FINAL PERFORMANCE REPORT

Federal Aid Grant No. F19AF00247 (T-111-R-1)

Status Assessment for the Southern Hickorynut in Oklahoma

Oklahoma Department of Wildlife Conservation

July 1, 2019 through December 31, 2022

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State: Oklahoma **Grant Number:** F19AF00247 (T-111-R-1)

Grant Program: State Wildlife Grants

Grant Title: Status Assessment for the Southern Hickorynut in Oklahoma

Grant Period: July 1, 2019 – December 31, 2022

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Executive Summary

The primary objective of this project focuses on the distribution, status and habitat needs of Southern Hickorynut (*Obovaria arkansasensis*) in Oklahoma. In addition, a second objective is to collect genetic samples for species verification and genetic isolation of *Obovaria arkansasensis* in the Kiamichi, Glover, Mountain Fork, and Upper Little Rivers. Surveys were conducted during the low flow water conditions in the summers of 2019, 2020, and 2021 in the Kiamichi River, the Mountain Fork River above Broken Bow Lake, the Glover River, and the Upper Little River above Pine Creek Lake. During timed searches, we sampled a total of 2,921 mussels at 47 sites in the Kiamichi River, Mountain Fork, Glover River, and Upper Little River basins, encountering at least 23 species. The most common species during sampling was *Amblema plicata* (threeridge), which comprised 49.4% of the mussels collected. *Tritogonia verrucosa* (pistolgrip) was the next most common at 9.6%, followed by *Actinonaias ligamentina* (mucket) at 9.4%, *Cyclonaias pustulosa* (pimpleback) at 7.6%, and *Fusconaia flava* (Wabash pigtoe) at 6.0%. All other species comprised less than 5% of the total timed search sample. We found an additional 225 mussels during quantitative surveys. Mussel populations in the Mountain Fork, Glover River, and Upper Little River are declining based on comparisons to previous surveys. The declines in mussel abundance that we observed are likely a legacy effect of an extended, severe drought from 2010-2012. We recommend continued monitoring of *Obovaria arkansasensis* populations and additional research to determine specific fish glochidial hosts for this species in Oklahoma.

BACKGROUND AND NEED:

The Southern Hickorynut, *Obovaria arkansasensis*, is a freshwater mussel that is increasingly rare across its distribution and is a species of greatest conservation need in Oklahoma. *O. arkansasensis* is considered a Tier I species of greatest conservation need in the Oklahoma Comprehensive Wildlife plan (Appendix E, pages 404 and 407). According to the IUCN, *O. arkansasensis* is vulnerable across its distribution; the species has experienced a 30% reduction in habitat and is now relegated to a few fragmented populations (Cummings and Cordeiro 2012). Southeastern Oklahoma represents the western edge of the range of this species. Mussel

populations in southeastern Oklahoma are threatened and declining, primarily by reservoir construction and operation (Vaughn and Taylor 1999, Galbraith et al. 2010, Allen et al. 2013, Vaughn et al. 2015) and planned water withdrawals may further impact populations. To assess the conservation status of this species in Oklahoma, surveys are needed to determine its current distribution and abundance. These data can be compared to historical surveys to determine any range expansions or contractions and to see if populations are declining.

Obovaria arkansasensis is a recent species designation for two formerly separate species. *Obovaria jacksoniana* (Southern Hickorynut) occurs from the Interior Highlands to the Gulf of Mexico and Mobile River basins where it occurs in mid to large size rivers. *Villosa arkansasensis* (Ouachita Creekshell) is endemic to the Ouachita Mountains of Oklahoma and Arkansas. Recent genetic and morphological analyses have shown that these two species are synonymous and should be considered one species, *O. arkansasensis* (Southern Hickorynut) (Inoue et al. 2013, Williams et al. 2017). However, phylogenetic analyses also have shown relative genetic isolation among drainages and further genetic work is needed to determine if there is in-progress speciation or cryptic species (Inoue et al. 2013).

Obovaria arkansasensis is currently known from Alabama, Mississippi, Tennessee, Louisiana, Arkansas, Missouri, Texas, and Oklahoma (NatureServe 2018). In Oklahoma, it has been found in the Kiamichi, Glover, Mountain Fork, and Little Rivers in the southeastern portion of the state, all tributaries of the Red River (Figure 1) (Vaughn et al. 1996, Vaughn 2003, Spooner and Vaughn 2007, Atkinson et al. 2012). The species is fairly common in the lower Little River below Pine Creek Lake, which was thoroughly surveyed for ODWC in 2015-16 (Project T-79) (Vaughn et al. 2016). There, the species occurred at 21 sites, with an average density of 5.16 individuals/m^2. Surveys are needed to determine the current distribution and abundance of the species in the Kiamichi, Glover, Mountain Fork, and Upper Little (above Pine Creek Lake) rivers.

OBJECTIVES

TRACS SMART Objective: Conduct one (1) investigation by June 30, 2022.
(NOTE: TRACS strategy - Research, Survey, Data Collection and Analysis)

TRACS Activity Tag 1: Fish and wildlife species data acquisition and analysis (1 investigation). Target Species: *Obovaria arkansasensis.*

Narrative Objectives:

Objective 1: Conduct semi-quantitative and quantitative surveys in the Kiamichi, Glover, Mountain Fork, and Upper Little River Oklahoma to ascertain the distribution, status and habitat needs of *Obovaria arkansasensis.*

Objective 2: Collect genetic samples for species verification and genetic isolation of *Obovaria arkansasensis* in the Kiamichi, Glover, Mountain Fork, and Upper Little Rivers.

METHODS

Surveys for mussels were conducted during low flow water conditions in the summers of 2019, 2020, and 2021. Surveys were conducted in the Kiamichi River, the Mountain Fork River above Broken Bow Lake, the Glover River, and the Upper Little River above Pine Creek Lake. We

visited and resampled locations where the species has been found previously (Figure 1). We also canoed stretches of the rivers looking for new occurrences.

When we found mussels, we primarily sampled them both semi-quantitatively with timed searches and quantitatively with 0.25 m^2 quadrats following protocols established by Vaughn et al. (1997) and Strayer and Smith (2003). Timed searches are usually necessary to discover rare species, while quadrat sampling is needed to determine density (Vaughn et al. 1997). Timed searches were conducted in all mussel beds and more time-consuming quantitative searches for density were conducted in large mussel beds (Vaughn et al. 2016). Most beds we encountered were small, and so we used primarily timed search methods. Timed searches consist of visual and tactile searching for mussels by hand, snorkel, or SCUBA in deeper areas (> 0.75 m). The amount of time spent varied with mussel bed size. For quantitative samples to determine density, we excavated 10–15 quadrats per mussel bed, depending on the size of the bed. For both sampling methods, mussels were identified to species before returning them to the mussel bed alive. We recorded the universal transverse Mercator (UTM) coordinates for each site using a global positioning system (GPS). We characterized habitat by taking standard pebble counts to characterize substrate size. We measured dissolved oxygen, total dissolved solids, conductivity, and pH. We also took discharge measurements at select site and characterized the substratum with pebble counts.

We took non-lethal mantle clippings from select individuals in each river for genetic analyses (Henley et al. 2006). Genetic analyses were conducted by Dr. Kevin J. Roe at Iowa State University, who specializes in freshwater mussel phylogenetics and population genetics (http://www.public.iastate.edu/~kjroe/researchpage.html). Dr. Roe also conducted the genetic analyses of *Obovaria arkansasensis* from the lower Little River from our 2015-16 surveys for ODWC (Vaughn et al. 2016).

RESULTS

During timed searches, we sampled a total of 2,921 mussels at 47 sites in the Kiamichi River, Mountain Fork, Glover River, and Upper Little River basins (Table 1**–**Table 2**,** Figure 2**--**Figure 3**), encountering at least 23 species (**Table 2Table 3. Quadrat-level summary of quantitative surveys. The "Area" column indicates sites where multiple locations within the same site were surveyed (e.g., opposite banks of the river). (Abbreviations: AL = *Actinonaias ligamentina*; AP = *Amblema plicata*; CP = *Cyclonaias pustulosa*; EL = *Ellipsaria lineolata*; FF = *Fusconaia flava*; LCa = *Lampsilis cardium*; LS = *Lampsilis siliquoidea*; LT = *Lampsilis teres*; LF = *Leptodea fragilis*; OR = *Obliquaria reflexa*; PP = *Potamilus purpuratus*; PO = *Ptychobranchus occidentalis*; QQ = *Quadrula quadrula*; SU = *Strophitus undulatus*; TP = *Toxolasma parvum*; TV = *Tritogonia verrucosa*; TD = *Truncilla donaciformes*; TT = *Truncilla truncat*a; Vsp = *Villosa* spp.; Ukn = Unknown/Unidentifiable.)

