FINAL PERFORMANCE REPORT

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Surveys to Assess Suitability of Alligator Snapping Turtle (*Macrochelys temminckii*) Reintroduction Sites in Oklahoma

Oklahoma Department of Wildlife Conservation

January 1, 2018 – December 31, 2018

SURVEYS TO ASSESS SUITABILITY OF ALLIGATOR SNAPPING TURTLE (*MACROCHELYS TEMMINCKII*) REINTRODUCTION SITES IN OKLAHOMA

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Teddy Pashia and Stephan Brown, Field Technicians

A. ABSTRACT

Alligator snapping turtle (*Macrochelys temminckii*) populations have declined in portions of the species' historic range in Oklahoma. Reintroduction efforts have begun reestablishing populations in the Caney and Verdigris rivers near the Oklahoma-Kansas border, and in the Washita River in southeastern Oklahoma. Post-reintroduction surveys have documented robust growth and survival rates, both of which serve as indicators that this approach may ultimately be an effective management strategy for the species. Because of the success of these early efforts, the next step to reestablishing the species throughout its historic range will be to expand reintroductions to more rivers (and river segments where dams interrupt dispersal pathways). The objectives of this study were to: 1) ascertain whether or not alligator snapping turtles were present in the river segments that were surveyed, 2) characterize the aquatic turtle community structure at each survey location, and 3) determine habitat suitability of each survey location based on known habitat preferences of the alligator snapping turtle. We conducted habitat surveys along five river segments, four of which were subsequently sampled for turtles. We found apparently reproducing populations of alligator snapping turtles at two of these sites—Big Cabin Creek, a tributary of the Neosho River, and the Poteau River near Arkoma, Oklahoma—making reintroduction in these rivers unnecessary. Habitat assessments took place on the Poteau River above Lake Wister, but the site was not further surveyed for alligator snapping turtles due to poor habitat quality. The fourth location, Deep Fork River, boasts highly suitable habitat for alligator snapping turtles. However, recent records indicate that the river may currently support a population despite lack of detection of the species in the current survey. Additional survey effort should take place before reintroductions are initiated at this site. The final site, Chouteau Creek (another tributary of the Neosho River), lacked alligator snapping turtles but otherwise supported a healthy turtle community, and suitable habitat was present. Of the sites surveyed, we propose that Chouteau Creek is the best suited for future reintroduction of alligator snapping turtles in Oklahoma.

B. BACKGROUND

The alligator snapping turtle (*Macrochelys temminckii*) is a large, highly aquatic species that inhabits Gulf of Mexico river drainages from eastern Texas through the Florida panhandle. Individuals rarely disperse over land but have historically moved readily throughout their riverine habitat into the northern reaches of its range (Roman et al. 1999). In recent decades, the alligator snapping turtle has experienced significant declines and extirpations throughout its range, largely due to habitat alteration and human exploitation (Ernst and Lovich 2009). The United States Fish and Wildlife Service was petitioned in 1983 to list the alligator snapping turtle as threatened, but the petition failed due to insufficient information regarding the species' status (Heck 1998). Currently, the alligator snapping turtle is listed as Vulnerable on the IUCN Red List of Threatened Species and is protected to some degree in all states where they occur (IUCN 2013, Roman and Bowen 2000, Reed et al. 2002). In Oklahoma, the alligator snapping turtle is one of just two reptiles that is listed as a Tier I Species of Greatest Conservation Need (Oklahoma Comprehensive Wildlife Conservation Strategy). The decline of this species within the state has been documented, but more surveys are needed to assess its current status in the watersheds where historic records exist. The species historically occurred in all major river systems in the eastern third of Oklahoma, and a survey in the late 1990s recorded four populations none of which were in the northern portion of the historic range (Riedle et al. 2005; Figure 1). Two of these populations—located at Sequoyah National Wildlife Refuge and nearby Lake Eufaula—exhibited recapture rates indicative of healthy populations.

In response to the decline of alligator snapping turtle populations in Oklahoma, a head-start program was initiated at Tishomingo National Fish Hatchery in 2000 with the goal of restoring populations in rivers where the species has been extirpated and to supplement small populations that are unlikely to rebound without intervention, thus laying the groundwork for establishing self-sustaining populations in Oklahoma. Head-started juvenile turtles have been reintroduced into the Caney, Verdigris, and Neosho rivers near the Oklahoma-Kansas border and in the Washita River in southeastern Oklahoma. Extensive post-reintroduction monitoring of released turtles has been conducted at the Caney and Washita river sites (Moore et al. 2013, Anthony et al. 2015, Dreslik et al. 2017). To date, the largest and best-monitored reintroduced population of alligator snapping turtles inhabits the Caney River. Post-reintroduction surveys have revealed that survival is high among older/larger individuals, body condition is stable, and growth rates exceed those of captive head-started juveniles in the same age classes (Anthony et al. 2015). These results indicate that after release, alligator snapping turtles are able to successfully navigate novel environments and obtain sufficient food to survive and flourish.

Because of the success of these early efforts, the next step to reestablishing the species throughout its historic range will be to expand reintroductions to more rivers (and river segments where dams interrupt dispersal pathways). The purpose of this study was to conduct habitat and turtle community surveys in rivers in eastern Oklahoma that have previously been identified as potentially suitable sites for reestablishing alligator snapping turtle populations. There are five criteria by which suitability of each location surveyed was determined: 1) historical presence of alligator snapping turtles based upon published records, 2) absence of a viable population of *M. temminckii*, 3) reduction or elimination of anthropogenic factors that are likely to have contributed to the species' extirpation in the area, 4) presence of suitable habitat, and 5) evidence that the site is still habitable, based upon the presence of a robust turtle community.

C. OBJECTIVES

1. Ascertain whether or not alligator snapping turtles (*Macrochelys temminckii*) are present in the river segments that were surveyed.
2. Characterize the aquatic turtle community structure at each survey location, including species richness and catch-per-unit effort for each species encountered.
3. Measure the habitat characteristics that are preferred by Alligator Snapping Turtles including: prevalence of underwater structure, channel depth, over-story canopy density along the banks, and prevalence of steep banks that are preferred by nesting females.

D. APPROACH

We targeted eight rivers to assess for suitability of alligator snapping turtle reintroduction. Without regard to rank, the proposed sites to conduct surveys in 2018 were the following (Figure 2):

