FINAL REPORT

SECTION 6

ENDANGERED SPECIES ACT

OKLAHOMA

DEPARTMENT OF WILDLIFE CONSERVATION

FEDERAL AID PROJECT E-40

STATUS, DISTRIBUTION AND HABITAT USE
OF THE ALLIGATOR SNAPPING TURTLE IN OKLAHOMA

OCTOBER 1, 1996 - SEPTEMBER 30, 1999

FINAL REPORT

State: Oklahoma Project Number: E-40

Project Title: Status, distribution, and habitat use of the alligator snapping turtle in Oklahoma

Project Period: 1 October 1996-30 September 1999

ABSTRACT

Oxbows, lakes, streams and rivers throughout the eastern one-third of Oklahoma were surveyed for alligator snapping turtles, *Macrochelys temminckii,* from May to August 1997-1999. We surveyed 67 sites capturing a total of 3,647 turtles representing 13 species, including 65 individuals of *M. temminckii.* Alligator snapping turtles were captured, marked and release at 11 sites. Basic habitat parameters such as stream morphology, cover availability, and substrate were recorded. *Macrochelys temminckii* was associated with survey sites that were shallower in water depth, exhibited low gradient banks, had less hard-packed clay substrate, more feeder creeks, aquatic vegetation, and more dense overhead canopy. From May through September 1999, ultrasonic transmitters were placed on 13 individuals of *M. temminckii* at Sequoyah National Wildlife Refuge to determine microhabitat requirements. Turtles inhabited a mean linear home range of 715.6 m. They occupied several core sites, consisting of structure such as beaver dens and log jams, within their

home range. Tagged individuals maintained a mean depth of 1.41 m and a mean temperature of 25.5^0 C. The depth and temperature that a turtle occupied fluctuated with the time of year. Habitat alteration and incidental and illegal take may be the primary cause of *M. temminckii* decline in Oklahoma. In areas where turtle harvesting occurs, overall turtle captures were low. Specific recommendations for future management of this species include evaluating possible habitat alterations for possible impacts on *M. temminckii* populations, broadening public awareness about *M. temminckii*, continuing to monitor current populations of *M. temminckii*, and increasing oversight of commercial turtle harvesting in Oklahoma.

PROJECT OBJECTIVES

The objectives of this project were 1) to identify extant populations of alligator snapping turtles in Oklahoma, 2) to assess overall population numbers and viability, 3) to identify and characterize important habitat for the species, 4) to capture, permanently mark, and release all specimens of alligator snapping turtles for any subsequent population monitoring, and in the third year of the study, 5) to mark 10 alligator snapping turtles with radio or ultrasonic telemetry equipment in an area where they are determined to be relatively common to monitor movements.

INTRODUCTION

The alligator snapping turtle, *Macrochelys temminckii,* is the largest freshwater turtle in North America, able to attain carapace lengths over 80 cm and mass measurements over 113 kg (according to Webb, 1995, the genus name *Macrochelys* now has precedence over the name *Macroclemys*, which was used at the beginning of this study). Adults exhibit strong sexual dimorphism as females reach a maximum size of only 27 kg (Pritchard, 1989). *Macrochelys temminckii* is confined to river systems that drain into the Gulf of Mexico, reaching the western extent of their range in the eastern one-third of Kansas and Oklahoma (Ernst et al., 1994). Although *M. temminckii* tends to stir a lot of interest due to its large size and extensive commercial exploitation in the southeastern portions of its range, little is known about the natural history of the species, particularly in the northern and western portions of its range (Pritchard, 1989; Shipman, 1993).

Pritchard (1989) and Ernst et al. (1994) suggested that *M. temminckii* populations have drastically declined throughout the turtle's range. The severity of the decline in portions of the range is still relatively unknown; however, *M. temminckii* is protected to varying degrees throughout its range. According to Ramus (1998), *M. temminckii* is protected in 9 of the 13 states in which it occurs. In Oklahoma, it is listed as a species of special concern and capture has been prohibited yearround since 1992 (OAC 800:25-19-6 and OAC 800:25-7-8). Possible causes for the decline of this species in neighboring Missouri and Arkansas are habitat alteration, and incidental and illegal take (Shipman and Riedle, 1994; Trauth et al., 1998).

We attempted to determine the current status of *M. temminckii* in Oklahoma, as well as address the paucity of data concerning its habitat use. Our objectives were to: 1) conduct a survey throughout the known range of *M. temminckii* in Oklahoma to determine its current distribution, 2) compare basic habitat parameters at sites where *M. temminckii* is present or absent, 3) describe overall aquatic turtle communities for eastern Oklahoma, and 4) determine microhabitat use of *M. temminckii* at Sequoyah National Wildlife Refuge.

MATERIALS AND METHODS

We sampled sites throughout the eastern one-third of Oklahoma (the historic range of of alligator snapping turtles in Oklahoma), from May through August 1997-1999. Many of these sites were at or near historic sites of occurrence for this species in Oklahoma, as determined by records from Glass (1949), Carpenter and Krupa (1989), and Heck (1998). We surveyed a variety of habitats to adequately survey 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 of *M. temminckii.* We surveyed many tributaries of the Arkansas River. Sites were sampled using commercial turtle hoop traps. These traps were 2.1 m in length and constructed of four 1.05 m hoops covered with 2.5 cm square mesh. Traps were set upstream from structures such as trees and log jams. We typically set traps in the afternoon or evening and checked them the following morning. Traps 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 by gill net, or incidental capture in the turtle traps themselves.