Site ID	Area	Quadrat	Species
F19VAU01	-	Q1	None
F19VAU01	-	Q2	None
F19VAU01	-	Q3	None
F19VAU01	-	Q4	None
F19VAU03	-	T0Q1	None
F19VAU03	-	T0Q2	AP
F19VAU03	-	T0Q2	AP
F19VAU03	-	T0Q2	AP
F19VAU03	-	T0Q2	AP

Site ID	Area	Quadrat	Species
F19VAU03	-	T0Q2	AP
F19VAU03	-	T0Q3	AP
F19VAU03	-	T0Q3	AP
F19VAU03	-	T0Q3	AL
F19VAU03	-	T1Q1	TV
F19VAU03	-	T1Q1	AP
F19VAU03	-	T1Q1	Vsp
F19VAU03	-	T1Q1	AP
F19VAU03	-	T1Q1	None
F19VAU03	-	T1Q2	LC
F19VAU03	-	T1Q2	LC
F19VAU03	-	T1Q2	AL
F19VAU03	-	T1Q2	AP
F19VAU03	-	T1Q2	None
F19VAU03	-	T1Q2	AP
F19VAU03	-	T1Q2	AL
F19VAU03	-	T1Q3	None
F19VAU03	-	T1Q3	AP
F19VAU03	-	T1Q3	AL
F19VAU03	-	T1Q3	CP
F19VAU03	-	T1Q3	CP
F19VAU03	-	T2Q1	None
F19VAU03	-	T2Q1	LT
F19VAU03	-	T2Q1	AP
F19VAU03	-	T2Q1	AP
F19VAU03	-	T2Q1	AP
F19VAU03	-	T2Q1	AP
F19VAU03	-	T2Q1	TV
F19VAU03	-	T2Q1	AL
F19VAU03	-	T2Q2	None
F19VAU03	-	T2Q2	Vsp
F19VAU03	-	T2Q2	AP
F19VAU03	-	T2Q2	AP
F19VAU03	-	T2Q2	AL
F19VAU03	-	T2Q2	EL
F19VAU03	-	T2Q2	FF
F19VAU03	-	T2Q3	None
F19VAU03	-	T2Q3	AP
F19VAU03	-	T3Q1	None
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	TV
F19VAU03	-	T3Q1	FF
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q2	None
F19VAU03	-	T3Q2	Ukn
F19VAU03	-	T3Q2	AP
F19VAU03	-	T3Q2	AP
F19VAU03	-	T3Q2	AP
F19VAU03	-	T3Q2	AL
F19VAU03	-	T3Q2	PP
F19VAU03	-	T3Q2	EL

Site ID	Area	Quadrat	Species
F19VAU03	-	T3Q2	CP
F19VAU03	-	T3Q3	None
F19VAU03	-	T4Q1	None
F19VAU03	-	T4Q1	AP
F19VAU03	-	T4Q1	QQ
F19VAU03	-	T4Q2	None
F19VAU03	-	T4Q2	PP
F19VAU03	-	T4Q2	AP
F19VAU03	-	T4Q2	AP
F19VAU03	-	T4Q2	AP
F19VAU03	-	T4Q3	None
F19VAU03	-	T4Q3	AP
F19VAU03	-	T4Q3	AP
F19VAU03	-	T4Q3	TV
F19VAU03	-	T4Q3	CP
F19VAU03	-	T5Q1	None
F19VAU03	-	T5Q2	None
F19VAU03	-	T5Q3	None
F19VAU03	-	T5Q3	AP
F19VAU03	-	T5Q3	CP
F19VAU04	C	T1Q1	TT
F19VAU04	C	T1Q1	LT
F19VAU04	C	T1Q1	None
F19VAU04	C	T1Q2	CP
F19VAU04	C	T1Q2	CP
F19VAU04	C	T1Q2	TV
F19VAU04	C	T1Q2	TV
F19VAU04	C	T1Q2	AP
F19VAU04	C	T1Q2	TT
F19VAU04	C	T1Q2	None
F19VAU04	C	T2Q1	CP
F19VAU04	C	T2Q1	CP
F19VAU04	C	T2Q1	AP
F19VAU04	C	T2Q1	AL
F19VAU04	C	T2Q1	LC
F19VAU04	C	T2Q1	OR
F19VAU04	C	T2Q2	TV
F19VAU04	C	T2Q2	AP
F19VAU04	C	T2Q2	CP
F19VAU04	C	T2Q2	TT
F19VAU04	C	T2Q2	AL
F19VAU04	C	T2Q2	None
F19VAU04	C	T2Q3	TV
F19VAU04	C	T2Q3	AL
F19VAU04	C	T2Q3	TT
F19VAU04	C	T2Q3	CP
F19VAU04	C	T2Q3	None
F19VAU04	C	T3Q1	PP
F19VAU04	C	T3Q1	LC
F19VAU04	C	T3Q1	LT
F19VAU04	C	T3Q1	QQ
F19VAU04	C	T3Q1	TT
F19VAU04	C	T3Q1	CP
F19VAU04	C	T3Q1	AP
F19VAU04	C	T3Q1	AL
F19VAU04	C	T3Q1	TV
F19VAU04	C	T3Q1	None

Site ID	Area	Quadrat	Species
F19VAU04	C	T3Q2	LF
F19VAU04	C	T3Q2	AL
F19VAU04	C	T3Q2	TV
F19VAU04	C	T3Q2	CP
F19VAU04	C	T3Q2	None
F19VAU04	C	T3Q2	AP
F19VAU04	C	T3Q2	FF
F19VAU04	C	T3Q2	TD
F19VAU04	C	T3Q2	TT
F19VAU04	C	T3Q3	OR
F19VAU04	C	T3Q3	AL
F19VAU04	C	T3Q3	None
F19VAU04	C	T3Q3	TV
F19VAU04	C	T3Q3	AP
F19VAU04	C	T3Q3	CP
F19VAU04	C	T3Q3	TT
F19VAU04	C	T4Q1	LF
F19VAU04	C	T4Q1	AP
F19VAU04	C	T4Q1	LC
F19VAU04	C	T4Q1	TT
F19VAU04	C	T4Q1	AL
F19VAU04	C	T4Q1	None
F19VAU04	C	T4Q1	CP
F19VAU04	C	T4Q2	AP
F19VAU04	C	T4Q2	TV
F19VAU04	C	T4Q2	TT
F19VAU04	C	T4Q2	None
F19VAU04	C	T4Q3	AL
F19VAU04	C	T4Q3	AP
F19VAU04	C	T4Q3	TV
F19VAU04	C	T4Q3	CP
F19VAU04	C	T4Q3	TT
F19VAU04	C	T4Q3	OR
F19VAU04	C	T5Q1	None
F19VAU04	C	T5Q1	AP
F19VAU04	C	T5Q1	TV
F19VAU04	C	T5Q1	LC
F19VAU04	C	T5Q1	TT
F19VAU04	C	T5Q1	CP
F19VAU04	C	T5Q2	AP
F19VAU04	C	T5Q2	CP
F19VAU04	C	T5Q2	TT
F19VAU04	C	T5Q3	LT
F19VAU04	C	T5Q3	LF
F19VAU04	C	T5Q3	CP
F19VAU04	C	T5Q3	None
F19VAU09	-	T0Q1	None
F19VAU09	-	T0Q1	PO
F19VAU09	-	T0Q2	None
F19VAU09	-	T0Q3	None
F19VAU09	-	T2Q1	PO
F19VAU09	-	T2Q1	Vsp
F19VAU09	-	T2Q1	None
F19VAU09	-	T2Q2	Vsp
F19VAU09	-	T2Q2	None
F19VAU09	-	T2Q3	None
F19VAU09	-	T3Q2	None

Site ID	Area	Quadrat	Species
F19VAU09	-	T3Q3	None
F19VAU09	-	T4Q1	None
F19VAU09	-	T4Q2	Vsp
F19VAU09	-	T4Q3	None
F19VAU11	A	T1Q1	None
F19VAU11	A	T2Q1	None
F19VAU11	A	T2Q2	None
F19VAU11	A	T3Q1	PO
F19VAU11	A	T3Q1	PO
F19VAU11	A	T3Q1	None
F19VAU11	A	T3Q2	None
F19VAU11	B	T1Q1	PO
F19VAU11	B	T1Q1	PO
F19VAU11	B	T1Q1	None
F19VAU11	B	T2Q1	PO
F19VAU11	B	T2Q1	None
F19VAU11	B	T2Q2	PO
F19VAU11	B	T2Q2	None
F19VAU11	B	T3Q1	PO
F19VAU11	B	T3Q1	PO
F19VAU11	B	T3Q1	PO
F19VAU11	B	T3Q1	Vsp
F19VAU11	B	T3Q1	None
F19VAU11	B	T3Q2	None
F19VAU14	-	T1Q1	AP
F19VAU14	-	T1Q2	PO
F19VAU14	-	T1Q3	AP
F19VAU14	-	T2Q1	None
F19VAU14	-	T2Q1	CP
F19VAU14	-	T2Q1	AP
F19VAU14	-	T2Q1	TT
F19VAU14	-	T2Q1	EL
F19VAU14	-	T2Q2	AP
F19VAU14	-	T2Q2	AP
F19VAU14	-	T2Q2	AP
F19VAU14	-	T2Q2	CP
F19VAU14	-	T2Q2	None
F19VAU14	-	T2Q3	PP
F19VAU14	-	T2Q3	TV
F19VAU14	-	T2Q3	CP
F19VAU14	-	T2Q3	CP
F19VAU14	-	T2Q3	TV
F19VAU14	-	T2Q3	AP
F19VAU14	-	T2Q3	AP
F19VAU14	-	T3Q1	AL
F19VAU14	-	T3Q1	AL
F19VAU14	-	T3Q1	AL
F19VAU14	-	T3Q1	PP
F19VAU14	-	T3Q1	EL
F19VAU14	-	T3Q2	AL
F19VAU14	-	T4Q1	AL
F19VAU14	-	T4Q1	AP
F19VAU14	-	T4Q1	None
F19VAU14	-	T4Q2	AP
F19VAU14	-	T4Q2	PO
F19VAU14	-	T4Q3	LC
F19VAU14	-	T4Q3	TV