1) **Neosho River above Lake Hudson (Big Cabin Creek)**. The Neosho River was likely historically one of the species' strongholds in the state. However, the presence of dams necessitates considering the river in discrete segments. Big Cabin Creek, a tributary of this stretch of river, was the focal sample location and was accessed north of Pensacola, Oklahoma at N4420 Rd. The sample reach stretched 6.66-km of river and was located in Mayes County.
2) **Neosho River above Fort Gibson Lake (Chouteau Creek)**. The main channel of the Neosho River and a tributary, Chouteau Creek, were sampled for a total sampled area of 5.84-km. Boat access was gained through the Mazie Landing Marina. The sampled reach was located in Mayes County. The majority of the sampling effort was conducted in the tributary. As such, this site will be referred to as Chouteau Creek for the remainder of this report. All reported statistics, however, include turtle captures and habitat measurements from both channels.
3) **Deep Fork River.** This river originates near Edmond, Oklahoma, and flows into the Canadian River at Lake Eufaula. A small number of alligator snapping turtles have been documented in the Deep Fork in recent years, but the population status of the species remains undetermined. Access to the river was obtained east of Henryetta on Highway 266. A total of 11.81-km of river was surveyed both upstream and downstream of the boat ramp. The surveyed area was located in Okmulgee County and included river within the boundaries of the Deep Fork National Wildlife Refuge.
4) **Poteau River near Lake Wister.** After flowing through the Ouachita National Forest in Arkansas, the Poteau River enters Lake Wister from the south near Wister, Oklahoma. Downstream of the lake, few public access points exist as the river flows through riffles and pools until reaching Arkoma, Oklahoma where the channel is adequately deep for boat travel. The river was scouted by boat for 3-km downstream of the Lake Wister dam and by foot east of Highway 59. Neither location was adequately deep for deploying traps. Upstream of the lake, habitat surveys took place along 11.81-km of river upstream of Potts Landing. After cursory assessment of the habitat data, the habitat was deemed unsuitable for alligator snapping turtles due to lack of structure preferred by adults. Turtle surveys were therefore not conducted at the site. All of the described river segments reside in Le Flore County.
5) **Poteau River near Arkoma, OK.** The Poteau River flows into the Arkansas River at the Oklahoma-Arkansas boarder. This segment of the river was accessed at Arkoma Park north

of highway 9A in Arkoma, Oklahoma. Both habitat and turtle surveys were conducted encompassing 8.05-km of river located in Le Flore County.

6) **Spavinaw Creek**. Spavinaw Lake was created in 1922 when an impoundment was constructed on Spavinaw Creek near its confluence with the Neosho River. Upstream, another dam forms Lake Eucha. We attempted to access Spavinaw Creek from Spavinaw Lake but were unable to enter the river channel due to shallow water and dense aquatic vegetation. The creek was then scouted by foot at E0425 Rd near the Spring Valley Ranch and at various foot access points in Lake Eucha Park. Overall, the creek was too shallow for turtle trapping, and banks were unsuitable for alligator snapping turtle nesting. Neither habitat surveys nor turtle surveys were conducted. The scouted area lies in Mayes County.
7) **Caney River**. Although reintroductions have been implemented on the Caney River above Hulah Lake, limited river access below the reservoir has prevented previous survey work. However, access is available in Bartlesville, Oklahoma, and northeast of Collinsville off of highway 169. The accessible area associated with this river segment lies in portions of Washington and Tulsa counties. Both of these locations, in addition to others, were visited, but the river was inadequate for boat travel and areas far enough away from potential public harassment were not accessible by foot. Neither habitat surveys nor turtle surveys were conducted.
8) **Verdigris River**. As is the case on the Caney River, surveys and subsequent reintroductions of alligator snapping turtles have occurred near the Kansas border on the Verdigris River upstream of an impoundment that forms Oologah Lake. Although sizeable portions of the river below this point have been channelized to facilitate barge traffic, significant suitable habitat appears to persist where segments of the original, more serpentine, channel remain intact. Several such segments are accessible east of Wagoner, Oklahoma, where the river flows beneath highway 51. This river segment is in Wagoner County. This river was not surveyed due to time constraints.

Each river segment was trapped for 100–120 trap nights by setting at least 15 nets daily for seven days. The turtle traps used included single-throat 0.9-m diameter and double-throat 1.2-m diameter hoop nets. Traps were set and georeferenced in the afternoon and checked the following morning. Each trap was baited daily with frozen Asian Carp obtained from Missouri Department of Conservation. Traps were set such that a portion of the net remained above water to allow turtles to breath. If inclement weather was predicted, trapping was post-poned or flotation devices were placed in traps to keep a portion of the net above the water in the case of rising water.

Upon each turtle capture, we recorded species, mass, shell measurements, sex, and shell scarring. Each turtle received a common scute notch to indicate capture and was not re-measured in the event of recapture. Softshell turtles received a small notch in their cartilaginous carapace margin which will heal but remained visible for the duration of the trapping period (Plummer 2008). We calculated species richness along with catch-per-unit-effort for each surveyed site. Community structure at each site was determined using the Shannon diversity index and species evenness, and Bray-Curtis similarity indices were used to assess similarity of species composition among sites.

To assess the quality of the habitat at each survey location for the alligator snapping turtle, habitat measurements were taken at 25 sampling points along each bank of the river and included characteristics of the river channel measured 5 m from the bank (corresponding to adult habitat use) and characteristics of the bank itself (corresponding to nesting habitat). Channel measurements included channel width, current speed measured on a qualitative scale from 1 (no current) to 4 (fast current), emergent and submergent structure within a 5 m radius measured on a scale from 0 (none) to 3 (high density), and overstory canopy measured with a densitometer. Submerged structures were also revealed using side-scan sonar. ReefMaster (v2.0) was used to process sonar data and count logs along the entire length of the surveyed area. Bank characteristics included percent substrate composition (sand, dirt, rock, vegetation, etc.), bank height, and bank slope.

E. RESULTS AND DISCUSSION

We sampled turtles over 475 net nights and captured 1301 individual of eight species (Table 1). Our captures were dominated by *Trachemys scripta* at all sites but the Deep Fork River, where captures were dominated by *Graptemys ouachitensis.* Because of this unique community composition, the Deep Fork River had relatively low similarity to all other samples sites as seen by the Bray-Curtis similarity index (Table 2). The remaining three sites were fairly similar to each other in species composition. Diversity was highest in the Deep Fork River based on Shannon Diversity Index, followed by Chouteau Creek, Big Cabin Creek, and Poteau River (Table 3). Evenness was moderate at all sites, ranging from 0.334 at the Poteau River to 0.593 at the Deep Fork. These results indicate some level of inequality in species abundance - most likely due to a disproportionate abundance of *T. scripta* in most rivers. Fairly high catch per unit effort and low recapture rates further indicate the good health and potentially robust populations of these turtle communities (Table 3).

Our focal species, *Macrochelys temminckii*, was captured at two sites - Big Cabin Creek and the Poteau River near Arkoma (Table 4). The capture of a range of size classes, including adults and juveniles, indicates the presence of a breeding population in both rivers. The capture rate in the Poteau River (0.13 individuals/UE) was much higher than in Big Cabin Creek (0.024 individuals/UE), suggesting that the population may be more robust in this location. Both of these sites had been surveyed in previous sample efforts (Riedle et al. 2005), but sampling effort at that time was low. The lack of detection of the alligator snapping turtle in previous sampling events highlights the importance of adequately sampling an area to be confident in declarations of absence of this elusive species.

When assessing quality of habitat, it is important to consider all life stages of the focal species (Thompson et al. 2017). Adult alligator snapping turtles have a strong preference for underwater structure such as dead and overhanging trees and beaver dens (Riedle et al. 2006). High canopy cover is also important for both adults and hatchlings along with a variety of water depths (Shipman 1993, Howey and Dinkelacker 2009, Riedle et al. 2006, Spangler 2017). Additionally, alligator snapping turtles preferentially nest on tall riparian shelves (Miller et al. 2014). The results of the habitat survey at each site are summarized in Table 5. Sites where alligator snapping turtles were found were characterized by low current, canopy cover greater than 40%, and banks that were roughly 2–3 m tall with a slope near 50°. Canopy cover was slightly less dense where alligator snapping turtles were absent (Figure 3), but equally tall and steep banks were present (Figure 4). The comparable habitat measurements between sites with and without alligator snapping turtles indicates high habitat suitability at sites where the species was undetected. Substrate composition was measured as a representation of nesting habitat. To facilitate nesting, banks should ideally consist of dirt or sandy soil without dense vegetation. The high vegetation cover found during our surveys is most likely an overestimation of the conditions actually experienced by females during nesting season. For example, the highest bank vegetation cover was found at the Poteau River where a large number of alligator snapping turtles were found. Either females are easily able to overcome dense vegetation, or banks are less densely covered during the nesting season than during the time we conducted our survey there (23 June – 1 July).