All individuals of all species of aquatic turtles were recorded. Basic habitat parameters were also collected at each site. These data included aquatic regime (percent riffle, percent run and percent pool); relative water current (scored as 0 = none, 1 = little, 2 = some, or 3 = much); stream morphology (scored as 0 = straight or channelized, 1 = slight bends in the stream, 2 = several bends within the stream, 3 = winding or braided stream); estimated percentage of tree canopy covering the site; estimated percentages of substrate (clay, mud, sand, gravel, rock, and bedrock); estimated amount of detritus (scored as 0 = none, 1 = little, 2 = some, or 3 = much); estimated amount of beaver activity (scored as 0 = none, 1 = little, 2 = some, or 3 = much); mean site width; mean site depth (scored as 1 = 0 to 1m, 2 = 1.1 to 2 m, 3 = 2.1 to 3 m, or 4 = > 3m); relative turbidity (scored as 0 = very clear, 1 = clear, 2 = slightly turbid, or 3 = very turbid); bank rise (scored as 0 = no rise, 1 = slight to 45 degree rise, 2 = 90 degree rise, or 3 = steep rise, bank overhanging water); percentages of cover (logs, log jams, trees, brush, and bank); relative amount of total cover (scored as 0 = none, 1 = little, 2 = some, or 3 = much); number of feeder creeks; amount of aquatic vegetation (scored as 0 = none, 1 = little, 2 = some, or 3 = much); and estimated percentage of vegetation covering the bank. The ordination program Canonical Correspondence Analysis (CCA) was used to determine site by species by habitat associations. CCA is a direct gradient analysis (Palmer, 1993) that shows relationships between a species and habitat variables where that species occurs.

We 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 0.63-cm hole drilled into numbered marginal scutes along the carapace. The marks corresponded to a numbering system as detailed by Santhuff (1993). We 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.

During Summer 1999, a telemetry project was conducted on a population of *M. temminckii* at Sequoyah National Wildlife Refuge, Sequoyah County, Oklahoma. The refuge encompasses parts of Kerr Reservoir, Arkansas River, Canadian River and their tributaries. The refuge came under United States Fish and Wildlife Service ownership in 1970, and there is no easy access to many of the smaller streams on the refuge. Sequoyah National Wildlife Refuge seems to harbor a healthy and fairly protected population of turtles due to these conditions. Two of the tributaries, Big Vian Creek and Little Vian Creek, served as the primary areas of study.

Temperature-sensitive ultrasonic tags were placed on 13 individuals of *M. temminckii*. The tags 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 plastic cable ties through the transmitters and holes, securing the tag in place. Turtles were tracked using a Sonotronics USR-5W digital receiver and a directional hydraphone. Turtle locations were pinpointed using triangulation.

Field work on the refuge consisted of alternating days of trapping and tracking. Frequent trapping was used to help determine overall population structure of *M. temminckii* on the refuge, and was conducted using the methodology described for the survey portion of this project. During tracking periods, microhabitat data were recorded for each turtle location. These data included temperature, water depth, percent canopy cover, substrate, and cover type used. A grid system was instituted on the site to aid in determining turtle movement. A numbered flag was placed every 50 m from the mouth of each stream, continuing upstream until the waterway became impassable by boat. By using this grid system, we could determine distance moved between tracking periods and overall home range of each turtle.

RESULTS

Survey Results

We surveyed 67 sites in 15 counties throughout eastern Oklahoma. Some sites were surveyed more than once due to the presence of *M. temminckii* or if seemingly good habitat was present. Our total trapping effort was 1,085 net nights, and we had 3,647 turtle captures of 13 species (Table1), including 65 individual *M. temminckii* at 11 sites: one site in the Little River, Horton Slough, Dirty Creek, Little Vian Creek, Hezekiah Creek, Mill Creek (McIntosh Co.), Mill Creek (Pushmataha Co.), Kiamichi River, and Dutchess Creek, and two sites on Big Vian Creek.

Canonical correspondence analysis indicated that *M. temminckii* was associated with survey sites that were shallower in water depth, exhibited low gradient banks, had less hard-packed clay substrate, more feeder creeks, aquatic vegetation, and more dense overhead canopy (Fig. 1). In CCA, associations were seen as the relative proximity of the species scores (represented by points) to the terminus of the habitat scores (displayed as vectors). The relative importance and relationships of the habitat variables are based upon the relative length and direction of the vectors (Palmer, 1993). Red ear sliders, *Trachemys scripta,* common snapping turtles, *Chelydra serpentina,* common musk turtles, *Sternotherus odoratus,* and Mississippi mud turtles, *Kinosternon subrubrum,* were also associated with the same habitat.

Telemetry Results

We had a total effort of 153 net nights while conducting the telemetry study at the Sequoyah National Wildlife Refuge. We captured 612 turtles of 8 species (Table 3), including 82 captures of *M. temminckii.* Twenty-four of the 82 captures were recaptures, so only 58 individuals were captured (Table 4). The 58 individuals of *M. temminckii* were 10 males, 16 females and 32 juveniles.

We placed ultrasonic tags on 13 individuals of *M. temminckii* (5 juveniles, 4 males, and 4 females). Adults size was determined as per Dobie (1971): carapace length = 37 cm for males and 33 cm for females. From 1 June to 26 September, we made 82 locational fixes on the 13 tagged turtles. Turtles generally occupied a core site that consisted of some structure such as a submerged log, or cover like overhanging bushes and beaver dens. These core sites also tended to have dense canopy cover. Core sites at recorded turtle locations had average canopy density of 78%. Individuals generally would occupy this core site for 1-14 days before moving to a new core site. Turtles primarily used only a few core sites within their home range.