Site ID	Area	Quadrat	Species
F19VAU14	-	T4Q3	AP
F19VAU14	-	T4Q3	PP
F19VAU14	-	T5Q1	AP
F19VAU14	-	T5Q2	AP
F19VAU14	-	T5Q3	None
F19VAU14	-	T6Q1	AP
F19VAU14	-	T6Q1	TT
F19VAU14	-	T6Q1	AL
F19VAU14	-	T6Q1	AL
F19VAU14	-	T6Q2	AP
F19VAU14	-	T6Q2	AP
F19VAU14	-	T6Q2	LC
F19VAU14	-	T6Q2	LC
F19VAU14	-	T6Q2	AL
F19VAU14	-	T6Q3	PP
F19VAU14	-	T6Q3	LC
F19VAU14	-	T6Q3	CP
F19VAU14	-	T6Q3	TV
F19VAU14	-	T6Q3	AP
F19VAU14	-	T6Q3	None
F20VAU01	-	T1Q1	Vsp
F20VAU01	-	T1Q1	None
F20VAU01	-	T1Q2	FF
F20VAU01	-	T1Q2	SU
F20VAU01	-	T1Q2	LS
F20VAU01	-	T1Q2	None
F20VAU01	-	T2Q1	TP
F20VAU01	-	T2Q1	None
F20VAU01	-	T2Q2	Vsp
F20VAU01	-	T2Q2	None
F20VAU01	-	T3Q1	None
F20VAU01	-	T3Q2	LS
F20VAU01	-	T3Q2	None
F20VAU01	-	T4Q1	None
F20VAU01	-	T4Q2	None
F20VAU01	-	T5Q1	None
F20VAU01	-	T5Q2	Vsp
F20VAU01	-	T5Q2	Vsp
F20VAU01	-	T6Q1	Vsp
F20VAU01	-	T6Q1	None
F20VAU01	-	T6Q2	Vsp
F20VAU01	-	T6Q2	None
F20VAU02	-	T1Q1	None
F20VAU02	-	T1Q1	Vsp
F20VAU02	-	T1Q2	Vsp
F20VAU02	-	T1Q2	None
F20VAU02	-	T2Q1	LS
F20VAU02	-	T2Q1	Vsp
F20VAU02	-	T2Q1	None
F20VAU02	-	T2Q2	Vsp
F20VAU02	-	T2Q2	Vsp
F20VAU02	-	T2Q2	LS
F20VAU02	-	T3Q1	None
F20VAU02	-	T3Q1	FF
F20VAU02	-	T3Q1	FF
F20VAU02	-	T3Q2	None
F20VAU02	-	T4Q1	Vsp

Site ID	Area	Quadrat	Species
F20VAU02	-	T4Q1	Vsp
F20VAU02	-	T4Q1	Vsp
F20VAU02	-	T4Q1	None
F20VAU02	-	T4Q2	Vsp
F20VAU02	-	T4Q2	None
F20VAU02	-	T5Q1	None
F20VAU02	-	T5Q2	None

Table **4**). The most common species was *Amblema plicata* (threeridge), which comprised 49.4% of the mussels collected. *Tritogonia verrucosa* (pistolgrip) was the next most common at 9.6%, followed by *Actinonaias ligamentina* (mucket) at 9.4%, *Cyclonaias pustulosa* (pimpleback) at 7.6%, and *Fusconaia flava* (Wabash pigtoe) at 6.0%. All other species comprised less than 5% of the total timed search sample (Table 2).

We found an additional 225 mussels during quantitative surveys (Table 3.). We quantitatively surveyed sites in the Kiamichi River and the Mountain Fork (Table 4, Figure 4), but the beds in the Glover and Upper Little Rivers tended to be too small to effectively sample quantitatively. The mussel beds in the Kiamichi River were denser, with mean mussel density ranging from 6–21 individuals/m^2 in the Kiamichi versus 2–6 individuals/m^2 in the Mountain Fork (Table 4, Figure 4).

Obovaria arkansasensis was uncommon across the surveyed areas of the four rivers—we found a total of 25 individuals (Table 2). The species was by far most common in the Kiamichi, where it occurred at five sites, and we found 14 individuals. The species also occurred at two sites in the Mountain Fork (3 individuals) and three sites in the Glover (8 individuals), but we did not find *O. arkansasensis* at any sites in the Upper Little River. Genetic tests confirm the samples we took as *O. arkansasensis* (Table 5). Thus, we are confident in the identity of this species. The sites where we found *O. arkansasensis* tended to be those lower in the watershed relative to the other sites we sampled (Figure 2). Although all the sites we surveyed could be considered "upper river" or at least "mid river" sites, the sites with *O. arkansasensis* in the Kiamichi were near Sardis Lake reservoir, around the middle reaches of the river. In the Mountain Fork, *O. arkansasensis* was found near the Narrows above Broken Bow Lake. In the Glover *O. arkansasensis* was found relatively close to the confluence of the Glover with the Little River. All of these sites are relatively low gradient compared to higher gradient "upper river" sites. Furthermore, in previous surveys, we found that *O. arkansasensis* was common in the lower Little River, below Pine Creek Lake. In that stretch of the river, it occurred at 21 sites, with an average density of 5.16 individuals per square meter in large mussel beds (Vaughn et al. 2016). Thus, it seems that *O. arkansasensis* prefers lower gradient sites, at least in the four rivers we sampled in southeastern Oklahoma.

The preference of *O. arkansasensis* for lower river sites could be because these sites are more likely to stay wetted and have moderate temperatures during summer droughts (see discussion below), because of fish host needs, or a combination of these factors. *O. arkansasensis* is a small mussel species generally less than 50 mm in length. Small mussel species are more susceptible to drought than larger mussels. During summer droughts in southeastern Oklahoma water can become very shallow and warm (Atkinson et al. 2014, Vaughn et al. 2015). Small mussels have higher metabolic rates, which makes them more sensitive to high water temperatures. Small mussels are also more likely to be preyed upon in shallow water. The fish host of *O. arkansasensis* are believed to be green sunfish (*Lepomis cyanellus*) and creole darters (*Etheostoma collettei*) (Inoue et al. 2013). Green sunfish are widespread habitat generalists, whereas creole darters prefer riffle habitat and in Oklahoma are restricted to lower reaches of the Little River, Glover River, and Mountain Fork River (Miller and Robison 2004).

Although not required as a part of this project, we also recorded the distribution and abundance of all federally listed species that we encountered. We found *Theliderma cylindrica* at two sites (3 individuals), both in the Glover River during timed searches (Table 2).

Physical-chemical habitat variables measured at each site are reported in Table 6—sites with missing data indicate instrument failures (except sites F21VAU09–12, where no habitat data were collected because these sites were only searched for *Obovaria arkansasensis* due to logistical limitations). Sediment particle sizes are reported in Table 7. Sediment particle sizes can be used in conjunction with hydrologic data collected at high flows to predict mussel habitat, as mussel beds tend to occur in areas that experience low shear stresses under high flows, but that remain flowing during drought periods (Vaughn and Taylor 1999, Allen and Vaughn 2010).

Mussel populations in the Mountain Fork, Glover River, and Upper Little River are declining based on comparisons to previous surveys (Vaughn 2003, Spooner and Vaughn 2007, Atkinson et al. 2012). The sites on the lower Glover where we found the federally listed species *Theliderma cylindrica* appeared to be in better condition than most of the other Glover River sites, based on the abundance of mussels found there. The populations of *Obovaria arkansasensis* appear to be declining in the Glover River, the Upper Little River, and possibly the Mountain Fork. At many of the historic sites where *O. arkansasensis* was found previously in these rivers, we did not find any individuals in 2019–2021. We notably found no *O. arkansasensis* individuals in the Upper Little River, where previous surveys found high abundances (Atkinson et al. 2012).

Southeastern Oklahoma has experienced several severe droughts in recent decades, most notably a severe hydrologic drought in 2011-12 where river flows were less than 10% of normal for 22 days in the Upper Little River and Mountain Fork River. Atkinson et al. (2014) surveyed mussels in the Mountain Fork River and Upper Little River immediately before (2010) and following (2012) this drought and documented declines in mussel abundance. The declines in mussel abundance that we observed are likely a legacy effect of this extended, severe drought.

Obovaria arkansasensis populations appear to be stable in the Kiamichi River, and overall mussel populations in this river are doing fairly well based on our surveys. However, recent drought related mussel declines have been documented in the Kiamichi (Galbraith et al. 2010, Atkinson et al. 2014, Vaughn et al. 2015) and linked to management of Sardis Lake (Galbraith et al. 2010, Vaughn et al. 2015). Mussel populations in the Kiamichi River are threatened by planned future water withdrawals. Establishing environmental flows that safeguard mussel populations in the river would protect *O. arkansasensis* in the future as well as the endangered species *Arcidens wheeleri* (Ouachita rock pocketbook) and *Leptodea leptodon* (scaleshell)

RECOMMENDATIONS

(1) *Obovaria arkansasensis* should be monitored in all four rivers in the future to determine if populations recover or continue to decline.

(2) The species seems to be doing well in the Kiamichi River but could be threatened by planned future water withdrawals and transfers. Establishment of environmental flows in the Kiamichi River to protect mussels and other aquatic life is recommended.

(3) Studies should be done to determine the fish host(s).

Significant Deviations:
There have been no significant deviations.

Equipment Purchased (Cumulative):
No equipment exceeding $5,000 in cost was purchased for this project.

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TABLES

Table 1. List of all sites, date surveyed, and latitude and longitude. The "Area" column indicates sites where multiple locations within the same site were surveyed (e.g., opposite banks of the river). Sites F21VAU09–12 were only searched for *Obovaria arkansasensis* and no other data were collected. (Abbreviations: CPUE = Catch-per-unit-effort; *S* = Species richness; KR = Kiamichi River; MF = Mountain fork; GL = Glover River; UL = Upper Little River).