Structure density was measured in two ways. First, a simple numerical scale was used at each sample point ranging from 0 (no structure) to 3 (high density of structure). Second, side-scan sonar was used to map the submerged structure on the river bottom (Figure 5). Estimating structure density at the local scale greatly underestimated the true log density as revealed by sonar. Log density was the highest in the Poteau River near Arkoma, followed by the Deep Fork River, Big Cabin Creek, Chouteau Creek, and Poteau River above Lake Wister (Table 5). By visual assessment, the structure in the Poteau River was considered too low to warrant further survey effort, but the true log density was much higher than our visual assessments estimated. This highlights the importance of quantitative habitat surveys versus the qualitative assessment that has been employed prior to these surveys. Side-scan sonar surveys also revealed interesting unnatural benthic structure (Figure 6a–e), along with schools of fish (Figure 6f) and potential alligator snapping turtles (Figure 7).

If reintroductions occur in eastern Oklahoma in the future, it is important to consider the likelihood of public interaction with released alligator snapping turtles that could result in the harassment of the population. One indication of potential interaction is the width of the riparian buffer zone. A larger buffer may result in less public use of the river and has the added benefit that it provides more canopy cover. We also counted the number of boats seen per day of sampling. The riparian buffer was fairly wide at all sites, but boat traffic was high in Chouteau Creek (7.57 boats/day all on the main channel of the Neosho River) and the Poteau River near Lake Wister (2.00 boats/day) making the likelihood of members of the public interacting with and potentially harassing turtles higher at these sites. The site least likely to support high public use was the Deep Fork River. This site displayed the largest riparian buffer and the lowest boat traffic rates while also being protected by the Deep Fork National Wildlife Refuge for long stretches of the river.

F. RECOMMENDATIONS

1. Due to the presence of potentially reproducing populations of alligator snapping turtles in Big Cabin Creek and the Poteau River near Arkoma, Oklahoma, reintroductions at these sites are unnecessary. However, **we strongly encourage additional survey efforts to determine the population size and demographics of these populations.** This information will contribute greatly to our understanding of the species overall status in Oklahoma.
2. **Of the surveyed sites, Chouteau Creek is the most suitable for future reintroductions.** While boat traffic was extremely high on the main channel of the Neosho River, the secluded tributary supported both a diverse turtle community lacking alligator snapping turtles and suitable habitat. Additional tributaries nearby, such as Pryor Creek, could serve as additional habitat for released turtles.
3. The habitat supported by the Deep Fork River is highly suitable for alligator snapping turtles as indicated by the robust turtle community, second highest log density, and canopy cover and bank morphology that was similar to rivers where alligator snapping turtles were found. Additionally, an alligator snapping turtle was captured at this same sample location within the last decade (Ligon unpublished data). The lack of alligator snapping turtle captures in our survey warrants further investigation. **If alligator snapping turtles remain undetected, reintroductions may be warranted.**

4. In addition to suitable habitat for alligator snapping turtles, the Deep Fork River supports a large Ouachita map turtle population, with high recruitment rates suggested by the large number of juveniles captured. To conserve the excellent habitat and the diverse and healthy turtle community in this river, the **Deep Fork National Wildlife Refuge should continue to be maintained, and any efforts to commercialize the river for recreation resisted.**
5. Although we did not conduct turtle surveys there, the Poteau River above Lake Wister has habitat that appears suitable for alligator snapping turtles. The river supports tall steep banks, but the submerged structure at the site was the lowest among the sites that we surveyed. **Turtle surveys should occur at this site, but due to the relative lack of structure and bedrock substrate revealed by sonar, alternative sampling methods should be employed.** This site may be a suitable release site if more survey effort takes place.
6. **Future surveys should continue to combine turtle trapping with quantitative habitat surveys. Adequate survey effort (approximately 100 net nights) must be taken in order to increase likelihood of detecting elusive species such as the alligator snapping turtle.** Habitat surveys should be conducted in early summer to better represent nesting habitat (bank substrate composition) while still accurately characterizing canopy cover. When at all possible, submerged structure should be quantified by side-scan sonar. If this method is not feasible, effort should be taken to count structure on a larger scale than the point-based score utilized in this study as a supplement to sonar.
7. **To greater understand the utility and accuracy of side-scan sonar as a method to assess underwater habitat, ground-truthing surveys should be conducted.** Additionally, side-scan surveys should be conducted at sites with known large alligator snapping turtle populations to test the potential to identify alligator snapping turtle individuals within the river (Figure 7).

G. SIGNIFICANT DEVIATIONS:

Water depths at each survey site were not directly measured at the habitat sample points but was estimated by the side-scan sonar unit. As described in the report, we were not able to assess habitat or trap turtles at the proposed Caney River site due to unexpectedly poor accessibility and a limited ability to navigate it by boat due to its small size. Time constraints caused by weather-related survey delays prevented us from surveying the Verdigris River, which was the last of our eight proposed sites. Extending the survey period into late August or September in order to cover the Verdigris River would have caused us to trap outside of the peak period for turtle activity. This likely would have resulted in lower trapping success and a seasonally biased assessment of the aquatic turtle community. Additionally, this could have given us a false negative result with respect to alligator snapping turtle occurrence.

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DATE: February 8, 2019

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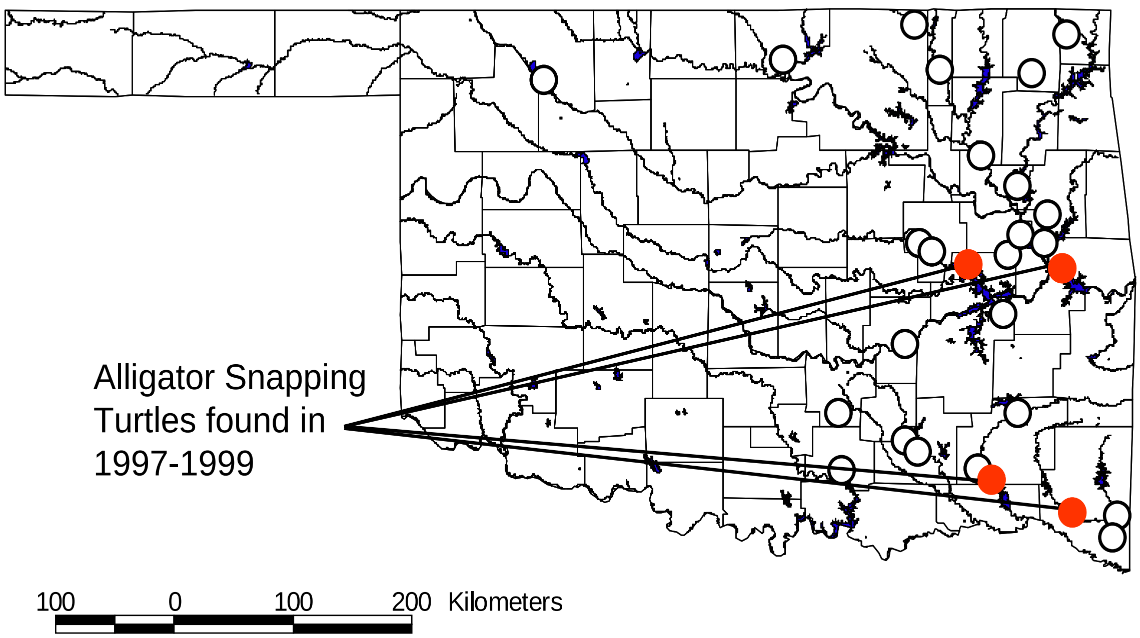


