375	445
7/30/1998	52	69	M	14	398	340	298	285	125	125	309	360
7/30/1998	53	???	F	15	410	340	326	300	135	115	286	376
7/30/1998	54	56	M	4.25	290	210	200	280	90	205	226	325
5/10/1999	58	76	F	16.8	510	440	350	350	190	160	32	47
5/11/1999	60	78	F	14.5	450	360	310	310	160	140	310	410
5/11/1999	59	79	F	18.6	460	340	360	330	180	160	320	420

Appendix B cont.

DATE	ID#	TAG	SEX	MASS	CL	CW	PL	PW	HL	HW	PA	TL
5/11/1999	61	80	F	12.7	420	300	310	280	140	120	300	400
5/11/1999	62	91	JV	4.5	310	210	240	210	120	110	230	300
5/11/1999	63	92	F	9	360	260	270	270	150	130	290	410
5/12/1999	64	93	JV	4.1	310	290	230	220	120	120	250	350
5/12/1999	65	82	JV	4.5	310	290	230	220	120	120	270	380
5/13/1999	66	83	M	10.9	400	380	290	290	140	140	350	440
5/19/1999	68	85	JV	5.4	320	270	250	240	130	100	260	300
5/21/1999	NA	NA	JV	0.22	110	100	80	80	40	40	100	120
5/21/1999	70	81	JV	3.6	280	210	210	200	120	100	250	280
5/21/1999	71	86	M	18.2	450	360	320	300	230	130	330	390
5/21/1999	72	88	JV	7.3	320	310	260	250	140	120	300	360
5/25/1999	73	89	F	10	384	318	262	244	200	110	139	289
5/25/1999	74	90	M	14.5	422	322	308	276	132	126	310	384
5/25/1999	75	87	JV	4.5	288	272	196	180	84	78	232	50
5/25/1999	76	95	JV	3.6	278	230	194	194	90	80	208	266
5/26/1999	77	94	JV	8.2	330	246	240	240	110	98	276	336
5/26/1999	78	98	F	14.5	440	338	320	290	136	124	340	400
5/26/1999	79	NA	JV	2.7	222	186	160	160	78	80	190	230
5/26/1999	80	97	M	10	376	282	256	244	124	114	302	350
5/26/1999	81	98	M	15.4	408	330	296	276	138	112	308	420
5/27/1999	82	99	JV	6.4	312	266	220	210	100	96	236	276
5/27/1999	83	NA	JV	4.1	272	216	190	190	90	78	210	260
5/27/1999	84	100	F	11.8	430	320	296	270	140	130	334	404
5/28/1999	NA	366	M	42.3	614	478	404	376	184	180	312	480
5/28/1999	85	121	JV	10.9	376	300	262	232	122	118	272	352
6/2/1999	86	125	F	17.3	440	362	314	294	142	130	348	426
6/4/1999	NA	357	F	16.8	454	390	330	296	142	120	318	404
6/11/1999	118	249	F	26.8	510	400	360	350	170	150	310	480

Appendix B cont.

DATE	ID#	TAG	SEX	MASS	CL	CW	PL	PW	HL	HW	PA	TL
6/12/1999	NA	285	JV	5.4	300	260	230	220	100	100	260	320
6/12/1999	87	NA	JV	2.3	250	200	160	180	90	80	200	260
6/12/1999	88	NA	JV	0.45	180	160	130	130	70	60	140	190
6/12/1999	NA	267	M	15.9	400	320	300	270	130	120	325	400
6/13/1999	NA	258	F	14.1	400	315	310	260	120	120	330	410
6/13/1999	89	116	F	17.3	430	352	320	300	140	122	278	360
6/13/1999	NA	284	M	17.3	410	398	340	290	150	138	286	372
6/13/1999	NA	348	M	34.5	536	395	380	320	189	154	320	470
6/16/1999	100	NA	JV	3.6	280	225	200	190	98	82	220	280
6/16/1999	101	117	JV	7.3	280	250	240	240	130	110	258	308
6/16/1999	102	NA	JV	4.5	280	210	212	198	110	98	191	232
6/28/1999	104	124	M	46.4	605	520	470	420	230	198	460	610
6/28/1999	101	NA	JV	0.9	200	180	156	150	75	58	168	210
6/28/1999	103	NA	JV	6.4	270	200	200	180	100	80	230	280
6/28/1999	102	NA	JV	0.9	190	150	243	103	74	54	160	190
6/28/1999	105	NA	JV	1.8	240	175	180	170	90	74	164	200
6/28/1999	106	119	F	17.7	460	360	340	320	176	130	340	410
7/9/1999	108	122	JV	5.4	290	260	220	200	110	100	242	298
7/9/1999	109	123	JV	5.4	300	220	224	201	110	88	251	291
7/9/1999	110	NA	JV	1.4	210	160	150	150	78	56	164	204
7/9/1999	111	NA	JV	1.8	260	190	190	180	100	80	220	270
7/9/1999	112	NA	JV	2.7	290	220	309	205	100	84	229	269
7/11/1999	113	102	F	14.1	419	340	318	294	150	130	422	470
7/11/1999	114	101	F	17.3	420	358	318	276	130	116	282	340
7/14/1999	115	NA	JV	3.6	270	260	175	170	115	110	170	200
7/15/1999	116	NA	JV	0.4	190	190	140	130	60	60	80	210
7/20/1999	NA	NA	JV	0.34	141	100	94	90	50	34	130	140
9/25/1999	120	108	JV	5.9	310	210	220	210	92	84	238	268

Appendix B cont.

DATE	ID#	TAG	SEX	MASS	CL	CW	PL	PW	HL	HW	PA	TL
9/25/1999	NA	276	M	11.8	410	300	290	260	134	98	296	390
9/25/1999	121	109	M	10	370	280	280	250	120	110	278	348
9/26/1999	122	NA	JV	1.3	248	170	72	70	92	70	174	204
5/10/2000	D1	NA	M	15.9	400	330	300	280	130	100	320	400
5/10/2000	D2	NA	JV	3.4	250	210	180	180	100	80	109	149
5/10/2000	D3	NA	JV	2.2	210	170	150	148	84	68	170	200
5/10/2000	D4	NA	JV	6.8	300	222	238	218	110	86	254	284
5/10/2000	D5	NA	JV	3.6	250	186	190	170	82	58	118	170
5/11/2000	D6	103	F	11.8	372	272	270	260	130	104	260	310
5/11/2000	D7	107	M	18.1	430	350	330	308	140	115	320	380
5/16/2000	D9	NA	M	6.8	310	228	230	220	100	98	260	300
5/17/2000	D10	NA	JV	5.9	300	230	204	198	80	66	240	280
5/17/2000	D11	NA	JV	2.2	280	200	200	180	92	80	250	290
5/17/2000	D12	111	M	36.3	542	400	400	360	190	150	320	400
5/17/2000	D13	NA	JV	3.6	260	180	200	170	90	70	180	210
6/7/2000	D25	64	M	13.6	422	370	280	270	140	120	290	340
6/7/2000	D21	NA	JV	1.8	210	180	150	150	80	60	180	210
6/9/2000	D15	NA	JV	4	270	180	170	180	98	70	180	200
6/9/2000	D17	NA	JV	7.7	310	230	226	210	100	80	260	300
6/10/2000	D18	67	F	15.9	433	300	320	270	150	130	340	400
6/10/2000	D19	NA	JV	NA	270	200	190	180	80	78	220	278
	D22	NA	F	16.8	440	318	320	300	150	120	360	430
6/23/2000	D23	NA	JV	6.8	300	250	220	210	120	94	225	265
6/23/2000	NA	3.15	JV	4.5	280	220	204	184	100	80	230	270
6/23/2000	D24	NA	F	16.3	400	320	320	290	140	120	370	430
6/23/2000	D25	NA	F	NA	420	336	310	290	150	135	280	320
6/26/2000	NA	459	M	7.2	346	240	258	232	130	100	260	320
6/26/2000	D26	NA	M	5.9	411	310	320	280	140	110	330	390

Appendix B cont.

DATE	ID#	TAG	SEX	MASS	CL	CW	PL	PW	HL	HW	PA	TL
6/30/2000	NA	NA	JV	1.8	200	154	140	140	76	52	160	200
6/30/2000	D27	66	M	6.8	320	230	228	208	120	100	260	330
6/30/2000	D28	60	F	7.2	334	290	242	218	120	100	270	330
6/30/2000	D29	NA	JV	5.4	300	230	220	210	90	76	232	272
6/30/2000	D30	NA	JV	5.4	306	230	230	210	110	80	220	270
6/30/2000	D31	NA	F	15	415	350	304	296	150	120	310	360
7/9/2000	D40	NA	F	18.6	450	340	360	300	150	130	340	380
7/10/2000	NA	NA	JV	2.7	220	160	150	150	90	60	170	200
7/11/2000	D41	NA	M	12.2	390	300	290	256	130	110	270	350
7/12/2000	D42	75	F	11.3	400	280	300	270	120	110	260	310
7/13/2000	D43	72	F	15	430	310	312	300	150	120	320	400
7/16/2000	D44	NA	F	19	430	310	350	290	130	110	320	400
7/18/2000	D45	NA	JV	6.8	332	230	230	220	120	90	210	270
7/18/2000	D46	NA	JV	4	260	202	198	180	90	72	230	250
7/18/2000	D47	NA	JV	6.3	311	210	230	210	100	82	250	310
7/18/2000	NA	NA	JV	0.45	144	120	103	101	50	32	130	160
7/17/2000	D48	NA	F	15.9	441	320	328	290	150	120	320	370
7/19/2000	D49	63	M	25	460	360	362	320	170	140	270	370
7/19/2000	D50	NA	JV	5	289	197	204	189	98	80	230	290
8/2/2000	NA	NA	F	16.8	450	425	340	320	140	130	340	430
8/3/2000	NA	NA	JV	NA	NA	NA	NA	NA	NA	NA	NA	NA