Drainage	Site ID	Site No.	Area	Date	Latitude	Longitude
KR	F19VAU01	1	-	7/10/2019	34°39'31.6"	95°32'50.8"
KR	F19VAU02	2	A	7/23/2019	34°39'41.8"	94°46'24.06"
KR	F19VAU02	2	B	7/23/2019	34°39'41.8"	94°46'24.06"
KR	F19VAU02	2	C	7/23/2019	34°39'41.8"	94°46'24.06"
KR	F19VAU02	2	D	7/23/2019	34°39'41.8"	94°46'24.06"
KR	F19VAU03	3	A	7/24/2019	34°39'39.7"	94°46'23.3"
KR	F19VAU03	3	B	7/24/2019	34°39'39.7"	94°46'23.3"
KR	F19VAU04	4	A	7/31/2019	34°36'46.4"	95°17'46.1"
KR	F19VAU04	4	B	7/31/2019	34°36'46.4"	95°17'46.1"
KR	F19VAU04	4	C	7/31/2019	34°36'46.4"	95°17'46.1"
KR	F19VAU05	5	-	8/1/2019	34°38'24.5"	95°04'48.8"
KR	F19VAU06	6	-	8/1/2019	34°38'37"	95°04'26.6"
MF	F19VAU07	7	-	8/6/2019	34°28'42.5"	94°31'23.9"
MF	F19VAU08	8	-	8/6/2019	34°27'05.9"	94°40'08.2"
MF	F19VAU09	9	-	8/7/2019	34°28'07.4"	94°31'25.5"
MF	F19VAU10	10	-	8/7/2019	34°27'41.2"	94°38'18.4"
MF	F19VAU11	11	A	8/8/2019	34°27'32.9"	94°38"18.4
MF	F19VAU11	11	B	8/8/2019	34°27'34.9"	94°38'17.1"
MF	F19VAU12	12	-	8/9/2019	34°27'05.2"	94°40'19.8"
MF	F19VAU13	13	-	8/9/2019	34°27'05.5"	94°40'05.5"
KR	F19VAU14	14	-	8/12/2019	34°37'09.6"	95°13'20.6"
KR	F19VAU15	15	-	8/12/2019	34°37'02.7"	95°14'21.2"
KR	F19VAU16	16	-	8/13/2019	34°40'21.5"	95°01'07.6"
KR	F19VAU17	17	A	8/13/2019	34°40'37.7"	95°00'50.5"
KR	F19VAU17	17	B	8/13/2019	34°40'37.7"	95°00'50.5"
KR	F19VAU18	18	-	8/13/2019	34°40'49.3"	95°00'54.7"
KR	F19VAU19	19	-	8/14/2019	34°33'57.1"	95°21'50.7"
KR	F19VAU20	20	-	8/15/2019	34°33'03.9"	95°25'57.6"
MF	F20VAU01	21	-	7/22/2020	34°29'53.5"	94°27'59.7"
MF	F20VAU02	22	-	7/23/2020	34°37'53.8"	94°35'43.0"
MF	F20VAU03	23	-	7/23/2020	34°27'40.82"	94°35'17.96"
GL	F20VAU04	24	-	7/24/2020	34°05'57.2"	94°54'08.1"
MF	F20VAU05	25	-	7/28/2020	34°26'33.0"	94°39'24.1"
MF	F20VAU06	26	-	7/28/2020	34°26'07.7"	94°39'39.3"
MF	F20VAU07	27	-	7/28/2020	34°25'07.4"	94°40'05.5"
GL	F20VAU08	28	A	7/29/2020	34°10'08.4"	94°54'47.0
GL	F20VAU08	28	B	7/29/2020	34°08'16.1"	94°53'58.9"
GL	F20VAU09	29	-	7/29/2020	34°08'9.2"	94°54'47"
GL	F20VAU10	30	-	7/29/2020	34°06'37.5"	94°53'23.2"
GL	F20VAU11	31	-	7/29/2020	34° 08'18.0"	94°54'08.0"
GL	F20VAU12	32	A	9/19/2020	34°14'35.3"	94°55'01.3"
GL	F20VAU12	32	B	9/19/2020	34°14'35.3"	94°55'01.3"
GL	F20VAU13	33	-	9/19/2020	34°12'30.8"	94°55'58.7"
GL	F20VAU14	34	-	9/19/2020	34°11'01.4"	94°55'42.0"
GL	F20VAU15	35	-	9/20/2020	34°16'51.3"	94°55'47.4"
GL	F21VAU01	36	-	7/14/2021	34°02'26.2"	94°56'00.3
GL	F21VAU02	37	-	7/14/2021	34°01'55.4"	94°56'21.5"
UL	F21VAU03	38	-	7/15/2021	34°29'33.2"	95°07'59.8"
UL	F21VAU04	39	-	7/15/2021	34°28'28.8"	95°11'09.8"

Drainage	Site ID	Site No.Area	Date	Latitude	Longitude
UL	F21VAU05	40-	7/15/2021	34°24'06.4"	95°09'44.5"
UL	F21VAU06	41-	8/4/2021	34°19'36.3"	95°11'56.1"
UL	F21VAU07	42-	8/4/2021	34°18'30.9"	95°11'02.7"
UL	F21VAU08	43-	8/4/2021	34°18'46.2"	95°11'00.6"
KR	F21VAU09	44-	8/2/2021	34°30'20.4"	95°30'15.2"
KR	F21VAU10	45-	8/3/2021	34°27'53.5"	95°03'18.6"
KR	F21VAU11	46-	8/3/2021	34°34'28.9"	95°21'16.2"
KR	F21VAU12	47-	8/4/2021	34°25'38.8"	95°34'54.1"

Table 2. Site-level counts for all species encountered during time searches. The "Area" column indicates sites where multiple locations within the same site were surveyed (e.g., opposite banks of the river). Sites F21VAU09–12 were only searched for *Obovaria arkansasensis* and no other data were collected. (Abbreviations: AL = *Actinonaias ligamentina*; AP = *Amblema plicata*; CP = *Cyclonaias pustulosa*; EL = *Ellipsaria lineolata*; FF = *Fusconaia flava*; LCa = *Lampsilis cardium*; LS = *Lampsilis siliquoidea*; LT = *Lampsilis teres*; LCo = *Lasmigona costata*; LF = *Leptodea fragilis*; OR = *Obliquaria reflexa*; OA = *Obovaria arkansasensis*; PD = *Plectomerus dombeyanus*; PP = *Potamilus purpuratus*; PO = *Ptychobranchus occidentalis*; PG = *Pyganodon grandis*; QQ = *Quadrula quadrula*; SU = *Strophitus undulatus*; TC = *Theliderma cylindrica*; TV = *Tritogonia verrucosa*; TD = *Truncilla donaciformes*; TT = *Truncilla truncata*; Vsp = *Villosa* spp.; Ukn = Unknown/Unidentifiable.)

Site ID	Area	Mussels	Hours	CPUE	*S*	AL	AP	CP	EL	FF	Lca	LS	LT	Lco	LF	OR	OA	PD	PP	PO	PG	QQ	SU	TC	TV	TD	TT	Vsp	Ukn
F19VAU01	-	9	1.5	6	2	0	3	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F19VAU02	A	1	1.0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F19VAU02	B	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F19VAU02	C	2	1.0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
F19VAU02	D	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F19VAU03	A	16	1.5	11	3	0	13	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
F19VAU03	B	295	2.0	148	11	33	227	15	5	7	1	0	0	0	0	1	0	0	1	1	0	1	0	0	3	0	0	0	0
F19VAU04	A	3	0.5	6	3	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
F19VAU04	B	6	0.5	12	6	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0
F19VAU04	C	172	2.0	86	13	3	56	44	0	0	2	0	2	0	2	6	0	0	0	8	0	1	1	0	32	2	13	0	0
F19VAU05	-	48	2.0	24	6	0	34	0	0	1	1	0	1	0	0	0	0	0	0	3	0	0	0	0	7	0	0	0	1
F19VAU06	-	0	2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F19VAU07	-	8	1.0	8	3	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
F19VAU08	-	3	1.0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0
F19VAU09	-	5	2.0	3	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
F19VAU10	-	0	2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F19VAU11	A	3	1.0	3	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
F19VAU11	B	9	2.0	5	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0
F19VAU12	-	1	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F19VAU13	-	2	0.5	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
F19VAU14	-	326	3.0	109	15	20	133	12	6	0	10	0	14	0	1	6	0	0	5	13	0	0	1	0	93	4	6	2	0
F19VAU15	-	231	2.0	116	13	3	123	16	1	0	9	0	1	0	0	6	0	0	2	6	0	0	1	0	44	2	17	0	0
F19VAU16	-	125	2.0	63	15	3	90	1	0	1	3	1	4	0	1	5	2	0	1	4	0	0	0	0	5	0	3	1	0
F19VAU17	A	60	2.0	30	10	4	40	6	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	4	1	1	1	0
F19VAU17	B	61	1.0	61	8	2	45	5	0	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	0
F19VAU18	-	149	3.0	50	14	2	90	10	1	1	1	0	9	0	0	5	0	0	4	3	0	10	0	0	11	1	1	0	0
F19VAU19	-	200	3.0	67	14	88	33	10	5	1	16	0	2	0	0	3	1	0	7	12	0	0	0	0	17	1	4	0	0
F19VAU20	-	351	3.0	117	13	91	162	15	13	0	1	0	0	0	2	10	0	0	2	3	0	2	0	0	29	3	18	0	0
F20VAU01	-	6	1.0	6	3	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
F20VAU02	-	18	1.0	18	4	0	1	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0
F20VAU03	-	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20VAU04	-	207	2.0	104	12	18	162	5	0	1	2	0	0	0	0	0	2	0	1	0	1	0	2	1	8	0	0	3	1
F20VAU05	-	66	2.5	26	9	0	31	1	0	1	4	3	0	3	0	0	1	0	0	0	0	0	6	0	0	0	0	13	3
F20VAU06	-	42	1.0	42	8	0	11	11	0	3	5	0	0	2	0	0	0	0	0	0	0	0	3	0	1	0	0	6	0
F20VAU07	-	84	1.0	84	10	0	45	3	0	8	5	1	0	2	0	0	2	0	0	0	0	0	1	0	1	0	0	16	0
F20VAU08	A	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20VAU08	B	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20VAU09	-	39	1.0	39	4	0	24	1	0	13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20VAU10	-	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20VAU11	-	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20VAU12	A	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20VAU12	B	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20VAU13	-	14	1.0	14	2	0	7	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20VAU14	-	6	0.5	12	2	0	1	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F20VAU15	-	1	1.5	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F21VAU01	-	35	1.0	35	8	3	21	3	1	1	3	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0
F21VAU02	-	116	1.0	116	13	3	24	44	1	9	5	0	1	0	0	0	4	0	6	0	0	2	1	2	9	0	0	0	5
F21VAU03	-	114	1.0	114	5	0	34	3	0	67	0	0	0	0	0	0	0	3	0	0	0	0	0	0	7	0	0	0	0
F21VAU04	-	81	1.0	81	5	0	30	7	0	39	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
F21VAU05	-	2	-	-	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Site ID	Area	Mussels	Hours	CPUE	*S*	AL	AP	CP	EL	FF	Lca	LS	LT	Lco	LF	OR	OA	PD	PP	PO	PG	QQ	SU	TC	TV	TD	TT	Vsp	Ukn
F21VAU06	-	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F21VAU07	-	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F21VAU08	-	4	0.5	8	3	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
F21VAU09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
F21VAU10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-
F21VAU11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-
F21VAU12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
-	-	2,921	60.8	38	252	274	1,444	221	33	175	80	9	36	7	7	43	25	3	30	58	1	16	21	3	279	14	64	77	12