Figure 1. Site map showing the historic (open circles) and current (closed circles) distribution of Alligator Snapping Turtles in Oklahoma. (Adapted from Riedle et al. 2005)

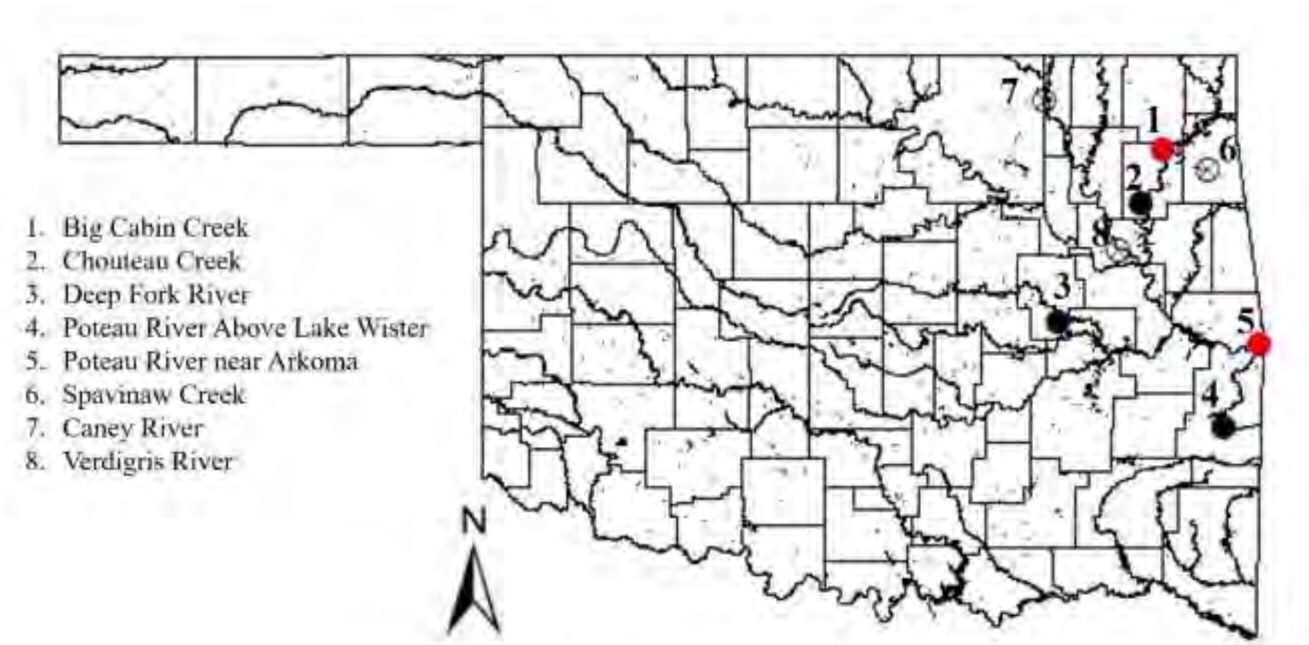


Figure 2. Sites included in 2018 surveys to assess suitability for alligator snapping turtle (*Macrochelys temminckii*) reintroduction in Oklahoma. Open crossed circles are sites where no sampling occurred, closed circles indicate sample locations, and closed red circles indicate where alligator snapping turtles were found.