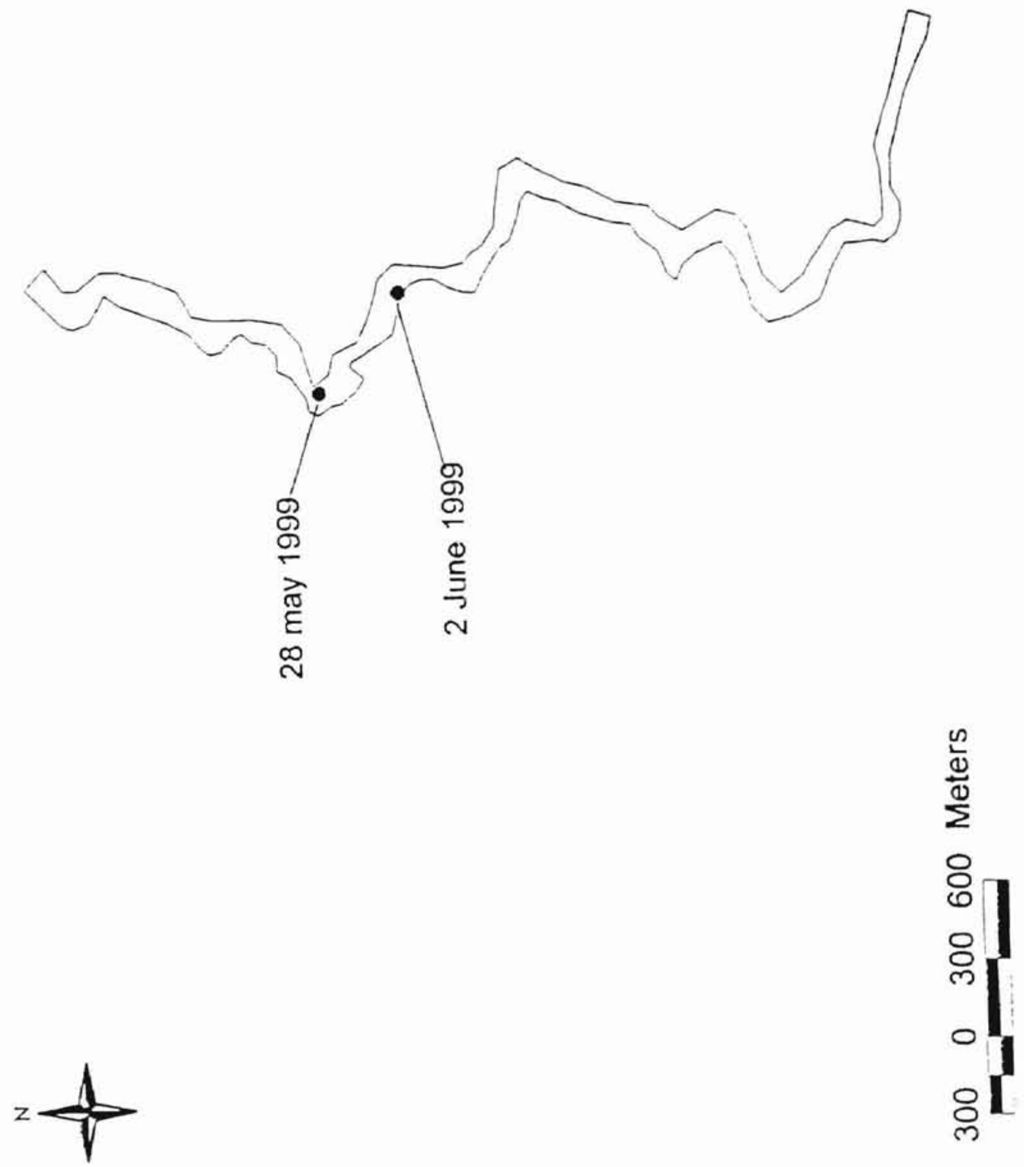
Appendix C. Sex and mass of *Macrochelys temminckii* outfitted with ultrasonic telemetry tags and their respective home range sizes. If no additional data were collected after the initial release of a turtle, a home range size of 0 was recorded.

APPENDIX C

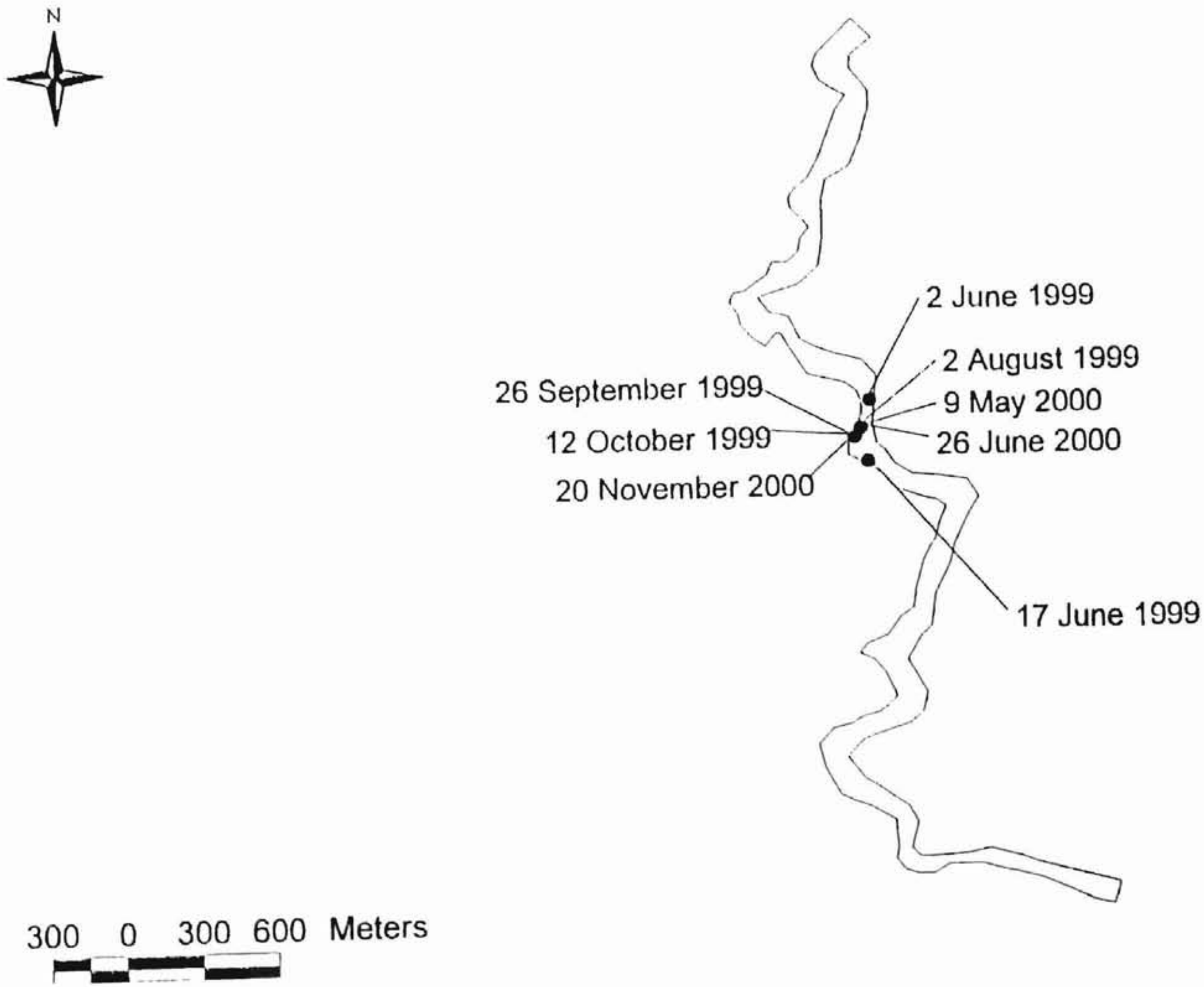
TAG#	SEX	MASS (kg)	HOME RANGE (m)
366	M	42.3	450
284	M	17.2	250
348	M	34.5	300
267	M	15.9	840
465	M	9.5	500
276	M	11.8	730
375	M	22.0	300
459	M	7.2	0
384	F	18.6	1205
258	F	14.1	620
357	F	16.8	810
249	F	26.8	0
555	JV	2.5	2335
447	JV	2.7	700
285	JV	5.4	150
558	JV	2.7	2300
368	JV	2.2	55
377	JV	4.5	900
315	JV	4.5	0

Appendix D. Distribution of location points for *Macrochelys temminckii* outfitted with ultrasonic telemetry tags.