Table 3. Quadrat-level summary of quantitative surveys. The "Area" column indicates sites where multiple locations within the same site were surveyed (e.g., opposite banks of the river). (Abbreviations: AL = *Actinonaias ligamentina*; AP = *Amblema plicata*; CP = *Cyclonaias pustulosa*; EL = *Ellipsaria lineolata*; FF = *Fusconaia flava*; LCa = *Lampsilis cardium*; LS = *Lampsilis siliquoidea*; LT = *Lampsilis teres*; LF = *Leptodea fragilis*; OR = *Obliquaria reflexa*; PP = *Potamilus purpuratus*; PO = *Ptychobranchus occidentalis*; QQ = *Quadrula quadrula*; SU = *Strophitus undulatus*; TP = *Toxolasma parvum*; TV = *Tritogonia verrucosa*; TD = *Truncilla donaciformes*; TT = *Truncilla truncat*a; Vsp = *Villosa* spp.; Ukn = Unknown/Unidentifiable.)

Site ID	Area	Quadrat	Species
F19VAU01	-	Q1	None
F19VAU01	-	Q2	None
F19VAU01	-	Q3	None
F19VAU01	-	Q4	None
F19VAU03	-	T0Q1	None
F19VAU03	-	T0Q2	AP
F19VAU03	-	T0Q2	AP
F19VAU03	-	T0Q2	AP
F19VAU03	-	T0Q2	AP
F19VAU03	-	T0Q2	AP
F19VAU03	-	T0Q3	AP
F19VAU03	-	T0Q3	AP
F19VAU03	-	T0Q3	AL
F19VAU03	-	T1Q1	TV
F19VAU03	-	T1Q1	AP
F19VAU03	-	T1Q1	Vsp
F19VAU03	-	T1Q1	AP
F19VAU03	-	T1Q1	None
F19VAU03	-	T1Q2	LC
F19VAU03	-	T1Q2	LC
F19VAU03	-	T1Q2	AL
F19VAU03	-	T1Q2	AP
F19VAU03	-	T1Q2	None
F19VAU03	-	T1Q2	AP
F19VAU03	-	T1Q2	AL
F19VAU03	-	T1Q3	None
F19VAU03	-	T1Q3	AP
F19VAU03	-	T1Q3	AL
F19VAU03	-	T1Q3	CP
F19VAU03	-	T1Q3	CP
F19VAU03	-	T2Q1	None
F19VAU03	-	T2Q1	LT
F19VAU03	-	T2Q1	AP
F19VAU03	-	T2Q1	AP
F19VAU03	-	T2Q1	AP
F19VAU03	-	T2Q1	AP
F19VAU03	-	T2Q1	TV
F19VAU03	-	T2Q1	AL
F19VAU03	-	T2Q2	None
F19VAU03	-	T2Q2	Vsp
F19VAU03	-	T2Q2	AP
F19VAU03	-	T2Q2	AP
F19VAU03	-	T2Q2	AL
F19VAU03	-	T2Q2	EL
F19VAU03	-	T2Q2	FF
F19VAU03	-	T2Q3	None

Site ID	Area	Quadrat	Species
F19VAU03	-	T2Q3	AP
F19VAU03	-	T3Q1	None
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q1	TV
F19VAU03	-	T3Q1	FF
F19VAU03	-	T3Q1	AP
F19VAU03	-	T3Q2	None
F19VAU03	-	T3Q2	Ukn
F19VAU03	-	T3Q2	AP
F19VAU03	-	T3Q2	AP
F19VAU03	-	T3Q2	AP
F19VAU03	-	T3Q2	AL
F19VAU03	-	T3Q2	PP
F19VAU03	-	T3Q2	EL
F19VAU03	-	T3Q2	CP
F19VAU03	-	T3Q3	None
F19VAU03	-	T4Q1	None
F19VAU03	-	T4Q1	AP
F19VAU03	-	T4Q1	QQ
F19VAU03	-	T4Q2	None
F19VAU03	-	T4Q2	PP
F19VAU03	-	T4Q2	AP
F19VAU03	-	T4Q2	AP
F19VAU03	-	T4Q2	AP
F19VAU03	-	T4Q3	None
F19VAU03	-	T4Q3	AP
F19VAU03	-	T4Q3	AP
F19VAU03	-	T4Q3	TV
F19VAU03	-	T4Q3	CP
F19VAU03	-	T5Q1	None
F19VAU03	-	T5Q2	None
F19VAU03	-	T5Q3	None
F19VAU03	-	T5Q3	AP
F19VAU03	-	T5Q3	CP
F19VAU04	C	T1Q1	TT
F19VAU04	C	T1Q1	LT
F19VAU04	C	T1Q1	None
F19VAU04	C	T1Q2	CP
F19VAU04	C	T1Q2	CP
F19VAU04	C	T1Q2	TV
F19VAU04	C	T1Q2	TV
F19VAU04	C	T1Q2	AP
F19VAU04	C	T1Q2	TT
F19VAU04	C	T1Q2	None
F19VAU04	C	T2Q1	CP
F19VAU04	C	T2Q1	CP
F19VAU04	C	T2Q1	AP
F19VAU04	C	T2Q1	AL
F19VAU04	C	T2Q1	LC
F19VAU04	C	T2Q1	OR
F19VAU04	C	T2Q2	TV

Site ID	Area	Quadrat	Species
F19VAU04	C	T2Q2	AP
F19VAU04	C	T2Q2	CP
F19VAU04	C	T2Q2	TT
F19VAU04	C	T2Q2	AL
F19VAU04	C	T2Q2	None
F19VAU04	C	T2Q3	TV
F19VAU04	C	T2Q3	AL
F19VAU04	C	T2Q3	TT
F19VAU04	C	T2Q3	CP
F19VAU04	C	T2Q3	None
F19VAU04	C	T3Q1	PP
F19VAU04	C	T3Q1	LC
F19VAU04	C	T3Q1	LT
F19VAU04	C	T3Q1	QQ
F19VAU04	C	T3Q1	TT
F19VAU04	C	T3Q1	CP
F19VAU04	C	T3Q1	AP
F19VAU04	C	T3Q1	AL
F19VAU04	C	T3Q1	TV
F19VAU04	C	T3Q1	None
F19VAU04	C	T3Q2	LF
F19VAU04	C	T3Q2	AL
F19VAU04	C	T3Q2	TV
F19VAU04	C	T3Q2	CP
F19VAU04	C	T3Q2	None
F19VAU04	C	T3Q2	AP
F19VAU04	C	T3Q2	FF
F19VAU04	C	T3Q2	TD
F19VAU04	C	T3Q2	TT
F19VAU04	C	T3Q3	OR
F19VAU04	C	T3Q3	AL
F19VAU04	C	T3Q3	None
F19VAU04	C	T3Q3	TV
F19VAU04	C	T3Q3	AP
F19VAU04	C	T3Q3	CP
F19VAU04	C	T3Q3	TT
F19VAU04	C	T4Q1	LF
F19VAU04	C	T4Q1	AP
F19VAU04	C	T4Q1	LC
F19VAU04	C	T4Q1	TT
F19VAU04	C	T4Q1	AL
F19VAU04	C	T4Q1	None
F19VAU04	C	T4Q1	CP
F19VAU04	C	T4Q2	AP
F19VAU04	C	T4Q2	TV
F19VAU04	C	T4Q2	TT
F19VAU04	C	T4Q2	None
F19VAU04	C	T4Q3	AL
F19VAU04	C	T4Q3	AP
F19VAU04	C	T4Q3	TV
F19VAU04	C	T4Q3	CP
F19VAU04	C	T4Q3	TT
F19VAU04	C	T4Q3	OR
F19VAU04	C	T5Q1	None
F19VAU04	C	T5Q1	AP
F19VAU04	C	T5Q1	TV
F19VAU04	C	T5Q1	LC

Site ID	Area	Quadrat	Species
F19VAU04	C	T5Q1	TT
F19VAU04	C	T5Q1	CP
F19VAU04	C	T5Q2	AP
F19VAU04	C	T5Q2	CP
F19VAU04	C	T5Q2	TT
F19VAU04	C	T5Q3	LT
F19VAU04	C	T5Q3	LF
F19VAU04	C	T5Q3	CP
F19VAU04	C	T5Q3	None
F19VAU09	-	T0Q1	None
F19VAU09	-	T0Q1	PO
F19VAU09	-	T0Q2	None
F19VAU09	-	T0Q3	None
F19VAU09	-	T2Q1	PO
F19VAU09	-	T2Q1	Vsp
F19VAU09	-	T2Q1	None
F19VAU09	-	T2Q2	Vsp
F19VAU09	-	T2Q2	None
F19VAU09	-	T2Q3	None
F19VAU09	-	T3Q2	None
F19VAU09	-	T3Q3	None
F19VAU09	-	T4Q1	None
F19VAU09	-	T4Q2	Vsp
F19VAU09	-	T4Q3	None
F19VAU11	A	T1Q1	None
F19VAU11	A	T2Q1	None
F19VAU11	A	T2Q2	None
F19VAU11	A	T3Q1	PO
F19VAU11	A	T3Q1	PO
F19VAU11	A	T3Q1	None
F19VAU11	A	T3Q2	None
F19VAU11	B	T1Q1	PO
F19VAU11	B	T1Q1	PO
F19VAU11	B	T1Q1	None
F19VAU11	B	T2Q1	PO
F19VAU11	B	T2Q1	None
F19VAU11	B	T2Q2	PO
F19VAU11	B	T2Q2	None
F19VAU11	B	T3Q1	PO
F19VAU11	B	T3Q1	PO
F19VAU11	B	T3Q1	PO
F19VAU11	B	T3Q1	Vsp
F19VAU11	B	T3Q1	None
F19VAU11	B	T3Q2	None
F19VAU14	-	T1Q1	AP
F19VAU14	-	T1Q2	PO
F19VAU14	-	T1Q3	AP
F19VAU14	-	T2Q1	None
F19VAU14	-	T2Q1	CP
F19VAU14	-	T2Q1	AP
F19VAU14	-	T2Q1	TT
F19VAU14	-	T2Q1	EL
F19VAU14	-	T2Q2	AP
F19VAU14	-	T2Q2	AP
F19VAU14	-	T2Q2	AP
F19VAU14	-	T2Q2	CP
F19VAU14	-	T2Q2	None