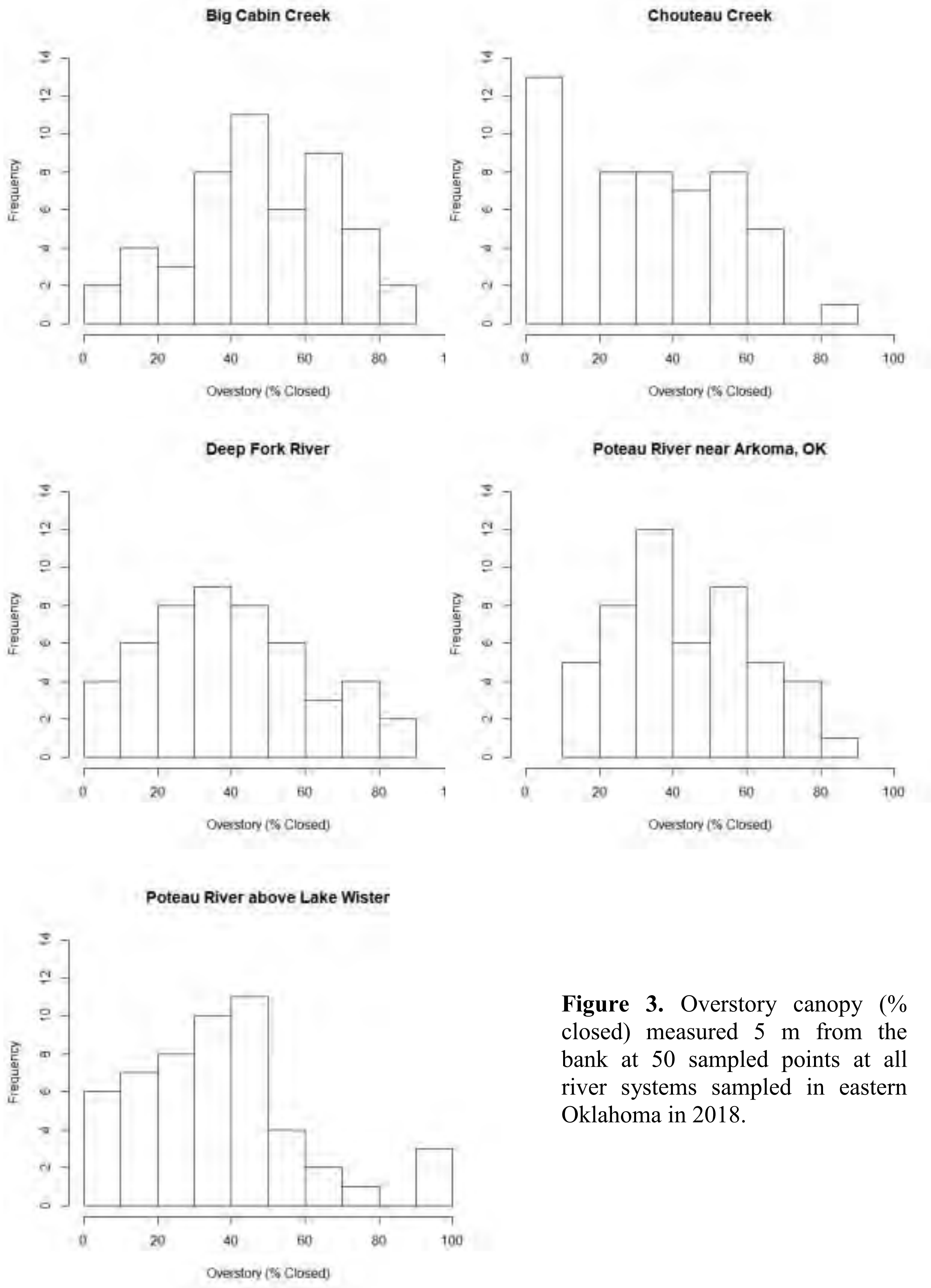
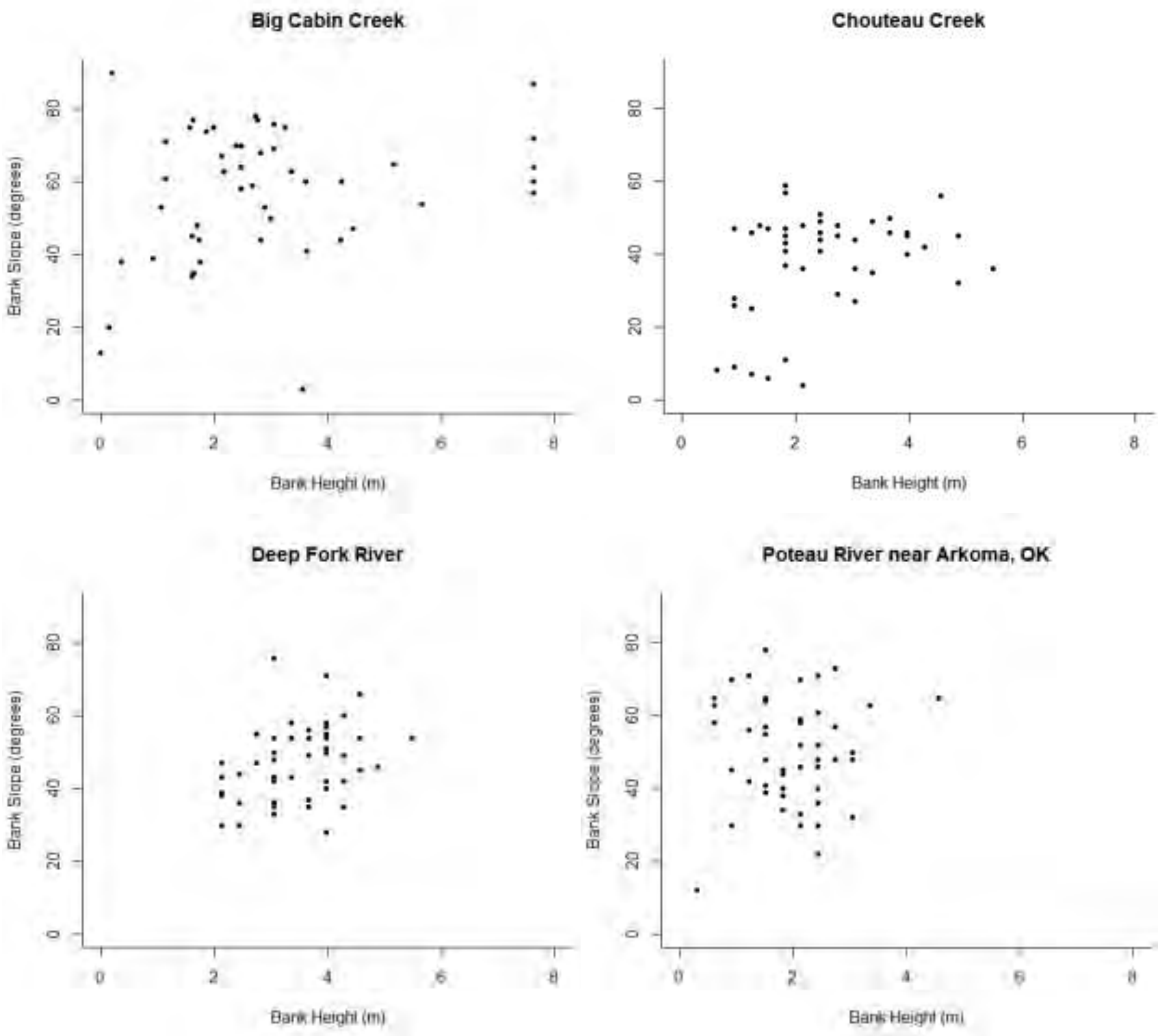


Figure 3. Overstory canopy (% closed) measured 5 m from the bank at 50 sampled points at all river systems sampled in eastern Oklahoma in 2018.



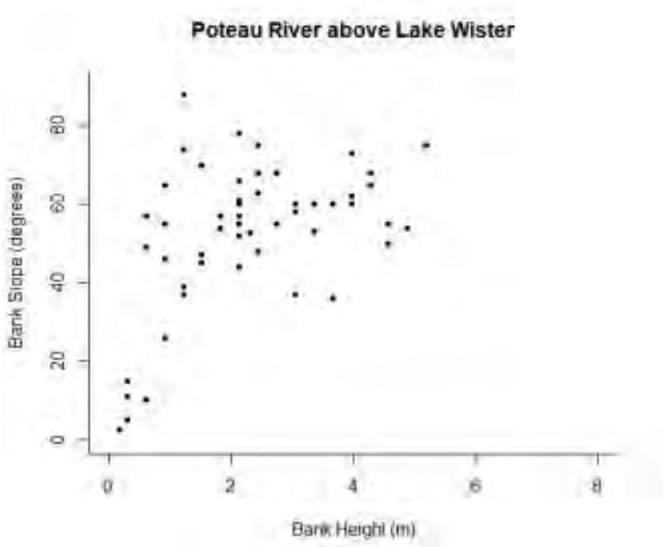


Figure 4. Bank height and slope measured at 50 sample points at all river system sampled in eastern Oklahoma in 2018.