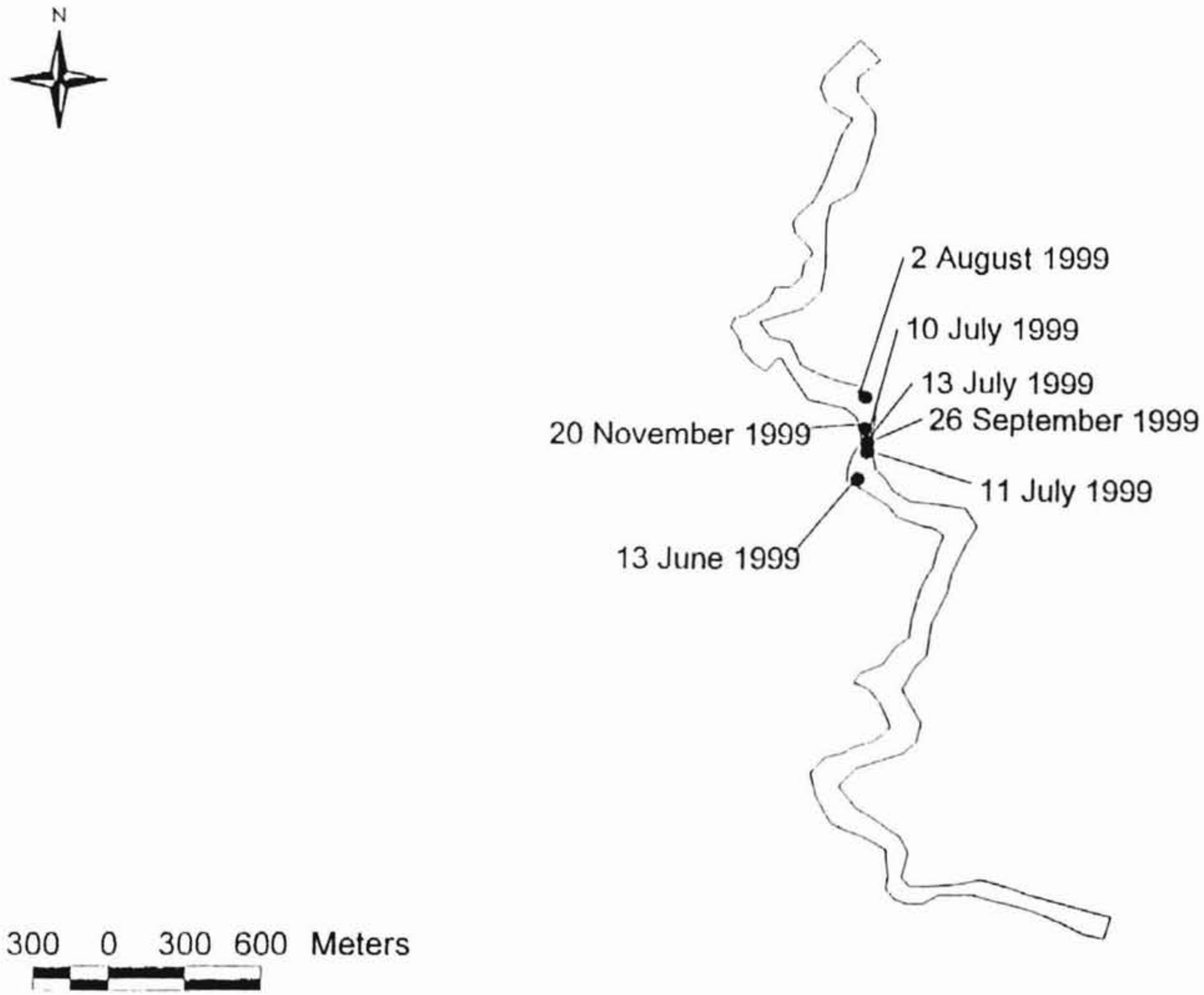
Distribution of location points in Big Vian Creek for turtle 366, a 42.3-kg male.


28 may 1999
2 June 1999
300 0 300 600 Meters
N

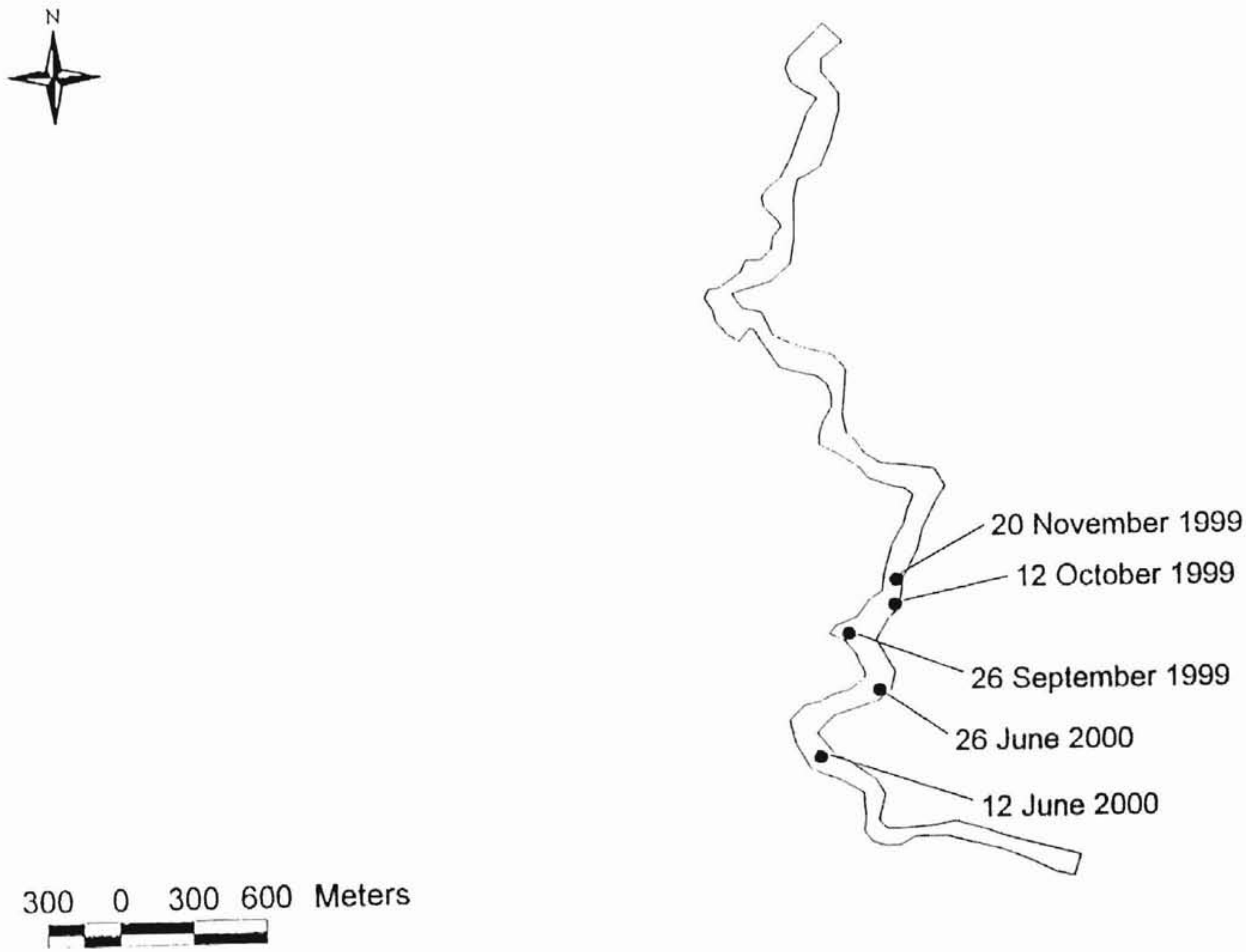
Distribution of location points in Big Vian Creek for turtle 284, a 17.2-kg male.


N
2 June 1999
2 August 1999
9 May 2000
26 June 2000
26 September 1999
12 October 1999
20 November 2000
17 June 1999
300 0 300 600 Meters

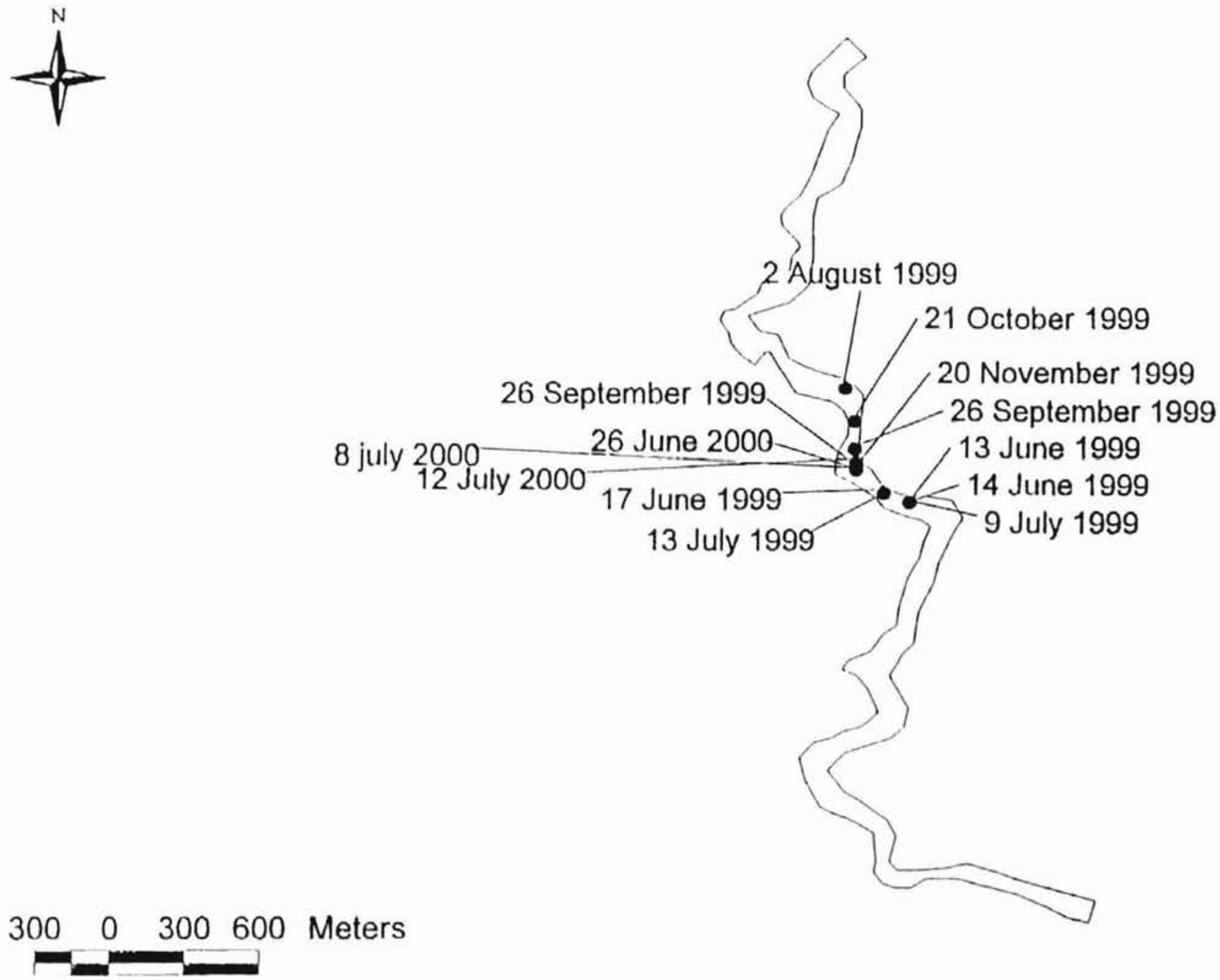
Distribution of location points in Big Vian Creek for turtle number 348, a 34.5-kg male.