Only 10 of the 13 tagged individuals could be located on a regular basis, so movement data for the project is based on those individuals. Turtles had a mean movement distance of 220 m between location fixes. Because stream environments were linear habitats, home ranges of turtles were figured as linear lengths. A home range was the distance between the two farthest points in a stream reach in which a turtle was located. The average linear home range for the 13 individuals in this study was 715.6 m.

Tagged turtles were located in water 0.5 m to 3 m deep. The mean overall depth for all turtles was 1.41 m, and the depth occupied in the water column by the turtles seemed to be linked to time of year. As the air and water temperatures warmed in late summer, turtles occupied deeper water, and then moved back to shallower water later in the season when air and water temperatures cooled (Fig. 2). This observation is probably due to the seasonal relationship between water depth and water temperature. The mean overall temperature for tagged individuals was 25.5^{0} C, with a minimum of 19^{0} C, and a maximum of 33.8^{0} C.

DISCUSSION

Based on records from Glass (1949), Carpenter and Krupa (1989), and Heck (1998), *M. temminckii* once occurred throughout the eastern one-third of Oklahoma. During this survey, *M. temminckii* was captured at only 11 of the 67 sites within the historic range of this species in Oklahoma that we sampled. The possible reasons for this decline are habitat alteration and historical, incidental, and illegal take.

There are several forms of habitat alteration that may have an effect on *M. temminckii* in Oklahoma. The Verdigris River has been channelized for navigational purposes throughout much of Oklahoma. This manipulation of the river channel turns a low energy meandering aquatic system into a higher energy system that is vastly different from the microhabitat preferred by *M. temminckii*.

Impounding of waters may have an effect on the dispersal of *M. temminckii* into new areas. *Macrochelys temminckii* is exclusively aquatic, except for females during egg laying (Pritchard, 1989). An impoundment such as a dam or a lock would block the movement of individuals up or downstream of the structure. The Arkansas River seems to be the major pathway for *M. temminckii* throughout central and northern portions of its range in Oklahoma. There are some older records of *M. temminckii* from north-central Oklahoma in Kay and Osage counties (Glass, 1949; Carpenter and Krupa, 1989), but there have been no recent reports and no individuals were captured during our survey. 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.

Thermal alteration of aquatic environments such as hypolimnetic release of cold water may also be responsible for the decrease in *M. temminckii* abundance. The Mountain Fork River in McCurtain County, Oklahoma, is managed as a cold water stream for trout fishing. The water temperature in the summer is maintained between 17^0 C and 21^0 C. The mean habitat temperature for *M. temminckii* in this study was 25^0 C. Little work has been done with the thermal requirements of *M. temminckii*, but Allen and Neil (1950) noted that they refuse food at temperatures $\leq 18^0$ C. Based on our observations, the thermal environment in rivers such as the Mountain Fork are not ideal for *M. temmenckii* or other aquatic turtle species. A 36.36-kg alligator snapping turtle was captured on the Mountain Fork River in 1993 by anglers (Shipman pers. obs.). No individuals were captured on the Mountain Fork during our survey. According to local turtle trappers, that was the last known individual of *M. temmenckii* captured in the Mountain Fork River.

Incidental and illegal take have had a major impact on populations of *M. temminckii* in Oklahoma. Historically, turtles were taken throughout their entire range in Oklahoma. Primarily only large adults were taken.

Heck (1998) suggested that *M. temmenckii* have been harvested historically in southeastern Oklahoma. During our survey, only a few small alligator snapping turtles were captured on the Little and Kiamichi rivers in McCurtain and Pushmataha counties. In Missouri, Shipman and Riedle (1994) found that in areas at or near where there had been active turtle harvesting, there was an absence of larger individuals of *M. temmenckii.* Areas where our overall turtle captures were low in Oklahoma (Fig. 3) corresponded with areas where, based on information from turtle trappers, conservation officers, and refuge managers, there has been intensive commercial turtle harvesting; however, additional quantification of habitat characteristics and availabilities among areas would be needed to demonstrate a cause-and-effect relationship.

Machrochelys temmenckii is incidentally captured by fisherman using trotlines and setlines (Shipman, 1993; Santhuff, 1993; Shipman and Riedle, 1994; and Shipman and Neeley, 1998). During the course of the telemetry work at Sequoyah National Wildlife Refuge, a 26.8-kg female was brought to the refuge office by a fisherman. The turtle had been snagged on a trotline. The turtle was measured, fitted with a telemetry tag and released. Whenever opportunities arose, we conducted informal surveys of local anglers at survey locations about sightings of alligator snapping turtles. These surveys produced accounts of sightings that seem probable to us based on the independent descriptions of the turtles they encountered and their knowledge of the differences between the two different species of snapping turtles. More often than not, the accounts of encounters ended with the turtles being killed.

The habitat use by alligator snapping turtles was addressed at two scales in this study. At the macrohabitat level, as indicated by CCA, *M. temminckii* appears to be a generalist, being found in the same type of habitats as other well-known generalist species, red ear sliders and common snapping turtles. The habitat where alligator snapping turtles were found is typical of the mid-reaches of intermediate streams and rivers. While alligator snapping turtles may be non-specific in their macrohabitat distribution, the telemetry work indicates that they are microhabitat specialists, in that they chose specific sites within their local environments. Factors associated with these core sites are, in terms of stream hydrology, associated with lower energy points in lotic environments (Shipman, 1993) where debris (detritus, logs, log jams, etc.) are deposited, providing structural cover and resources for aquatic organisms. This concurs with previous findings (Sloan and Taylor, 1987; Shipman, 1993; Harrel et al., 1996; Shipman and Neeley, 1998).