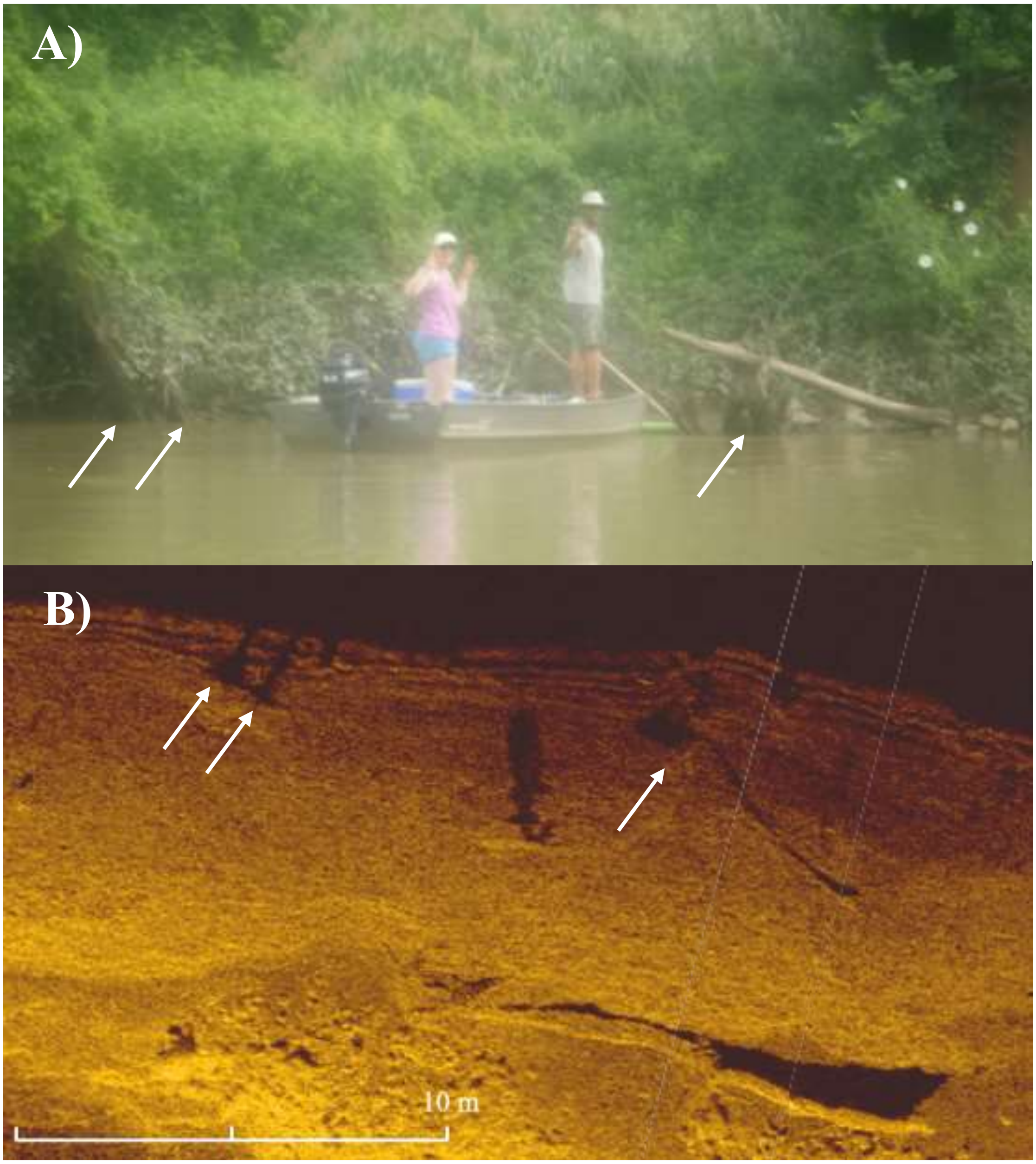


Figure 5. The habitat surrounding a capture point of a juvenile alligator snapping turtle within the Poteau River near Arkoma, OK summer 2018. A) Graduate student Samantha Hannabass and field technician Stephan Brown checking traps while graduate student Kameron Voves and field technician Teddy Pashia conduct the sonar survey. S. Hannabass demonstrates the size of the alligator snapping turtle in the net. This exhibits the typical emergent structure surrounding sample locations and represents the preferred habitat of the alligator snapping turtle. B) Side-scan sonar image of the corresponding submergent structure at the same capture site. Arrows indicate main features depicted in both images.

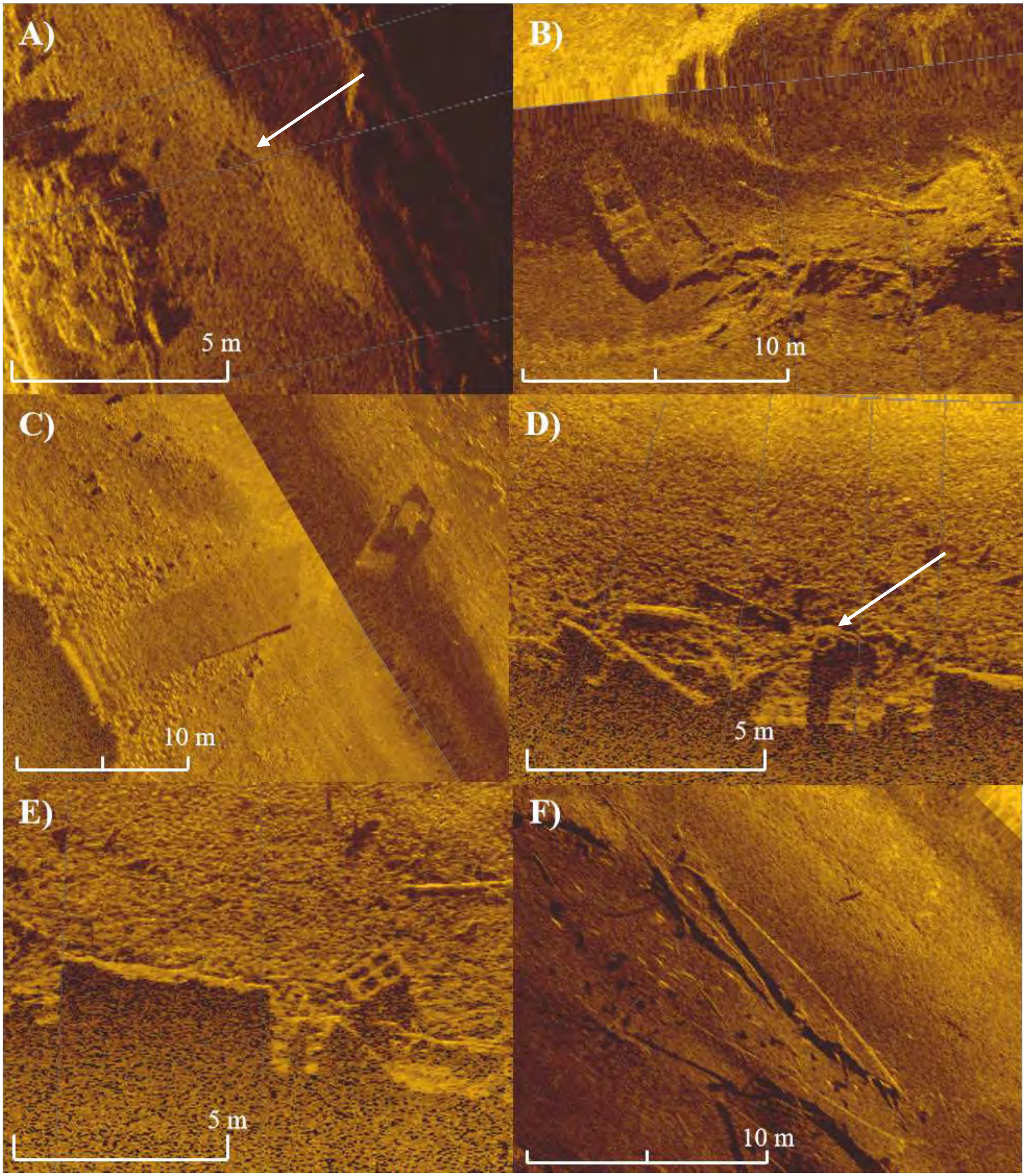


Figure 6. Side-scan sonar images depicting interesting benthic structure. A) Arrow indicates the shadow of a deployed hoop net in the Poteau River near Arkoma, OK. B) A submerged vehicle next to a brush pile near the boat ramp in the Poteau River near Arkoma, OK. C) A sunken boat at the base of the concrete boat ramp in the Poteau River above Wister Lake. D) Arrow indicates a tire surrounded by logs in Big Cabin Creek. E) What appears to be a window frame near logs in Big Cabin Creek. F) Fish and their sonar shadows surrounding a large log in the Deep Fork River.