N
2 August 1999
10 July 1999
13 July 1999
26 September 1999
20 November 1999
11 July 1999
13 June 1999
300 0 300 600 Meters

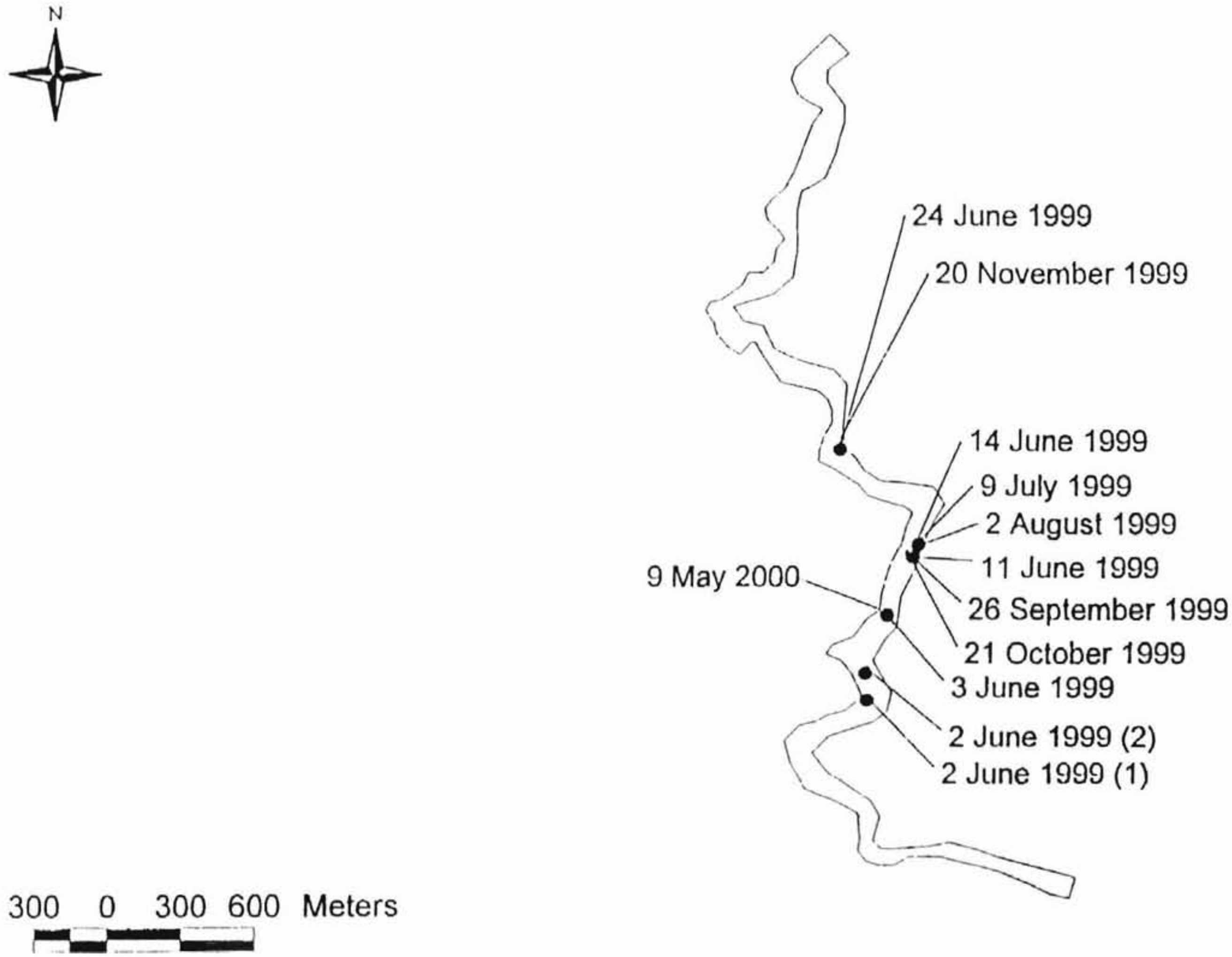
Distribution of location points in Big Vian Creek for turtle 276, an 11.8-kg male.


N
20 November 1999
12 October 1999
26 September 1999
26 June 2000
12 June 2000
300 0 300 600 Meters

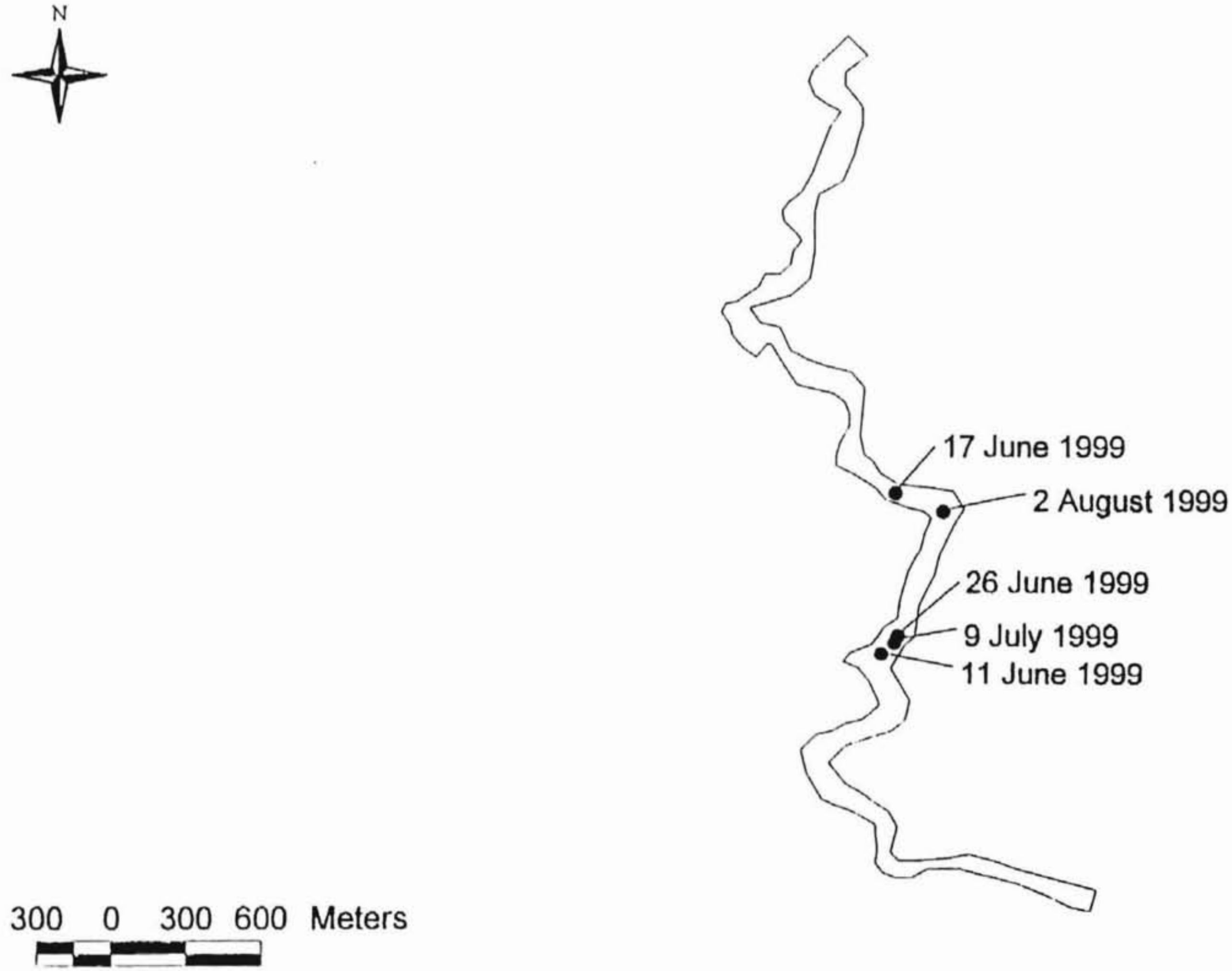
Distribution of location points in Big Vian Creek for turtle 258, a 14.1-kg female.