Tagged turtles occupied linear home ranges between 150 m and 2,250 m in length. They occupied several core sites within that home range, alternating between sites every few days to a couple of weeks.

RECOMMENDATIONS

1. Habitat manipulations such as channelization and thermal alterations may change habitat in a way that is unfavorable with respect to habitat preferences of *M. temminckii*. Therefore, we recommend that any such activity in areas where *M. temminckii* is known to occur be evaluated for its potential impact.

2. Incidental and illegal take may be a threat to existing populations of *M. temminckii* in Oklahoma. The Missouri Department of Conservation has instituted public awareness programs for anglers and law enforcement on *M. temminckii* conservation and management in areas where the species was known to occur. We recommend that the ODWC adopt a similar informational campaign.

3. Known populations of *M. temminckii* should continue to be monitored and more surveys should be conducted to find additional populations. Prime areas that may contain *M. temmenckii*, but that are in need of further study, include the Deep Fork and Canadian rivers near Lake Eufala and the Poteau River downstream from Lake Wister.

4. Rigorous monitoring of the status of aquatic turtle populations in riverine environments in eastern Oklahoma should be conducted. The low turtle capture rates in some Oklahoma streams with seemingly adequate habitats for turtles, particularly in southeastern river drainages such as the Little River are of concern. The cause of this phenomenon is uncertain, but it is unlikely due to inherent or historical differences in species composition in those river drainages compared with others in Oklahoma. Possible causes for such observations, in the absence of empirical data, include water quality changes, differential habitat availability, habitat alteration, and overharvesting. In some drainages (particularly the Little River) low numbers of red ear sliders, a very hardy and ubiquitous species that is the most commercially important species in Oklahoma, and our anecdotal observations suggest to us that overharvesting could be a problem in some locations. Efforts should be made to ensure that Oklahoma aquatic turtle populations are monitored and managed so that they are not overharvested.

ACKNOWLEDGEMENTS

We wish to thank these cooperating agencies for supporting this research: The Oklahoma Department of Wildlife Conservation; Sequoyah National Wildlife Refuge; The Oklahoma Cooperative Fish and Wildlife Research Unit, USGS; and the Department of Zoology, Oklahoma State University.

This work was also aided by the efforts of these volunteers and field technicians: Tyler Ashby, Audrey Buck, Ken Cole, Corey Fincher, Shane Kasson, Jason Knight, Melayna Martens, Merilee Mason, Chris O'Melia, Casey Osterhaut, Melissa Stangland-Willis, Richard Stark, Tiffany Talbot, Jill Witham, and Joy Yoshioka.

Prepared by: J. Daren Riedle, Paul A. Shipman, Stanley F. Fox, and David M. Leslie, Jr. Oklahoma Cooperative Fish and Wildlife Research Unit, Stillwater, Oklahoma.

Date: 15 November 1999

Approved by: Harold Namminga, Oklahoma Department of Wildlife Conservation, Oklahoma City, Oklahoma.

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Table 1. 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=alligator snapping turtle, CHSE=common snapping turtle, KISU=Mississippi mud turtle, STCA=razorback musk turtle, STOD=common musk turtle, APSP=spiny softshell, APMU=smooth softshell, CHPI=painted turtle, GRGE=common map turtle, GRKH=false map turtle, GRPS=ouachita map turtle, PSCO=river cooter, TRSC=red ear slider).

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

Table 1 cont.

LOCATION	DATE	NETS	COUNTY	MATE	CHSE	KISU	STCA	STOD	APSP	APMU	CHPI	GRGE	GRKH	GRPS	PSCO	TRSC
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
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

Table 1 cont.

LOCATION	DATE	NETS	COUNTY	MATE	CHSE	KISU	STCA	STOD	APSP	APMU	CHPI	GRGE	GRKH	GRPS	PSCO	TRSC
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
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

Table 1 cont.

LOCATION	DATE	NETS	COUNTY	MATE	CHSE	KISU	STCA	STOD	APSP	APMU	CHPI	GRGE	GRKH	GRPS	PSCO	TRSC
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
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

Table 2. Alligator snapping turtle size data from survey (CL=carapace length, CW=carapace width, PL=plastron length, PW=plastron width).

