Project Title: FINAL REPORT
Freshwater mussel biodiversity status and evaluation of population response to catastrophic flooding within the Big Thicket National Preserve, Texas (*part 2*)

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Introduction

As one of the most biodiverse ecosystems on the North American continent, it's no surprise that the streams of the Big Thicket region of Southeast Texas are home to the most speciose populations of freshwater mussels in the state, including the state's highest number of endemic species. Currently about half of the freshwater mussel (unionid) species listed as threatened by the state are endemic to the Thicket. They include the Louisiana Pigtoe (*Pleurobema riddellii*), Sandbank Pocketbook (*Lampsilis satura*), Southern Hickorynut (*Obovaria arkansasensis*), Texas Heelsplitter (*Potamilus amphichaenus*), and Texas Pigtoe (*Fusconaia askewi*). As long-lived practically sessile benthic macroinvertebrates, unionids are especially vulnerable to changes in instream hydrology caused by extreme climactic events, such as flooding and drought, that can quickly alter all aspects of water quality.

As a result of anthropogenic climate change, extreme flood and drought events are predicted to increase in duration and regularity. In fact, over the past decade record-breaking extreme precipitation events have become routine in Texas. Since 2015 Texas has been the host of at least five of the nation's most devastating natural disasters (Memorial Day Flood (2015), Tax Day Flood (2016), Hurricane Harvey (2017), The Great June Flood (2018), and Tropical Storm Imelda (2019)). Note that three of the five occurred within the Big Thicket Ecoregion. Since the 1st of January 2016 the Neches River at Evadale (Figure 1) has been at or above NWS flood stage on 5 separate occasions (USGS waterdata.gov). Most recently, during Tropical Storm Imelda (September 2019), rainfall totals of >36 inches were reported within the region (max reported ttl of 43.39" at North Fork Taylors Bayou) (A. Smith, 2020 NOAA). Conversely, this summer portions coastal Texas and Louisiana are experiencing extreme to exceptional drought conditions. The most severe drought Texas has experienced in the past 70 years occurred in 2011/2012. During this week in 2011, 98.02% of the state was in drought status. As of this week (June 7, 2022), due to a continued period of higher than average temperatures and little to no precipitation, 88.25% of the state is considered to be in drought status by the U.S. Drought Monitor, with portions of the Thicket classified to be in a D3 extreme drought (US Drought Monitor, 2022).

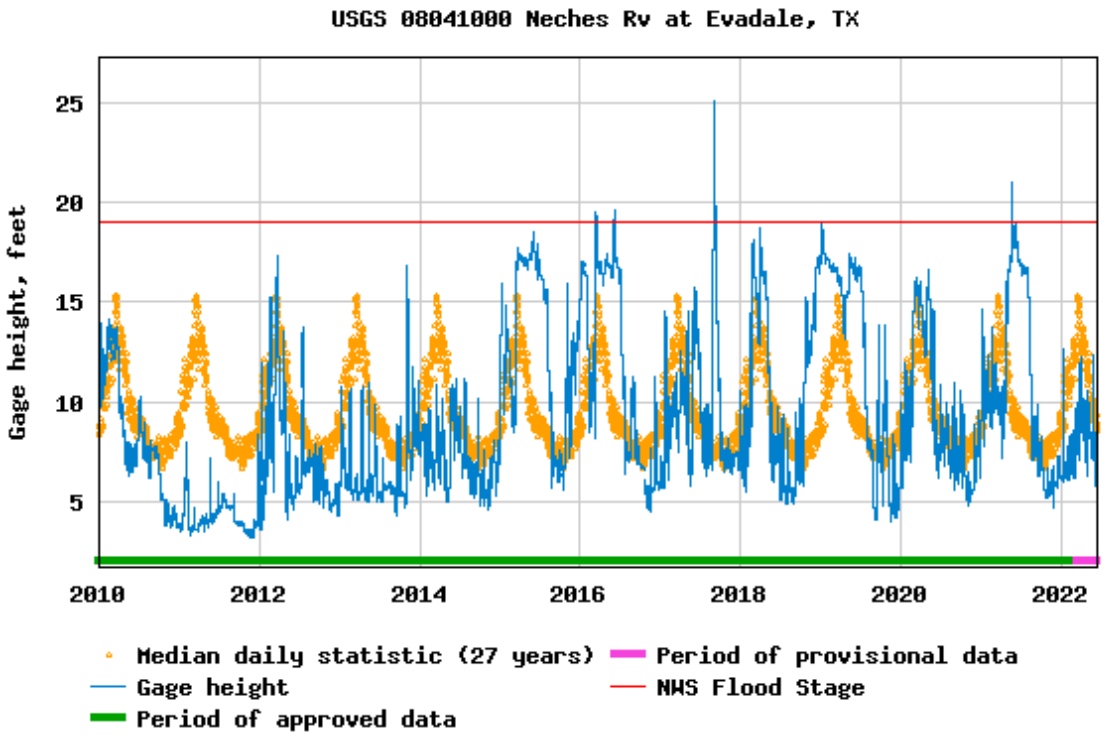


Figure 1. USGS hydrograph Neches River at Evadale, TX (accessed June 16, 2022)