N
2 August 1999
21 October 1999
20 November 1999
26 September 1999
26 September 1999
13 June 1999
26 June 2000
8 july 2000
12 July 2000
14 June 1999
17 June 1999
9 July 1999
13 July 1999
300 0 300 600 Meters

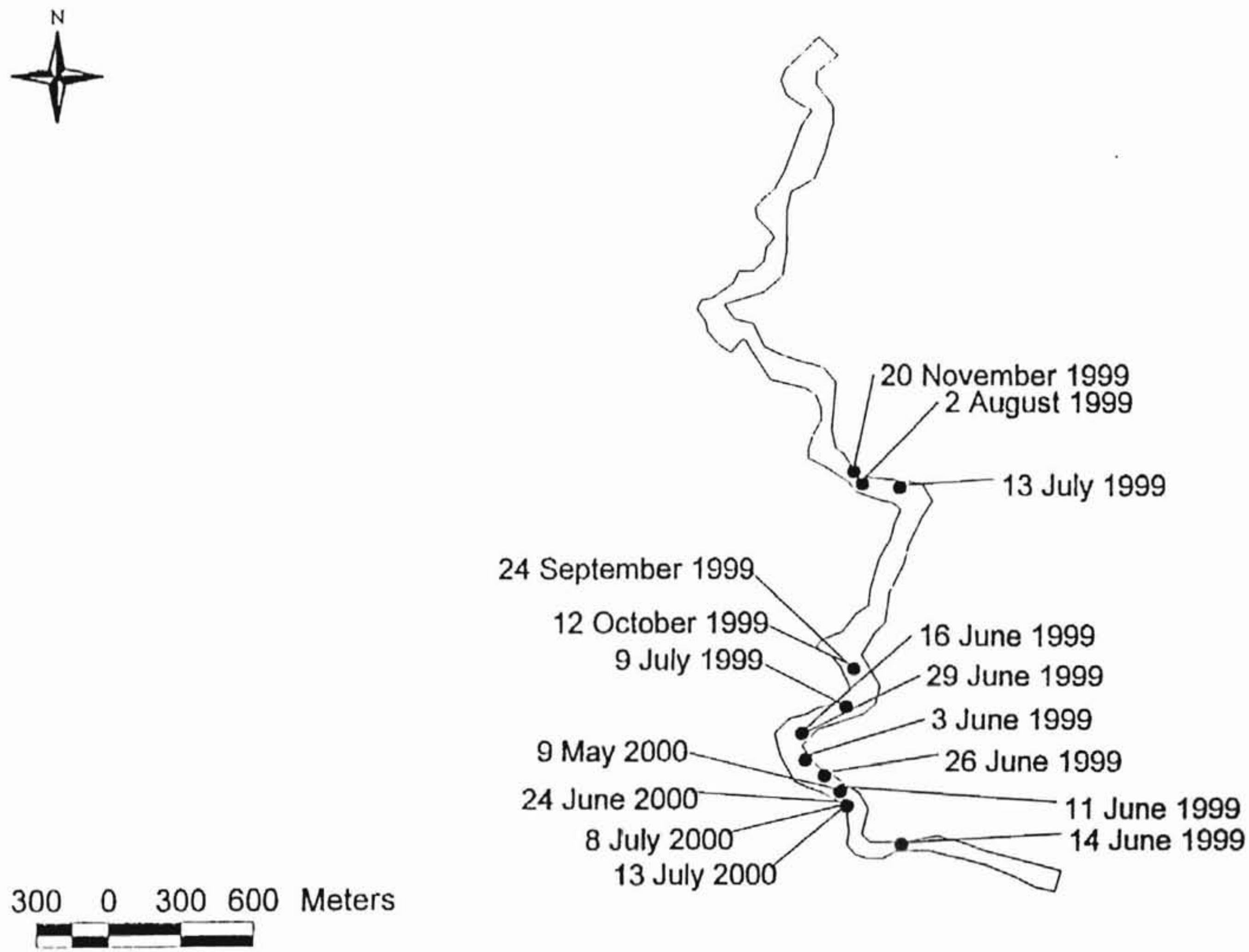
Distribution of location points in Big Vian Creek for turtle 384, an 18.6-kg female.


N
24 June 1999
20 November 1999
14 June 1999
9 July 1999
2 August 1999
11 June 1999
9 May 2000
26 September 1999
21 October 1999
3 June 1999
2 June 1999 (2)
2 June 1999 (1)
300 0 300 600 Meters

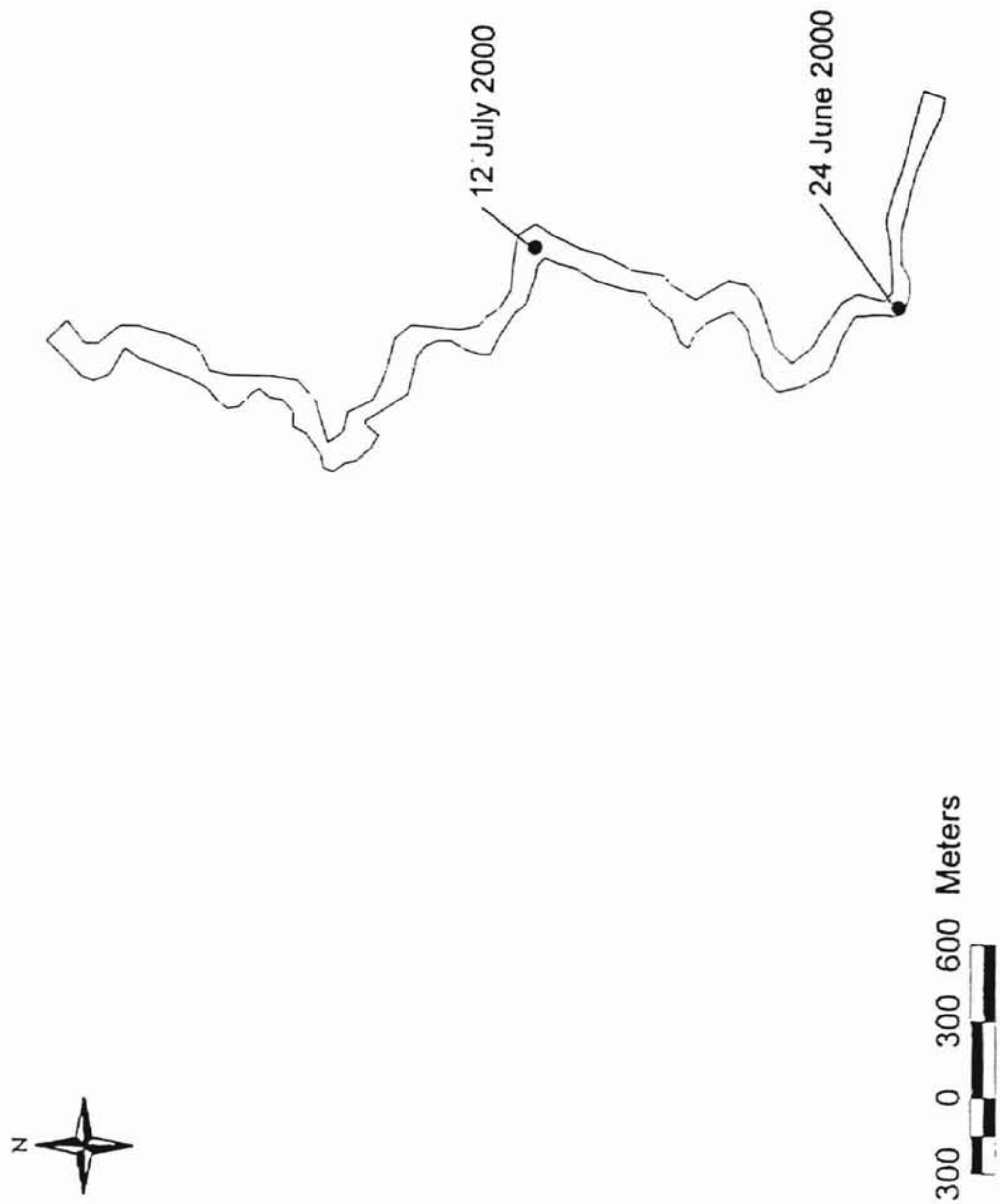
Distribution of location points in Big Vian Creek for turtle 447, a 2.7-kg juvenile.