Site ID	Area	Quadrat	Species
F19VAU14	-	T2Q3	PP
F19VAU14	-	T2Q3	TV
F19VAU14	-	T2Q3	CP
F19VAU14	-	T2Q3	CP
F19VAU14	-	T2Q3	TV
F19VAU14	-	T2Q3	AP
F19VAU14	-	T2Q3	AP
F19VAU14	-	T3Q1	AL
F19VAU14	-	T3Q1	AL
F19VAU14	-	T3Q1	AL
F19VAU14	-	T3Q1	PP
F19VAU14	-	T3Q1	EL
F19VAU14	-	T3Q2	AL
F19VAU14	-	T4Q1	AL
F19VAU14	-	T4Q1	AP
F19VAU14	-	T4Q1	None
F19VAU14	-	T4Q2	AP
F19VAU14	-	T4Q2	PO
F19VAU14	-	T4Q3	LC
F19VAU14	-	T4Q3	TV
F19VAU14	-	T4Q3	AP
F19VAU14	-	T4Q3	PP
F19VAU14	-	T5Q1	AP
F19VAU14	-	T5Q2	AP
F19VAU14	-	T5Q3	None
F19VAU14	-	T6Q1	AP
F19VAU14	-	T6Q1	TT
F19VAU14	-	T6Q1	AL
F19VAU14	-	T6Q1	AL
F19VAU14	-	T6Q2	AP
F19VAU14	-	T6Q2	AP
F19VAU14	-	T6Q2	LC
F19VAU14	-	T6Q2	LC
F19VAU14	-	T6Q2	AL
F19VAU14	-	T6Q3	PP
F19VAU14	-	T6Q3	LC
F19VAU14	-	T6Q3	CP
F19VAU14	-	T6Q3	TV
F19VAU14	-	T6Q3	AP
F19VAU14	-	T6Q3	None
F20VAU01	-	T1Q1	Vsp
F20VAU01	-	T1Q1	None
F20VAU01	-	T1Q2	FF
F20VAU01	-	T1Q2	SU
F20VAU01	-	T1Q2	LS
F20VAU01	-	T1Q2	None
F20VAU01	-	T2Q1	TP
F20VAU01	-	T2Q1	None
F20VAU01	-	T2Q2	Vsp
F20VAU01	-	T2Q2	None
F20VAU01	-	T3Q1	None
F20VAU01	-	T3Q2	LS
F20VAU01	-	T3Q2	None
F20VAU01	-	T4Q1	None
F20VAU01	-	T4Q2	None
F20VAU01	-	T5Q1	None
F20VAU01	-	T5Q2	Vsp

Site ID	Area	Quadrat	Species
F20VAU01	-	T5Q2	Vsp
F20VAU01	-	T6Q1	Vsp
F20VAU01	-	T6Q1	None
F20VAU01	-	T6Q2	Vsp
F20VAU01	-	T6Q2	None
F20VAU02	-	T1Q1	None
F20VAU02	-	T1Q1	Vsp
F20VAU02	-	T1Q2	Vsp
F20VAU02	-	T1Q2	None
F20VAU02	-	T2Q1	LS
F20VAU02	-	T2Q1	Vsp
F20VAU02	-	T2Q1	None
F20VAU02	-	T2Q2	Vsp
F20VAU02	-	T2Q2	Vsp
F20VAU02	-	T2Q2	LS
F20VAU02	-	T3Q1	None
F20VAU02	-	T3Q1	FF
F20VAU02	-	T3Q1	FF
F20VAU02	-	T3Q2	None
F20VAU02	-	T4Q1	Vsp
F20VAU02	-	T4Q1	Vsp
F20VAU02	-	T4Q1	Vsp
F20VAU02	-	T4Q1	None
F20VAU02	-	T4Q2	Vsp
F20VAU02	-	T4Q2	None
F20VAU02	-	T5Q1	None
F20VAU02	-	T5Q2	None

Table 4. Site-level mussel densities from quantitative surveys conducted using quadrats. SE is standard error.

Site ID	Mean mussel density (ind/m^2)	SE
F19VAU03	15	3
F19VAU04C	21	2
F19VAU09	2	1
F19VAU11A	2	2
F19VAU11B	6	3
F19VAU14	11	2
F20VAU01	4	1
F20VAU02	5	1

Table 5. Genetic verification of *O. arkansasensis* specimens.

Year	Sample	Site ID	Surveyed species	Genetic identification	% identity
2019	19OBO1	F19VAU06	*O. arkansasensis*	*O. arkansasensis*	99.60
2019	19OBO2	F19VAU06	*O. arkansasensis*	*O. arkansasensis*	99.60
2019	19OBO3	F19VAU06	*O. arkansasensis*	*O. arkansasensis*	99.40
2019	19OBO4	F19VAU06	*O. arkansasensis*	*O. arkansasensis*	99.60
2019	19OBO5	F19VAU06	*O. arkansasensis*	*O. arkansasensis*	99.50
2019	19OBO6	F19VAU16	*O. arkansasensis*	*O. arkansasensis*	99.50
2019	19OBO7	F19VAU16	*O. arkansasensis*	*O. arkansasensis*	99.50
2019	19OBO8	F19VAU19	*O. arkansasensis*	*O. arkansasensis*	99.20
2020	20OBO1	F20VAU04	*O. arkansasensis*	*O. arkansasensis*	99.10
2020	20OBO2	F20VAU04	*O. arkansasensis*	*O. arkansasensis*	100.00
2020	20OBO3	F20VAU05	*O. arkansasensis*	*O. arkansasensis*	100.00
2020	20OBO4	F20VAU07	*O. arkansasensis*	*O. arkansasensis*	97.80
2020	20OBO5	F20VAU07	*O. arkansasensis*	*O. arkansasensis*	99.50
2021	21OBO1	F21VAU09	*O. arkansasensis*	*O. arkansasensis/O. jacksoniana*	97.54
2021	21OBO2	F21VAU09	*O. arkansasensis*	PCR failure	-
2021	21OBO3	F21VAU09	*O. arkansasensis*	*O. arkansasensis/O. jacksoniana*	95.01
2021	21OBO4	F21VAU10	*O. arkansasensis*	PCR failure	-
2021	21OBO5	F21VAU10	*O. arkansasensis*	*O. arkansasensis/O. jacksoniana*	97.56
2021	21OBO6	F21VAU10	*O. arkansasensis*	PCR failure	-
2021	21OBO7	F21VAU10	*O. arkansasensis*	PCR failure	-
2021	21OBO8	F21VAU10	*O. arkansasensis*	*O. arkansasensis/O. jacksoniana*	91.33
2021	21OBO9	F21VAU10	*O. arkansasensis*	*O. arkansasensis/O. jacksoniana*	98.48
2021	21OBO10	F21VAU10	*O. arkansasensis*	PCR failure	-
2021	21OBO11	F21VAU01	*O. arkansasensis*	*O. arkansasensis/O. jacksoniana*	76.41
2021	21OBO12	F21VAU01	*O. arkansasensis*	*O. arkansasensis/O. jacksoniana*	95.88
2021	21OBO13	F21VAU02	*O. arkansasensis*	*O. arkansasensis/O. jacksoniana*	88.87
2021	21OBO14	F21VAU02	*O. arkansasensis*	PCR failure	-
2021	21OBO15	F21VAU02	*O. arkansasensis*	*O. arkansasensis/O. jacksoniana*	89.84
2021	21OBO16	F21VAU02	*O. arkansasensis*	*O. arkansasensis/O. jacksoniana*	88.51
2021	21OBO17	F21VAU12	*O. arkansasensis*	*O. arkansasensis/O. jacksoniana*	100.00

Table 6. Physical-chemical habitat variables recorded for sites where *Obovaria arkansasensis* was found. The "Area" column indicates sites where multiple locations within the same site were surveyed (e.g., opposite banks of the river). Sites F21VAU09–12 were only searched for *Obovaria arkansasensis* and no environmental data were collected.