LOCATION	DATE	ID#	TAG	SEX	MASS	CL	CW	PL	PW
LITTLE RIVER	7/10/97	*NA*	*NA*	*JV*	*NA*	*NA*	*NA*	*NA*	*NA*
HORTON SLOUGH	7/10/97	10	10	M	3.60	267	212	189	187
HORTON SLOUGH	7/11/97	1	1	F	4.25	283	234	207	197
HORTON SLOUGH	7/11/97	2	2	F	10.25	370	305	262	262
HORTON SLOUGH	7/11/97	3	3	JV	1.00	179	145	126	124
HORTON SLOUGH	7/11/97	4	4	JV	1.50	202	155	143	130
HORTON SLOUGH	7/12/97	5	5	F	3.25	269	201	73	75
BIG VIAN CREEK	7/12/97	6	6	JV	1.80	220	161	160	146
BIG VIAN CREEK	7/12/97	7	7	F	6.25	332	254	225	220
BIG VIAN CREEK	7/12/97	8	8	JV	2.75	257	184	174	164
BIG VIAN CREEK	7/12/97	9	9	F	4.25	303	210	200	190
BIG VIAN CREEK	7/12/97	11	11	JV	1.90	220	165	144	137
LITTLE RIVER	7/13/97	*NA*	*NA*	*JV*	*NA*	*NA*	*NA*	*NA*	*NA*
LITTLE RIVER	7/14/97	*NA*	*NA*	*JV*	*NA*	*NA*	*NA*	*NA*	*NA*
MILL CREEK[1]	7/16/97	12	12	F	3.10	254	211	163	187
KIAMICHI RIVER	7/16/97	13	13	F	3.25	260	201	175	172
BIG VIAN CREEK	7/30/97	14	14	M	2.75	259	199	180	180
BIG VIAN CREEK	7/30/97	15	15	JV	1.50	223	165	149	165
BIG VIAN CREEK	7/30/97	16	16	JV	1.50	219	150	145	142
BIG VIAN CREEK	7/30/97	1	1	F	*Recapt*				
BIG VIAN CREEK	7/31/97	17	19	JV	2.25	222	183	156	160
BIG VIAN CREEK	7/31/97	11	11	JV	*Recapt*				
DIRTY CREEK	7/31/97	18	*NA*	F	*NA*	364	282	274	262
BIG VIAN CREEK	7/3/98	24	24	M	4.50	287	205	209	209
BIG VIAN CREEK	7/3/98	25	*NA*	JV	2.00	209	178	150	150
BIG VIAN CREEK	7/3/98	26	*NA*	JV	2.70	222	175	157	150
BIG VIAN CREEK	7/3/98	27	17	F	11.00	370	281	288	261
BIG VIAN CREEK	7/3/98	28	*NA*	JV	2.50	230	150	161	147
BIG VIAN CREEK	7/9/98	17	19	JV	*Recapt*				
BIG VIAN CREEK	7/9/98	29	29	JV	2.75	245	180	163	167
LITTLE VIAN CREEK	7/21/98	30	*NA*	JV	2.00	240	170	165	165
LITTLE VIAN CREEK	7/22/98	8	8	JV	*Recapt*				
LITTLE VIAN CREEK	7/23/98	31	*NA*	JV	1.75	210	157	147	150
LITTLE VIAN CREEK	7/23/98	32	*NA*	JV	0.50	140	115	100	100
LITTLE VIAN CREEK	7/23/98	33	*NA*	JV	1.00	195	145	138	138
LITTLE VIAN CREEK	7/23/98	34	3	JV	2.50	230	165	165	160
LITTLE VIAN CREEK	7/23/98	35	23	M	5.00	295	235	210	210
LITTLE VIAN CREEK	7/23/98	36	*NA*	F	4.00	280	230	194	180
LITTLE VIAN CREEK	7/28/98	37	36	JV	3.50	268	195	190	190
LITTLE VIAN CREEK	7/28/98	38	38	F	17.00	433	360	340	295
LITTLE VIAN CREEK	7/28/98	39	*NA*	JV	2.50	225	200	163	165
LITTLE VIAN CREEK	7/28/98	40	43	M	14.00	390	300	285	265
LITTLE VIAN CREEK	7/28/98	41	44	M	9.50	380	290	277	255
LITTLE VIAN CREEK	7/28/98	42	47	F	19.00	450	360	340	305
LITTLE VIAN CREEK	7/28/98	43	48	F	7.00	330	270	234	230
LITTLE VIAN CREEK	7/28/98	44	50	M	41.80	595	442	415	360
LITTLE VIAN CREEK	7/28/98	45	49	F	10.20	380	310	275	255

Table 2 cont.

LOCATION	DATE	ID#	TAG	SEX	MASS	CL	CW	PL	PW
LITTLE VIAN CREEK	7/29/98	46	65	JV	2.25	259	186	178	170
LITTLE VIAN CREEK	7/29/98	47	61	F	12.25	392	317	294	263
LITTLE VIAN CREEK	7/29/98	48	71	F	12.25	415	320	305	269
LITTLE VIAN CREEK	7/29/98	49	74	M	16.25	460	327	347	332
LITTLE VIAN CREEK	7/30/98	50	55	M	7.50	380	290	285	265
LITTLE VIAN CREEK	7/30/98	51	70	M	22.00	495	392	345	315
LITTLE VIAN CREEK	7/30/98	52	69	M	14.00	398	340	298	285
LITTLE VIAN CREEK	7/30/98	53	*NA*	F	15.00	410	340	326	300
LITTLE VIAN CREEK	7/30/98	54	56	M	4.25	290	210	200	280
HEZEKIAH CREEK	7/30/98	55	58	F	18.75	448	356	324	324
MILL CREEK[2]	7/22/99	90	20	F	16.40	480	440	335	310
MILL CREEK[2]	7/22/99	91	22	M	8.60	360	320	250	260
MILL CREEK[2]	7/22/99	92	21	JV	1.80	260	240	180	180
MILL CREEK[2]	7/22/99	93	35	F	11.00	370	340	260	250
MILL CREEK[2]	7/22/99	94	42	M	15.00	430	390	300	270
MILL CREEK[2]	7/22/99	95	45	F	8.60	300	170	210	210
MILL CREEK[2]	7/22/99	96	46	M	10.40	320	290	260	230
MILL CREEK[2]	7/22/99	97	51	F	8.20	310	290	220	200
DUTCHESS CREEK	7/23/99	98	53	JV	1.80	250	230	170	170
DUTCHESS CREEK	7/23/99	99	NA	JV	0.68	190	170	140	140
DUTCHESS CREEK	7/23/99	130	NA	JV	0.90	230	200	160	150
DUTCHESS CREEK	7/23/99	131	62	M	18.20	410	380	300	280

[1] = Mill Creek, Pushmataha County
[2] = Mill Creek, McIntosh County
NA = Data not available
Recapt = Recapture

Table 3. Sample locations (BVC=Big Vian Creek, LVC=Little Vian Creek), sample dates, net nights, and number of turtles captured by species (APSP=spiny softshell, GRKH=false map turtle, GRPS=ouachita map turtle, PSCO=river cooter, STOD=common musk turtle, TRSC=red ear slider, CHSE=common snapping turtle, MATE=alligator snapping turtle).