N
17 June 1999
2 August 1999
26 June 1999
9 July 1999
11 June 1999
300 0 300 600 Meters

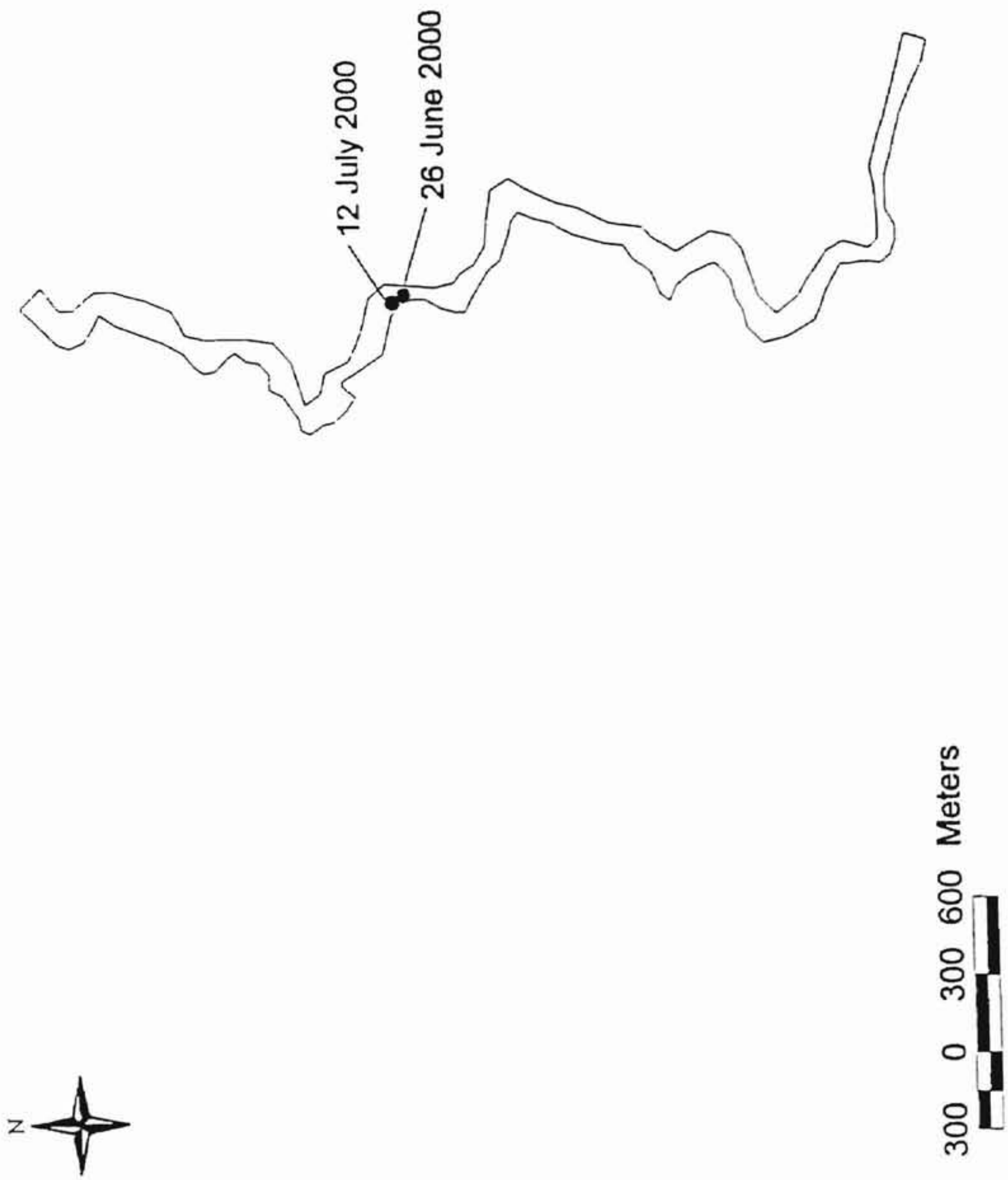
Distribution of location points in Big Vian Creek for turtle 555, a 2.5-kg juvenile.


N
20 November 1999
2 August 1999
13 July 1999
24 September 1999
12 October 1999
16 June 1999
9 July 1999
29 June 1999
3 June 1999
9 May 2000
26 June 1999
24 June 2000
11 June 1999
8 July 2000
14 June 1999
13 July 2000
300 0 300 600 Meters

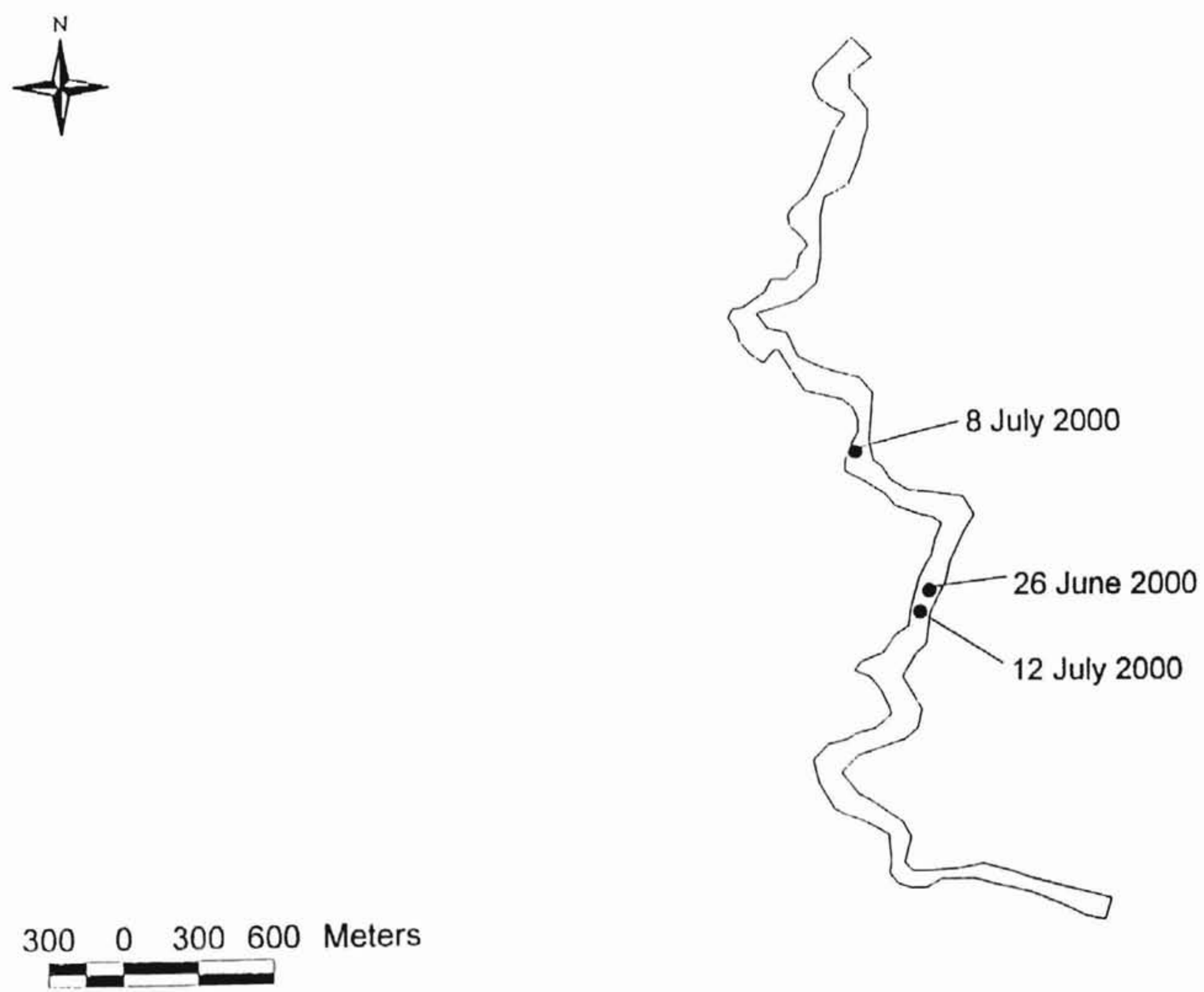
Distribution of location points in Big Vian Creek for turtle 558, a 2.7-kg juvenile.