Site ID	Area	Conductivity (µS/cm)	Dissolved oxygen (mg/L)	pH	Temperature (°C)	Total dissolved solids (mg/L)
F19VAU01	-	48.3	-	6.63	26.0	-
F19VAU02	A	-	-	-	-	-
F19VAU02	B	-	-	-	-	-
F19VAU02	C	-	-	-	-	-
F19VAU02	D	-	-	-	-	-
F19VAU03	A	-	-	-	27.2	-
F19VAU03	B	-	-	-	-	-
F19VAU04	A	52.9	7.49	6.64	33.4	34.3
F19VAU04	B	52.8	7.54	6.87	33.1	34.3
F19VAU04	C	53.3	7.28	6.95	32.6	34.7
F19VAU05	-	50.7	6.11	6.42	29.5	32.9
F19VAU06	-	51.2	6.55	6.90	29.9	33.3
F19VAU07	-	-	-	-	-	-
F19VAU08	-	-	-	-	-	-
F19VAU09	-	41.5	7.02	7.22	30.3	27.1
F19VAU10	-	-	-	-	-	-
F19VAU11	A	41.3	7.45	7.38	31.8	26.8
F19VAU11	B	41.5	7.43	7.28	31.9	27.0
F19VAU12	-	35.5	5.89	7.38	29.5	23.1
F19VAU13	-	-	-	-	-	-
F19VAU14	-	54.9	7.22	7.09	34.5	35.6
F19VAU15	-	56.9	7.30	7.19	33.9	37.0
F19VAU16	-	62.3	5.75	6.90	30.8	40.4
F19VAU17	A	51.8	6.17	7.11	31.8	40.1
F19VAU17	B	-	-	-	-	-
F19VAU18	-	63.6	6.08	7.05	32.5	41.4
F19VAU19	-	61.9	6.87	7.65	31.4	40.2
F19VAU20	-	59.2	7.08	7.34	32.7	38.4
F20VAU01	-	37.8	5.78	7.30	30.0	24.5
F20VAU02	-	37.2	6.14	7.22	29.0	24.1
F20VAU03	-	-	-	-	-	-
F20VAU04	-	61.2	5.43	6.93	30.4	39.8
F20VAU05	-	63.2	6.51	7.21	29.9	23.6
F20VAU06	-	36.1	8.06	7.59	32.0	23.4
F20VAU07	-	36.8	6.82	7.11	31.0	23.9
F20VAU08	A	51.1	7.06	7.19	29.6	33.2
F20VAU08	B	-	-	-	-	-
F20VAU09	-	49.5	6.86	7.28	29.6	32.1
F20VAU10	-	84.4	8.36	7.03	31.3	55.0
F20VAU11	-	-	-	-	-	-
F20VAU12	A	39.9	7.85	-	22.6	23.2
F20VAU12	B	-	-	-	-	-
F20VAU13	-	37.3	8.25	-	25.3	24.1
F20VAU14	-	39.0	8.60	6.95	-	24.7
F20VAU15	-	35.2	8.03	6.88	22.5	24.0
F21VAU01	-	93.6	7.36	6.73	30.5	55.0
F21VAU02	-	104.5	7.81	6.57	31.6	60.7
F21VAU03	-	37.4	5.46	7.10	28.4	22.8
F21VAU04	-	37.2	6.50	6.99	28.7	22.6
F21VAU05	-	-	-	-	-	-

Site ID	Area	Conductivity (µS/cm)	Dissolved oxygen (mg/L)	pH	Temperature (°C)	Total dissolved solids (mg/L)
F21VAU06	-	-	-	-	-	-
F21VAU07	-	-	-	-	-	-
F21VAU08	-	-	-	-	-	-
F21VAU09	-	-	-	-	-	-
F21VAU10	-	-	-	-	-	-
F21VAU11	-	-	-	-	-	-
F21VAU12	-	-	-	-	-	-

Table 7. Median sediment grain size recorded for sites where *Obovaria arkansasensis* was found. At sites where quantitative surveys were conducted, sediment size was sampled at the quadrat scale; at sites where time searches were performed, sediment size was sampled at the stream reach scale. The "Area" column indicates sites where multiple locations within the same site were surveyed (e.g., opposite banks of the river).

Site ID	Area	Sample scale	Median sediment size (mm)
F19VAU01	-	Q1	16.20
F19VAU01	-	Q2	16.35
F19VAU01	-	Q3	19.85
F19VAU01	-	Q4	17.00
F19VAU03	-	T0Q1	25.30
F19VAU03	-	T0Q2	18.10
F19VAU03	-	T0Q3	18.75
F19VAU03	-	T1Q1	34.05
F19VAU03	-	T1Q1	28.30
F19VAU03	-	T1Q2	12.65
F19VAU03	-	T1Q2	28.80
F19VAU03	-	T1Q3	26.80
F19VAU03	-	T1Q3	39.15
F19VAU03	-	T2Q1	27.45
F19VAU03	-	T2Q1	32.70
F19VAU03	-	T2Q2	30.75
F19VAU03	-	T2Q2	36.85
F19VAU03	-	T2Q3	21.40
F19VAU03	-	T2Q3	28.75
F19VAU03	-	T3Q1	46.70
F19VAU03	-	T3Q1	28.65
F19VAU03	-	T3Q2	16.40
F19VAU03	-	T3Q2	13.90
F19VAU03	-	T3Q3	46.10
F19VAU03	-	T3Q3	34.45
F19VAU03	-	T4Q1	32.00
F19VAU03	-	T4Q1	26.10
F19VAU03	-	T4Q2	26.40
F19VAU03	-	T4Q2	26.95
F19VAU03	-	T4Q3	18.55
F19VAU03	-	T4Q3	45.05
F19VAU03	-	T5Q1	19.10
F19VAU03	-	T5Q1	29.65
F19VAU03	-	T5Q2	16.05
F19VAU03	-	T5Q2	38.00
F19VAU03	-	T5Q3	8.60
F19VAU03	-	T5Q3	31.35
F19VAU06	-	Reach	82.55
F19VAU09	-	T0Q1	17.35
F19VAU09	-	T0Q2	20.60
F19VAU09	-	T0Q3	27.30
F19VAU09	-	T1Q1	19.20
F19VAU09	-	T1Q2	27.35
F19VAU09	-	T1Q3	12.45
F19VAU09	-	T2Q1	27.50
F19VAU09	-	T2Q2	27.55
F19VAU09	-	T2Q3	51.95
F19VAU09	-	T3Q1	15.55
F19VAU09	-	T3Q2	39.55
F19VAU09	-	T3Q3	46.45

Site ID	Area	Sample scale	Median sediment size (mm)
F19VAU09	-	T4Q1	44.95
F19VAU09	-	T4Q2	14.25
F19VAU09	-	T4Q3	32.35
F19VAU11	A	T1Q1	20.40
F19VAU11	A	T2Q1	13.45
F19VAU11	A	T2Q2	20.00
F19VAU11	A	T3Q1	16.95
F19VAU11	A	T3Q2	12.50
F19VAU11	B	T1Q1	38.95
F19VAU11	B	T2Q1	29.25
F19VAU11	B	T2Q2	36.15
F19VAU11	B	T3Q1	18.50
F19VAU11	B	T3Q2	35.35
F19VAU14	-	T1Q1	15.05
F19VAU14	-	T1Q2	41.50
F19VAU14	-	T1Q3	0.00
F19VAU14	-	T2Q1	40.85
F19VAU14	-	T2Q2	44.90
F19VAU14	-	T2Q3	49.70
F19VAU14	-	T3Q1	33.20
F19VAU14	-	T3Q2	40.40
F19VAU14	-	T3Q3	24.65
F19VAU14	-	T4Q1	19.95
F19VAU14	-	T4Q2	33.90
F19VAU14	-	T4Q3	19.30
F19VAU14	-	T5Q1	27.70
F19VAU14	-	T5Q2	21.10
F19VAU14	-	T5Q3	11.80
F19VAU14	-	T6Q1	39.00
F19VAU14	-	T6Q2	41.10
F19VAU14	-	T6Q3	30.50
F20VAU04	-	Reach	34.00
F20VAU05	-	Reach	67.85
F20VAU07	-	Reach	90.10
F21VAU01	-	Reach	57.45
F21VAU02	-	Reach	27.20
F21VAU09	-	Reach	23.00
F21VAU10	-	Reach	32.00
F21VAU12	-	Reach	38.00
F9VAU16	-	Reach	47.25

FIGURES

Figure 1.Historical and recent (2015–2016) occurrences of *Obovaria arkansasensis* in Oklahoma. Records are from the Oklahoma Biodiversity Information System database and Vaughn publications.