LOCATION	DATE	NET NIGHTS	SPECIES							
			APSP	GRKH	GRPS	PSCO	STOD	TRSC	CHSE	MATE
BVC	5/10/99	5	0	0	0	1	0	21	0	2
BVC	5/11/99	5	0	0	1	0	0	30	1	6
LVC	5/12/99	5	1	3	0	1	0	13	0	2
BVC	5/13/99	10	0	0	0	0	0	0	2	4
BVC	5/14/99	5	1	0	3	0	0	47	3	0
BVC	5/18/99	5	0	0	0	1	0	22	1	0
LVC	5/19/99	6	0	0	0	0	0	11	0	3
BVC	5/21/99	5	0	0	0	0	0	0	0	4
BVC	5/25/99	5	0	0	0	0	0	12	0	4
BVC	5/26/99	6	0	0	0	0	0	11	1	5
LVC	5/27/99	5	0	1	0	0	0	13	0	3
BVC	5/28/99	5	0	0	1	0	0	8	0	2
BVC	6/2/99	3	0	0	0	1	0	2	1	2
BVC	6/3/99	5	0	0	1	0	0	13	1	1
LVC	6/4/99	5	0	0	0	0	0	0	0	1
BVC	6/11/99	2	0	0	0	0	0	7	0	2
LVC	6/12/99	6	0	0	1	1	0	35	0	6
BVC	6/13/99	5	0	0	0	0	0	9	0	4
LVC	6/16/99	5	0	0	0	0	0	12	0	5
BVC	6/24/99	5	0	0	0	0	2	16	0	0
BVC	6/28/99	5	0	0	0	0	0	10	3	8
BVC	7/9/99	7	0	0	0	0	0	7	0	8
BVC	7/11/99	7	0	0	0	0	0	4	1	4
LVC	7/14/99	10	0	0	0	0	1	67	3	1
BVC	7/15/99	7	0	0	1	0	0	39	1	1
BVC	7/20/99	1	0	0	0	0	0	0	0	1
BVC	9/25/99	7	0	0	0	0	0	40	0	0
LVC	9/26/99	6	1	1	0	1	0	38	0	3

Table 4. Alligator snapping turtle size data from telemetry study (CL=carapace length, CW=carapace width, PL=plastron length, PW=plastron width), for turtles captured during the telemetry study at Sequoyah National Wildlife Refuge, by location (BVC=Big Vian Creek, LVC=Little Vian Creek).

LOCATION	DATE	ID#	TAG	SEX	MASS	CL	CW	PL	PW
BVC	5/10/99	58	76	F	16.80	510	440	350	350
BVC	5/11/99	60	78	F	14.50	450	360	310	310
BVC	5/11/99	59	79	F	18.60	460	340	360	330
BVC	5/11/99	61	80	F	12.70	420	300	310	280
BVC	5/11/99	62	91	JV	4.50	310	210	240	210
BVC	5/11/99	63	92	F	9.00	360	260	270	270
LVC	5/12/99	64	93	JV	4.10	310	290	230	220
LVC	5/12/99	65	82	JV	4.50	310	290	230	220
BVC	5/13/99	66	83	M	10.90	400	380	290	290
LVC	5/19/99	68	85	JV	5.40	320	270	250	240
BVC	5/21/99	*NA*	*NA*	JV	0.22	110	100	80	80
BVC	5/21/99	70	81	JV	3.60	280	210	210	200
BVC	5/21/99	71	86	M	18.20	450	360	320	300
BVC	5/21/99	72	88	JV	7.30	320	310	260	250
BVC	5/25/99	73	89	F	10.00	384	318	262	244
BVC	5/25/99	74	90	M	14.50	422	322	308	276
BVC	5/25/99	75	87	JV	4.50	288	272	196	180
BVC	5/25/99	76	95	JV	3.60	278	230	194	194
BVC	5/26/99	77	94	JV	8.20	330	246	240	240
BVC	5/26/99	78	98	F	14.50	440	338	320	290
BVC	5/26/99	79	*NA*	JV	2.70	222	186	160	160
BVC	5/26/99	80	97	M	10.00	376	282	256	244
BVC	5/26/99	81	98	M	15.40	408	330	296	276
LVC	5/27/99	82	99	JV	6.40	312	266	220	210
LVC	5/27/99	83	*NA*	JV	4.10	272	216	190	190
LVC	5/27/99	84	100	F	11.80	430	320	296	270
BVC	5/28/99	*NA*	366	M	42.30	614	478	404	376
BVC	5/28/99	85	121	JV	10.90	376	300	262	232
BVC	6/2/99	86	125	F	17.30	440	362	314	294
LVC	6/4/99	*NA*	357	F	16.80	454	390	330	296
BVC	6/11/99	118	249	F	26.80	510	400	360	350
LVC	6/12/99	*NA*	285	JV	5.40	300	260	230	220
LVC	6/12/99	87	*NA*	JV	2.30	250	200	160	180
LVC	6/12/99	88	*NA*	JV	0.45	180	160	130	130
LVC	6/12/99	*NA*	267	M	15.90	400	320	300	270
BVC	6/13/99	*NA*	258	F	14.10	400	315	310	260
BVC	6/13/99	89	116	F	17.30	430	352	320	300
BVC	6/13/99	*NA*	284	M	17.30	410	398	340	290
BVC	6/13/99	*NA*	348	M	34.50	536	395	380	320
LVC	6/16/99	100	*NA*	JV	3.60	280	225	200	190
LVC	6/16/99	101	117	JV	7.30	280	250	240	240
LVC	6/16/99	102	*NA*	JV	4.50	280	210	212	198
BVC	6/28/99	104	124	M	46.40	605	520	470	420
BVC	6/28/99	101	*NA*	JV	0.90	200	180	156	150
BVC	6/28/99	103	*NA*	JV	6.40	270	200	200	180