12 July 2000
24 June 2000
300 0 300 600 Meters
N

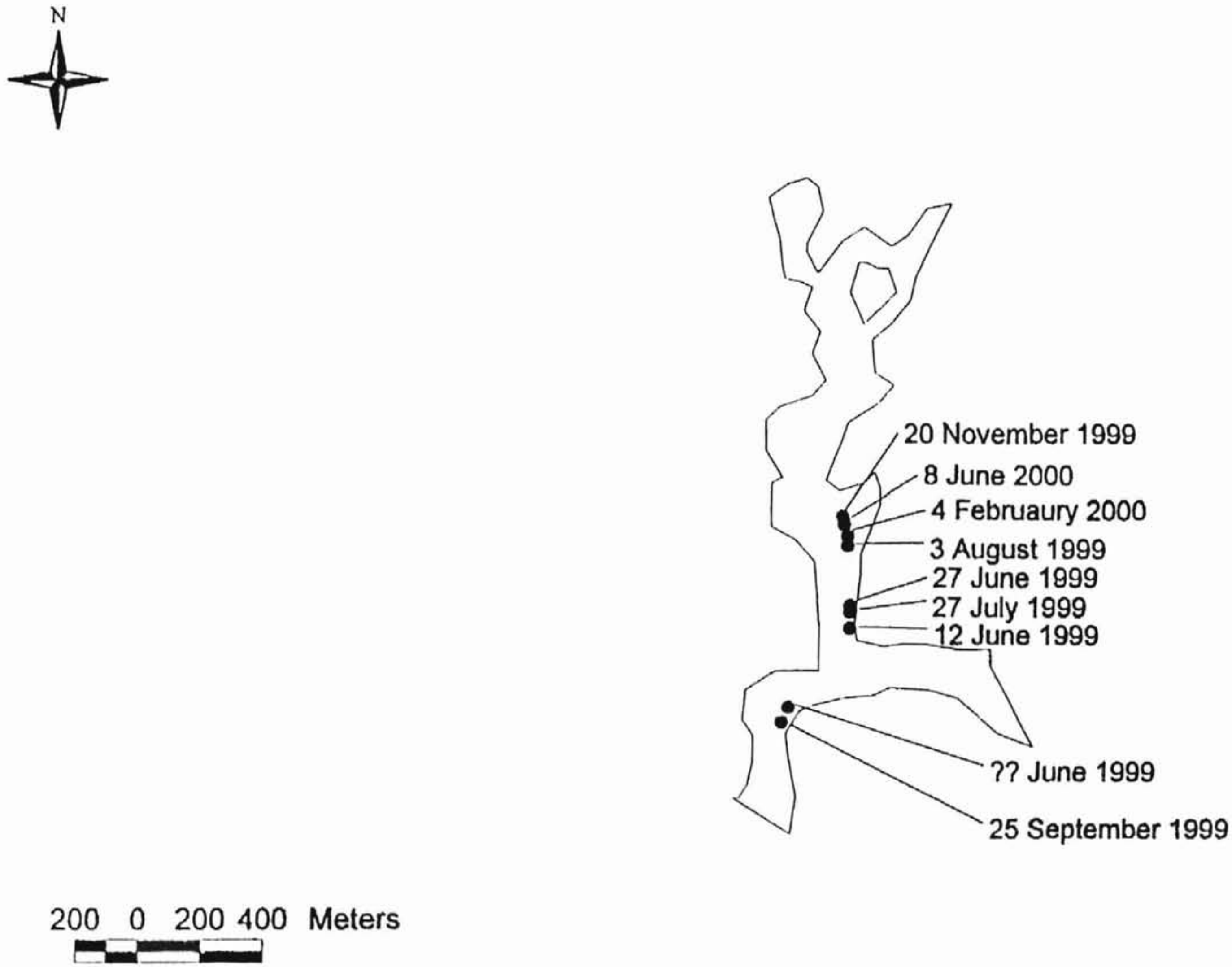
Distribution of location points in Big Vian Creek for turtle 368, a 2.2-kg juvenile.


12 July 2000
26 June 2000
300 0 300 600 Meters
N

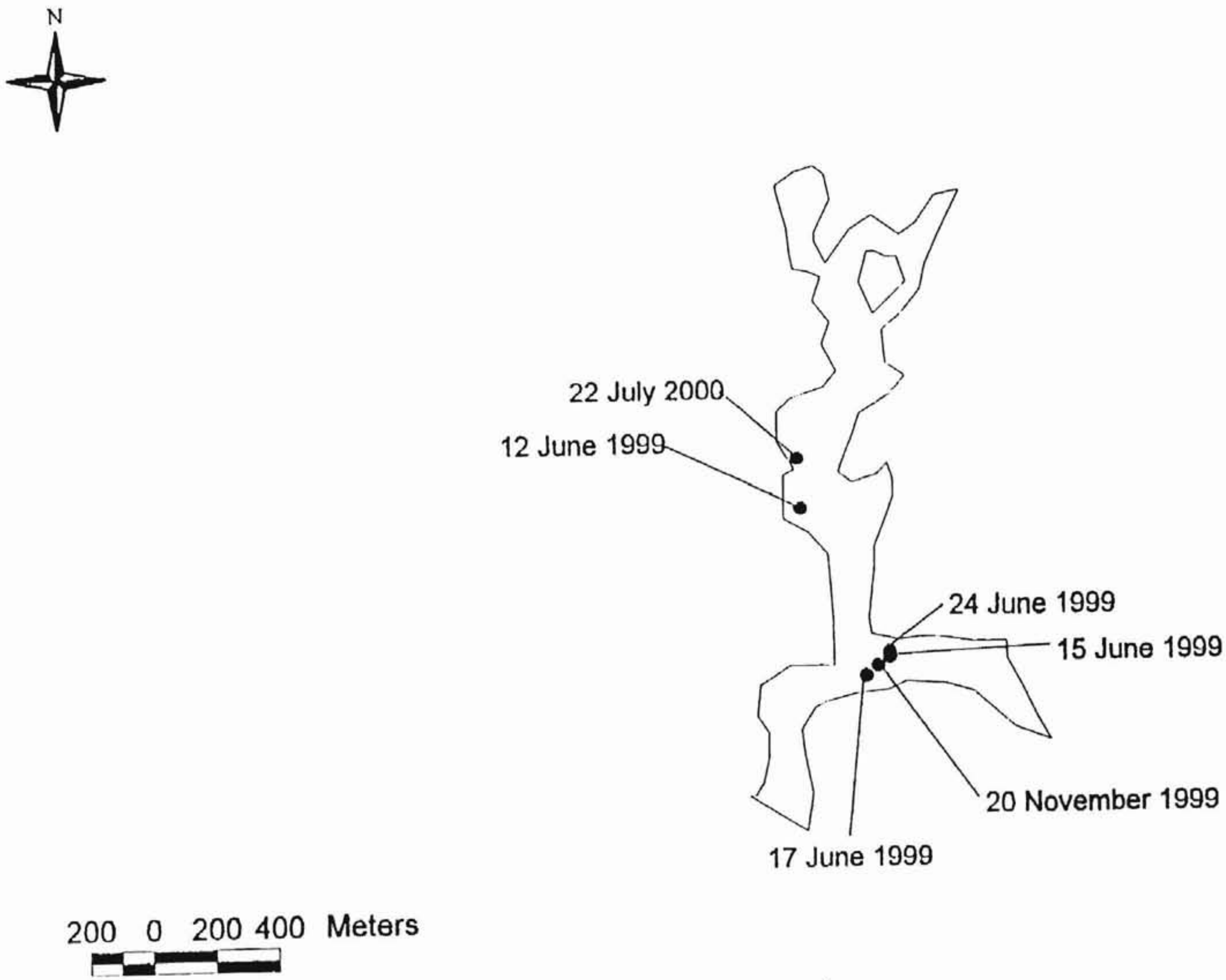
Distribution of location points in Big Vian Creek for individual 377, a 4.5-kg juvenile.


N
8 July 2000
26 June 2000
12 July 2000
300 0 300 600 Meters

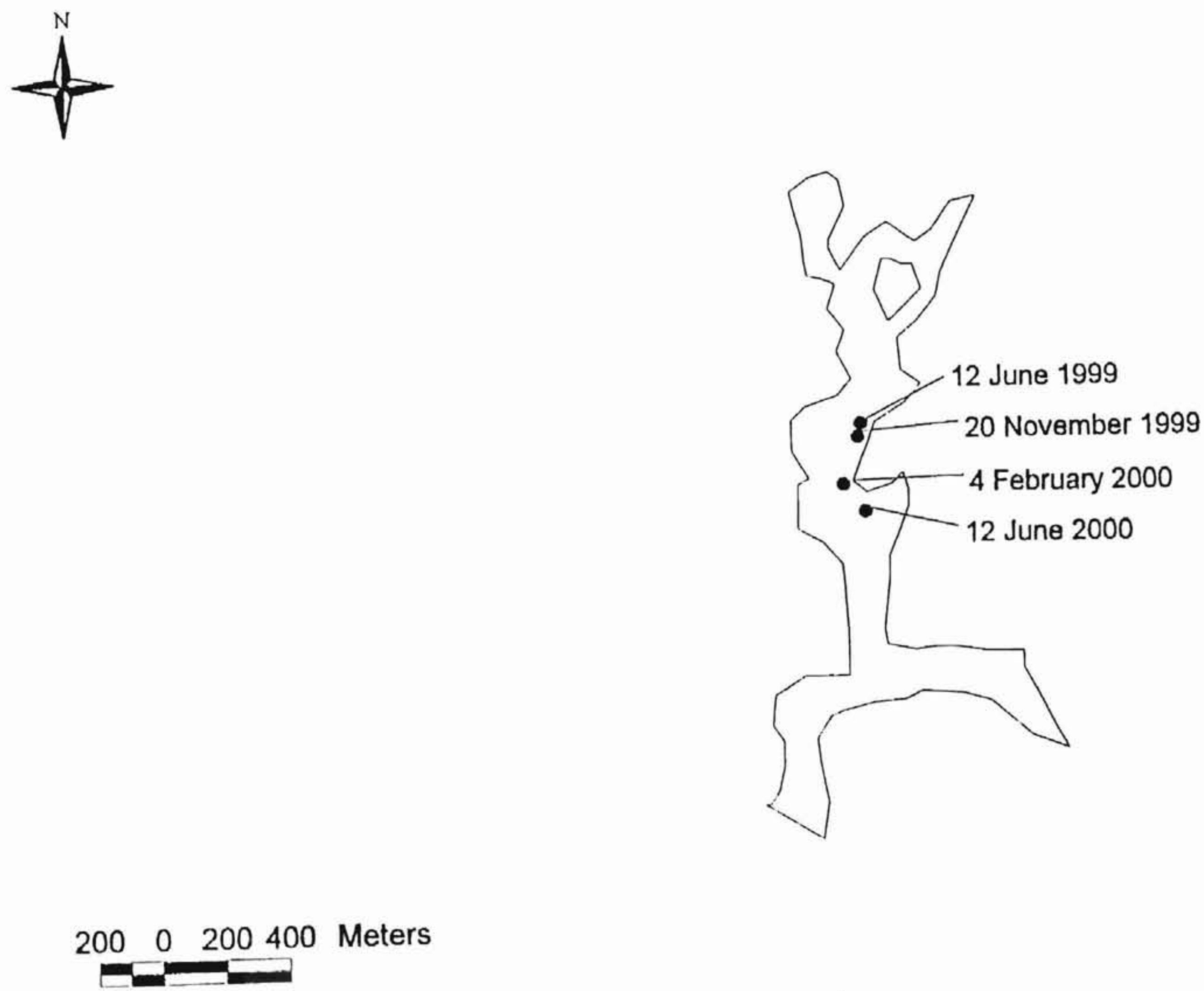
Distribution of location points in Little Vian Creek for turtle 267, a 15.9-kg male.