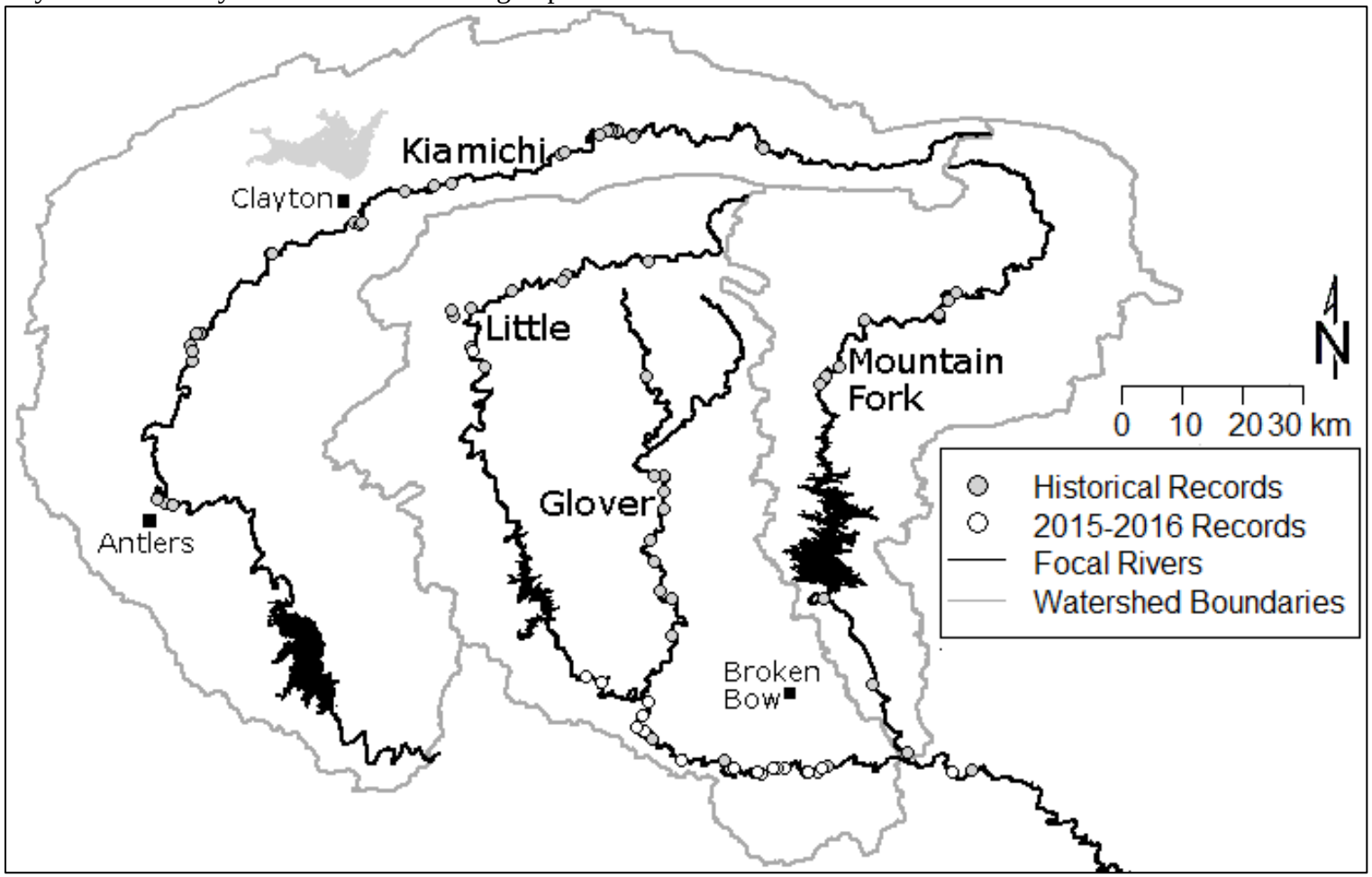

Figure 2. Locations of all sites sampled in 2019–2021.

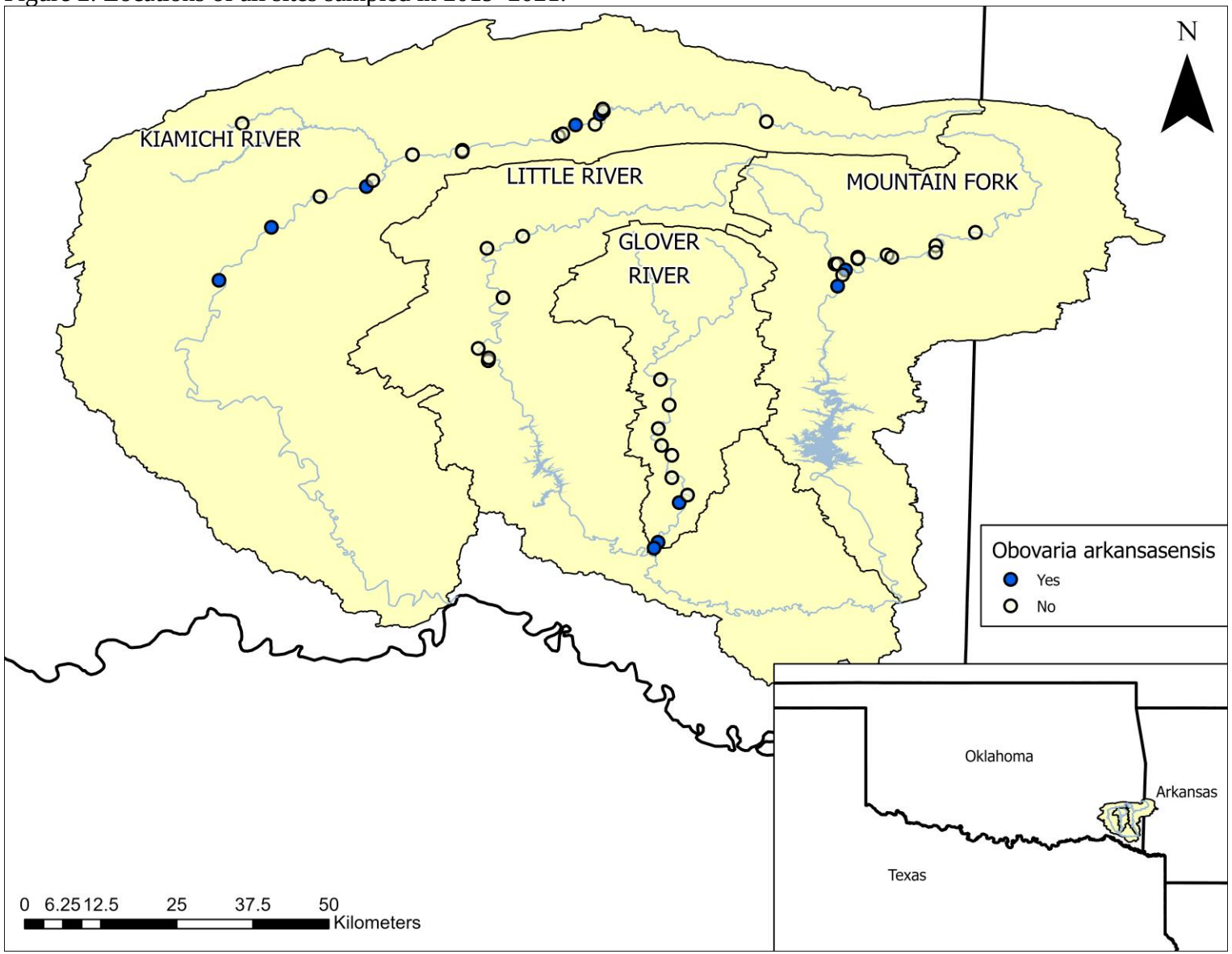

Figure 3. Abundance of mussels at all sites sampled with timed searches. Sites are displayed from left to right in upstream to downstream order. The site to the left of the dashed line in panel A is on North Jackfork Creek, and the sites to the left of the dashed line in panel B are from Eagle Fork Creek. Stacked bars indicate sites where multiple areas were surveyed (e.g., opposite banks of the river).

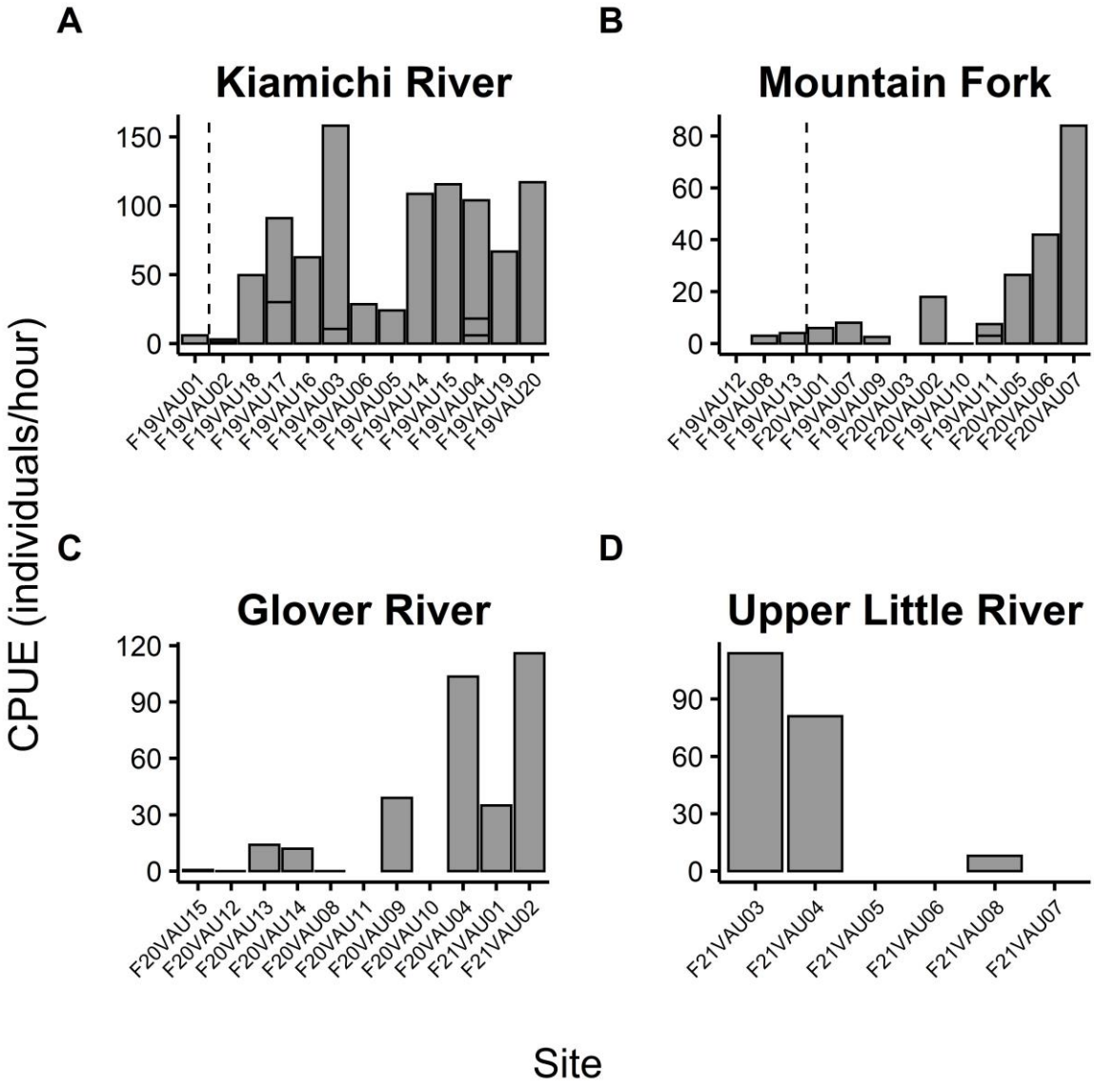

Figure 4. Densities of mussels at sites where quadrat sampling was conducted. Sites are displayed from left to right in upstream to downstream order.