Table 4 cont.

LOCATION	DATE	ID#	TAG	SEX	MASS	CL	CW	PL	PW
BVC	6/28/99	105	*NA*	JV	1.80	240	175	180	170
BVC	6/28/99	106	119	F	17.70	460	360	340	320
BVC	7/9/99	108	122	JV	5.40	290	260	220	200
BVC	7/9/99	109	123	JV	5.40	300	220	224	201
BVC	7/9/99	110	*NA*	JV	1.40	210	160	150	150
BVC	7/9/99	111	*NA*	JV	1.80	260	190	190	180
BVC	7/9/99	112	*NA*	JV	2.70	290	220	309	205
BVC	7/11/99	113	102	F	14.10	419	340	318	294
BVC	7/11/99	114	101	F	17.30	420	358	318	276
LVC	7/14/99	115	*NA*	JV	3.60	270	260	175	170
BVC	7/15/99	116	*NA*	JV	0.40	190	190	140	130
BVC	7/20/99	*NA*	*NA*	JV	0.34	141	100	94	90
BVC	9/25/99	120	108	JV	5.90	310	210	220	210
BVC	9/25/99	*NA*	276	M	11.80	410	300	290	260
BVC	9/25/99	121	109	M	10.00	370	280	280	250
LVC	9/26/99	122	*NA*	JV	1.30	248	170	72	70