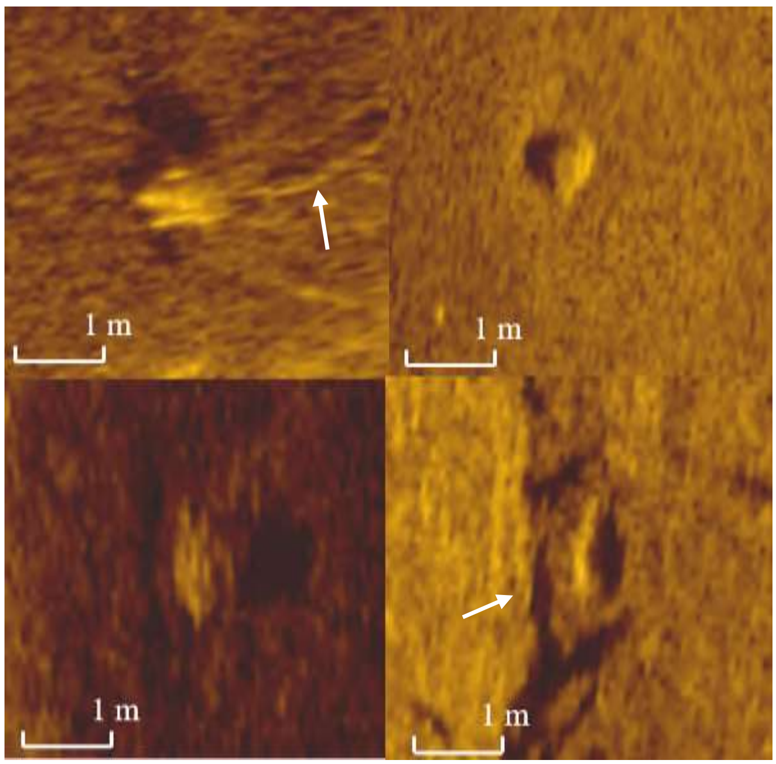


Figure 7. Examples of potential alligator snapping turtles revealed by side-scan sonar in the Poteau River near Arkoma, Oklahoma in summer 2018. Arrows indicate structure objects.

K. TABLES

Table 1. Total number of individuals of each species captured on all river systems sampled in Oklahoma in 2018. Rivers are ordered from north to south. Species codes are as follows: APSP = *Apalone spinifera*, CHSE = *Chelydra serpentina*, GROU = *Graptemys ouachitensis*, GRPS = *G. pseudogeographica*, MATE = *Macrochelys temminckii,* PSCO = *Pseudemys concinna*, *STOD = Sternotherus odoratus,* and TRSC = *Trachemys scripta.*

River	APSP	CHSE	GROU	GRPS	MATE	PSCO	STOD	TRSC
Big Cabin	25	13	24	5	3	1	-	318
Chouteau	23	2	50	1	-	2	3	216
Deep Fork	27	-	166	7	-	2	3	73
Poteau	7	-	13	1	17	3	-	246

Table 2. Bray-Curtis similarity index. A value of 1 indicates similar community composition where a value of 0 indicates dissimilar composition.

	Big Cabin	**Poteau**	**Chouteau**
Poteau	0.8018		
Chouteau	0.7784	0.8185	
Deep Fork	0.3838	0.3398	0.5287

Table 3. Number of species, number of individuals (# Ind.), number of net nights (effort), catch per unit effort (C/UE), recapture rate (RR), Shannon Diversity Index (H'), and Equitability Index (E) for all river systems sampled in eastern Oklahoma in 2018. For H', higher values indicate higher relative diversity. Evenness values closer to 0 indicate disproportionate species abundance where value close to 1 signify equal abundance. Rivers are ordered from north to south.

River	# Species	# Ind.	Effort	C/UE	RR	H'	E
Big Cabin	7	389	124	3.14	0.255	0.735	0.378
Chouteau	7	297	104	2.86	0.147	0.863	0.443
Deep Fork	6	278	120	2.32	0.038	1.063	0.593
Poteau	6	287	127	2.26	0.130	0.598	0.334

Table 4. List of *Macrochelys temminckii* captured in Oklahoma in 2018. *Measurement affected by shell damage.

River	Carapace Length (mm)	Plastron Length (mm)	Mass (g)	Sex
Big Cabin Creek	457.0	357.0	42000	F
Big Cabin Creek	258.0	194.8	6950	J
Big Cabin Creek	282.2	218.1	5500	J
Poteau—Arkoma	421.0	329.0	18500	F
Poteau—Arkoma	411.9	319.8	15600	F
Poteau—Arkoma	428.0	325.5	18500	M
Poteau—Arkoma	303.1	236.0	6750	J
Poteau—Arkoma	178.9	138.8	1250	J
Poteau—Arkoma	307.0	233.2	6150	J
Poteau—Arkoma	253.2	177.1	2930	J
Poteau—Arkoma	215.2	165.0	2220	J
Poteau—Arkoma	331.1	255.0	8470	J
Poteau—Arkoma	254.6	197.2	3845	J
Poteau—Arkoma	318.9	241.0	6670	J
Poteau—Arkoma	330.2	256.0	8470	J
Poteau—Arkoma	219.0	172.0	2570	J
Poteau—Arkoma	233.0	184.2	2770	J
Poteau—Arkoma	238.0*	191.0	2115	J
Poteau—Arkoma	164.0	130.5	1040	J
Poteau—Arkoma	202.0	151.6	1875	J

Table 5. Habitat survey summary of the all river systems sampled in Oklahoma in 2018. Current was measured on a scale from 0 (no current) to 3 (much current), and emergent and submergent structure was measured on a scale from 0 (none) to 3 (high density). Sonar log density is the number of total logs counted by sonar per kilometer of sampled area. Metrics are reported as $\bar{x} \pm 1$ SE.

Habitat measurement	**Big Cabin**	**Chouteau**	**Deep Fork**	**Poteau—Arkoma**	**Poteau—Wister**
Channel Characteristics					
Channel Width (m)	55.26±2.43	114.54±9.49	39.88±0.64	58.34±0.82	64.72±1.26
Current	0.00±0.00	1.52±0.12	0.00±0.00	0.00±0.00	1.00±0.00
Emergent Structure	0.78±0.13	1.02±0.12	1.12±0.14	1.08±0.13	0.40±0.09
Submergent Structure	1.18±0.16	1.12±.127	1.14±0.14	0.96±0.13	0.62±0.11
Sonar Log Density (logs/km)	200.82±na	171.35±na	345.48±na	383.51±na	124.54±na
Overstory (% occupied)	47.43±2.87	33.67±3.17	38.91±3.04	42.83±2.58	36.76±3.36
Bank Characteristics					
Substrate composition (%)					
Sand	0.60±0.60	29.40±4.79	6.80±2.83	0.00±0.00	24.60±4.44
Dirt/clay	48.80±3.25	40.00±4.60	47.60±4.84	23.0±3.70	20.10±4.14
Vegetation	38.20±4.54	21.10±2.13	45.6±4.49	74.90±4.07	54.5±4.26
Rock	12.20±3.25	9.50±3.36	0.00±0.00	2.60±1.951	0.20±0.14
Height (m)	2.95±0.294	2.73±0.25	3.48±0.19	1.96±0.11	2.30±0.19
Slope (°)	55.20±3.47	38.76±2.26	47.46±1.54	49.48±2.04	52.72±2.62
Human Disturbance					
Riparian Buffer (m)	140.26±22.68	434.34±72.28	698.24±114.02	65.25±8.23	682.34±117.94
Boat Traffic (boats/day)	0.67	7.57	0.44	0.50	2.00

L. APPENDICES

Appendix A. Turtle capture results and morphometric summary in Big Cabin Creek. All = males, females, and juveniles. M = males, F = females, J = juveniles, U = unknown escapee MCL = mid-line carapace length. Metrics are expressed as $\bar{x} \pm 1$ SD.