N
20 November 1999
8 June 2000
4 Februaury 2000
3 August 1999
27 June 1999
27 July 1999
12 June 1999
?? June 1999
25 September 1999
200 0 200 400 Meters

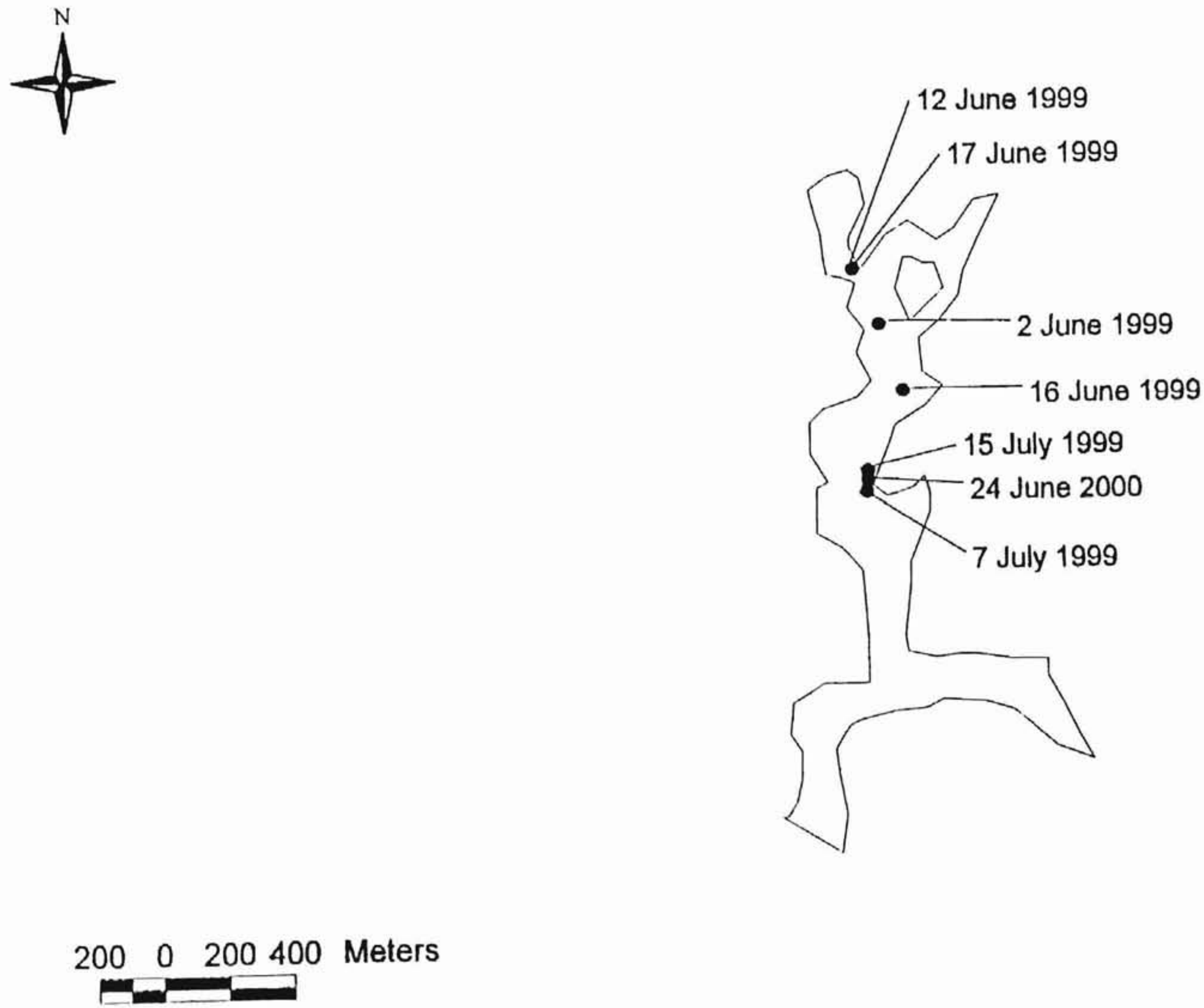
Distribution of location points in Little Vian Creek for turtle 465, a 9.5-kg male.


N
22 July 2000
12 June 1999
24 June 1999
15 June 1999
20 November 1999
17 June 1999
200 0 200 400 Meters

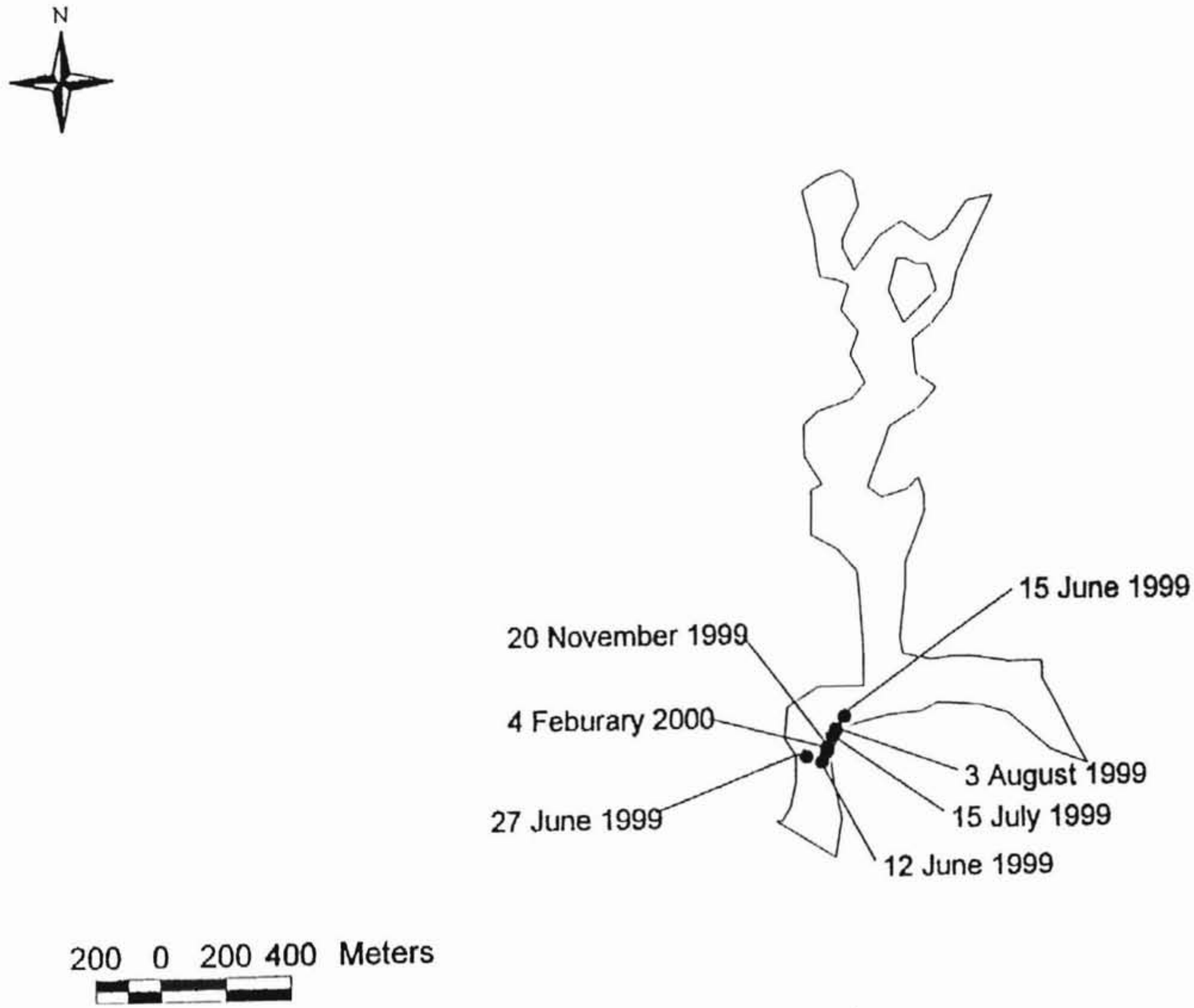
Distribution of location points in Little Vian Creek for turtle 375, a 22-kg male.


N
12 June 1999
20 November 1999
4 February 2000
12 June 2000
200 0 200 400 Meters

Distribution of location points in Little Vian Creek for turtle 357, a 16.8-kg female.


N
12 June 1999
17 June 1999
2 June 1999
16 June 1999
15 July 1999
24 June 2000
7 July 1999
200 0 200 400 Meters

Distribution of location points in Little Vian Creek for turtle 285, a 5.4-kg juvenile.


N
15 June 1999
20 November 1999
4 Feburary 2000
3 August 1999
15 July 1999
27 June 1999
12 June 1999
200 0 200 400 Meters

V

VITA

Jimmy Daren Riedle

Candidate for the Degree of

Master of Science

Thesis: THE ECOLOGY OF THE ALLIGATOR SNAPPING TURTLE, *Macrochelys temminckii*, IN OKLAHOMA

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