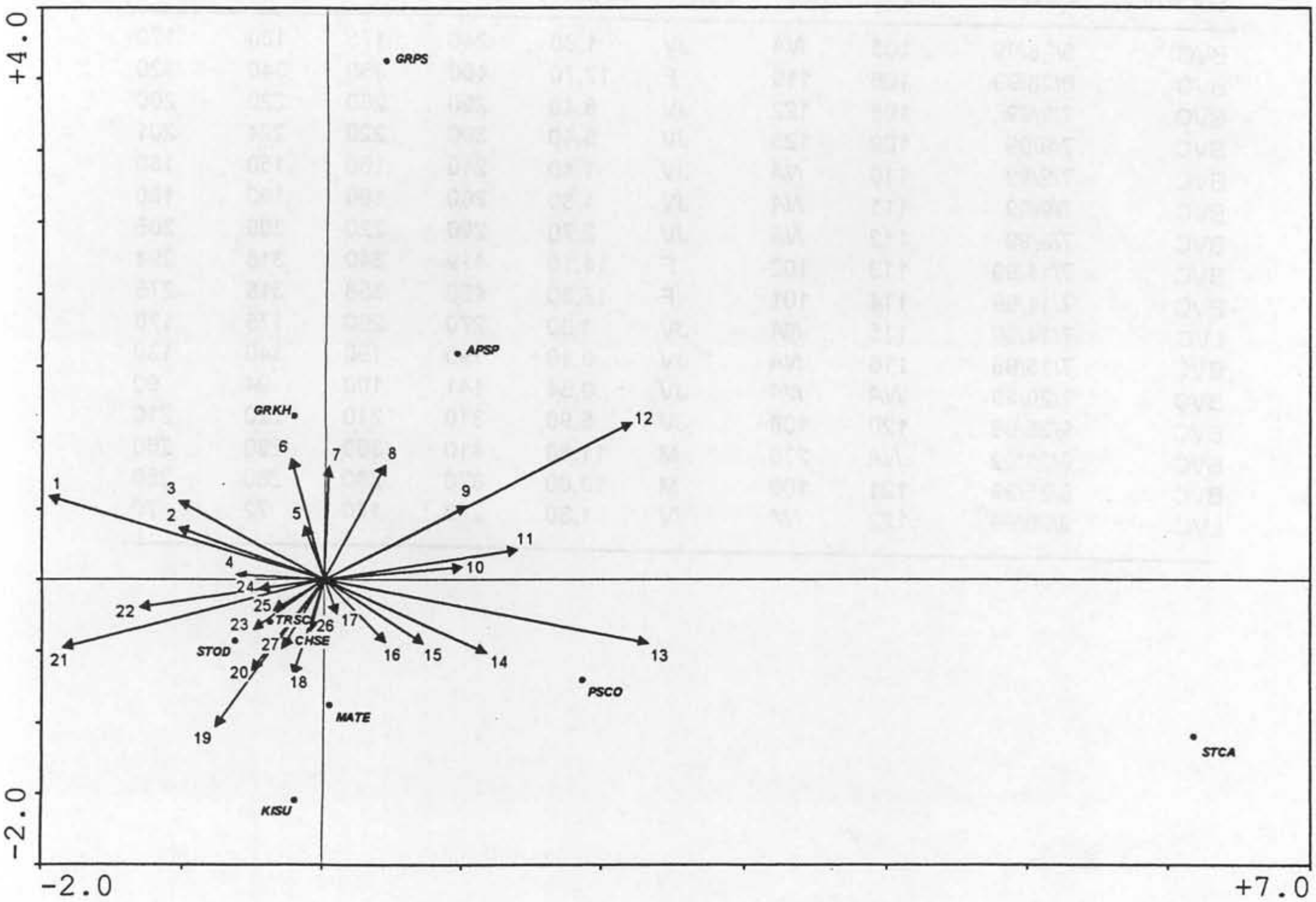

Figure 1. Species X habitat associations as determined by canonical correspondence analysis. Species scores (shown as points): *MATE*=alligator snapping turtle, *CHSE*=common snapping turtle, *KISU*=Mississippi mud turtle, *STCA*=razorback musk turtle, *STOD*=common musk turtle, *APSP*=spiny softshell, *GRKH*=false map turtle, *GRPS*=ouachita map turtle, *PSCO*=river cooter, and *TRSC*=red ear slider (extremely rare species are excluded from the analysis). Habitat scores (shown as vectors): 1=percent pool, 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=relative amount of bank covered by vegetation, 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).

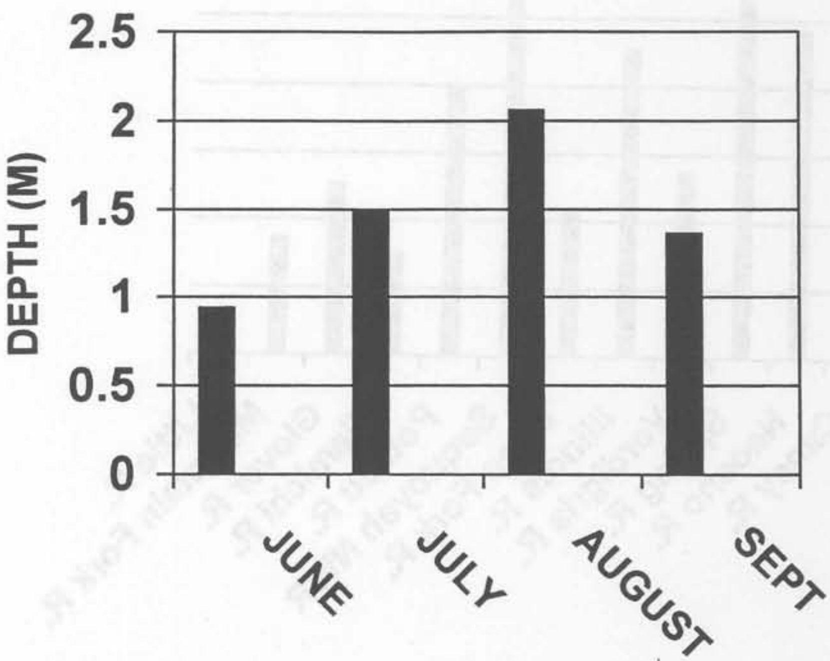

Figure 2. Mean depth of alligator snapping turtle locations across telemetry study field season.

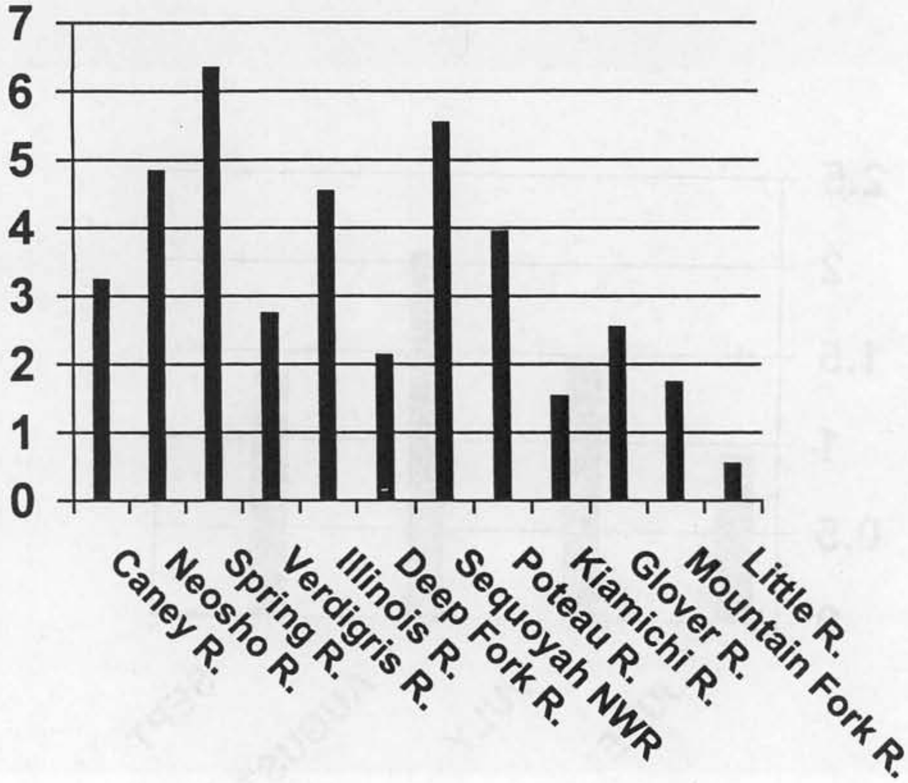

Figure 3. Number of turtles captured per net night in each surveyed river. Rivers are ordered from north to south.