Species	Sex	Number of captures	Number of individuals	MCL (mm)	Mass (g)
Apalone spinifera	All	28	25	277.77±89.95	2558.33±2302.49
	M	7	7	172.15±26.09	613.83±77.40
	F	21	18	317.38±70.46	3206.50±2321.96
	J	0	0	-	-
Chelydra serpentina	All	16	13	236.54±38.32	3830.83±186.39
	M	5	5	213.70±25.52	2847.50±929.71
	F	8	7	249.87±42.29	4341.42±2230.90
	J	3	1	257.40±na	4190.00±na
Graptemys ouachitensis	All	25	24	166.35±42.12	712.88±435.96
	M	7	7	103.45±5.36	145.00±17.62
	F	18	17	188.55±20.57	946.71±271.87
	J	0	0	-	-
Graptemys pseudogeographica	All	5	5	199.60±52.74	1166.40±703.04
	M	1	1	118.90±na	202.00±na
	F	4	4	219.78±31.55	1407.5±521.05
	J	0	0	-	-
Macrochelys temminckii	All	3	3	332.37±108.61	18150±20667.42
	M	0	0	-	-
	F	1	1	467.00±na	42000±na
	J	2	2	270.05±17.04	6225.00±1025.30
Pseudemys concinna	All	1	1	239.30±na	1730.00±na
	M	0	0	-	-
	F	1	1	239.30±na	1730.00±na
	J	0	0	-	-
Trachemys scripta	All	444	318	183.77±44.90	918.97±2312.59
	M	331	240	181.59±26.80	861.85±404.60
	F	108	73	193.20±61.43	1127.7±3940.27
	J	2	2	101.85±90.38	193.50±3090.30
	U	3	3	-	-

Appendix B. Turtle capture results and morphometric summary in Chouteau Creek and the Neosho River. All = males, females, and juveniles. M = males, F = females, J = juveniles, U = unknown escapee MCL = mid-line carapace length. Metrics are expressed as $\bar{x} \pm 1$ SD.

Species	Sex	Number of captures	Number of individuals	MCL (mm)	Mass (g)
Apalone spinifera	All	24	23	232.56±87.41	1717.13±2129.24
	M	15	14	173.89±14.39	530.50±146.26
	F	9	9	323.82±87.41	3563.00±2477.00
	J	0	0	-	-
Chelydra serpentina	All	2	2	248.85±15.63	3530.00±523.26
	M	1	1	237.80±na	3160.00±na
	F	1	1	259.90±na	3900.00±na
	J	0	0	-	-
Graptemys ouachitensis	All	50	50	115.27±38.87	287.21±292.17
	M	32	32	106.71±7.65	161.36±40.86
	F	11	11	181.36±9.70	813.64±114.58
	J	7	7	58.74±4.28	35.29±5.77
Graptemys pseudogeographica	All	1	1	100.10±na	112.00±na
	M	1	1	100.10±na	112.0±na
	F	0	0	-	-
	J	0	0	-	-
Pseudemys concinna	All	2	2	225.35±34.58	1171.50±422.14
	M	2	2	225.35±34.58	1171.50±422.14
	F	0	0	-	-
	J	0	0	-	-
Sternotherus odoratus	All	3	3	107.63±3.32	225.33±31.56
	M	2	2	107.40±4.67	217.50±40.31
	F	1	1	108.10±na	241.00±na
	J	0	0	-	-
Trachemys scripta	All	266	216	202.90±162.12	1003.34±439.69
	M	205	169	205.92±181.27	955.23±371.56
	F	58	45	194.29±42.43	1204.40±586.34
	J	2	1	80.60±na	85.90±na
	U	1	1	-	-

Appendix C. Turtle capture results and morphometric summary in the Deep Fork River. All = males, females, and juveniles. M = males, F = females, J = juveniles, MCL = mid-line carapace length. Metrics are expressed as $\bar{x} \pm 1$ SD.

Species	Sex	Number of captures	Number of individuals	MCL (mm)	Mass (g)
Apalone spinifera	All	29	27	210.31±38.53	1527.48±1698.09
	M	15	13	164.25±28.88	485.38±214.68
	F	14	14	253.09±67.32	2495.14±1905.28
	J	0	0	-	-
Graptemys ouachitensis	All	172	166	103.32±34.86	206.69±222.40
	M	93	88	92.11±8.30	106.40±29.88
	F	54	53	141.82±32.81	451.48±253.00
	J	25	25	61.31±11.37	40.79±16.22
Graptemys pseudogeographica	All	8	7	96.66±15.83	133.84±49.44
	M	3	3	105.50±15.20	153.00±48.22
	F	4	3	95.67±11.15	135.43±50.18
	J	1	1	73.10±na	71.60±na
Pseudemys concinna	All	2	2	181.10±40.87	806.50±485.78
	M	1	1	210.00±na	1150.00±na
	F	1	1	152.20±na	463.00±na
	J	0	0	-	-
Sternotherus odoratus	All	3	3	90.43±10.71	135.50±52.96
	M	2	2	96.40±3.96	160.50±43.13
	F	1	1	78.50±na	85.50±na
	J	0	0	-	-
Trachemys scripta	All	75	73	183.39±23.99	941.88±308.51
	M	53	51	181.72±19.57	881.08±228.50
	F	22	22	187.25±32.28	1082.82±415.00
	J	0	0	-	-

Appendix D. Turtle capture results and morphometric summary in the Poteau River near Arkoma, OK. All = males, females, and juveniles. M = males, F = females, J = juveniles, MCL = mid-line carapace length. Metrics are expressed as $\bar{x} \pm 1$ SD.

Species	Sex	Number of captures	Number of individuals	MCL (mm)	Mass (g)
Apalone spinifera	All	9	7	231.97±59.56	1641.29±1754.37
	M	5	4	179.80±19.81	648.50±196.08
	F	4	3	301.53±103.79	2965.00±2139.23
	J	0	0	-	-
Graptemys ouachitensis	All	13	13	153.98±35.34	558.81±295.51
	M	3	3	96.20±13.62	96.83±22.89
	F	10	10	171.31±13.32	697.4±154.39
	J	0	0	-	-
Graptemys pseudogeographica	All	1	1	73.00±na	57.00±na
	M	0	0	-	-
	F	0	0	-	-
	J	1	1	73.00±na	57.00±na
Macrochelys temminckii	All	18	17	285.69±84.78	6460.29±5832.38
	M	1	1	428.00±na	18500.00±na
	F	2	2	416.45±6.43	17050.00±2050.61
	J	15	14	254.63±58.31	4087.50±2660.28
Pseudemys concinna	All	3	3	227.07±45.78	1670.67±751.13
	M	0	0	-	-
	F	3	3	227.07±45.78	1670.67±751.13
	J	0	0	-	-
Trachemys scripta	All	286	246	180.15±23.48	862.95±330.48
	M	184	162	172.91±16.12	720.78±198.69
	F	102	84	194.10±28.62	1137.13±360.93
	J	0	0	-	-