Methodology

A total of 19 sites were selected spanning six units of the Big Thicket National Preserve (Figure 2). We selected and surveyed stream reaches with hydraulic features favorable to freshwater mussels. This included steam reaches not examined by past surveys. Sites were selected through a combination of analysis of past available data (2002, 2014, 2018), examination of past flow patterns, evaluation of historic imagery, and in situ observations related to specific habitat requirements suitable to the life history needs of the state-threatened mussels. Access to sampling sites was made by motorboat, vehicle, and foot as conditions required. Sites surveyed outside of a BTNP unit were placed within the nearest unit for comparison.

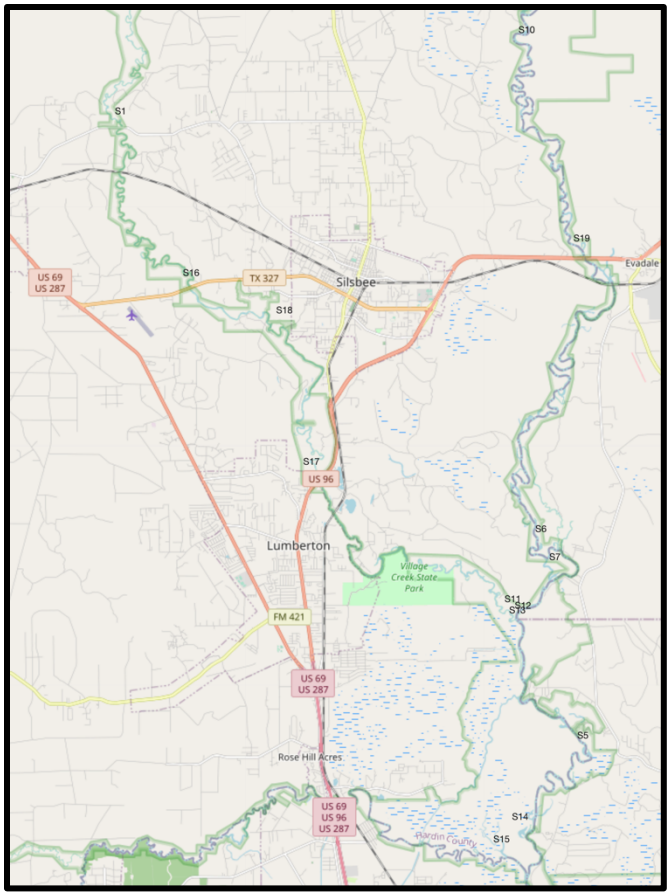


Figure 2. Map of the Big Thicket Region of Texas with 2022 sites indicated by name

At each site a minimum of one person-hour was spent locating mussels through tactile searches. Search time was extended by one-half person hour until no new species were detected. This process is known to be useful for the detection rare species (Metcalfe-Smith et al., 2000). The maximum time spent searching one site was 4.5 person-hours. All sites were georeferenced and photographed. Specimens were identified, counted, and returned to the stream. Rare, unusual, exceptionally small and State Threatened Species were measured (L x W x H) and individually photographed. Mesohabitat type at each sampling location was recorded along with mean depth, channel wetted width, and visual estimates of the percent substrate composition based on the modified Wentworth scale. Also, adjacent land use, anthropogenic influences, presence of exotic species, percent shade, and shoreline and aquatic vegetation composition were documented to allow for analysis of temporal change at each site.

In addition, to inform identification of species which were difficult to distinguish by external morphology or species that do not have genetic markers on file, genetic samples were collected by nonlethal methods. Tissues samples were sent to the John G. Shedd Aquarium Daniel P. Haerther

Center for Conservation and Research to be sequenced by Kentaro Inoue, Ph.D., Freshwater Mussel Conservation Biologist (https://www.sheddaquarium.org/care-and-conservation/shedd-research/surveying-freshwater-mussels). When appropriate, dead individuals (shells) were retained to be stored at Texas State University for analysis or reference.

Objectives

Though unforeseen circumstances, major flooding from Imelda in 2019, COVID-19 restrictions in 2020-2021, and an extended period of minor flooding in 2021, impeded the scheduled completion time and geographic range of this project, the oveall goals are still three-fold: (1) to identify and document poorly surveyed areas of the BTNP such as the numerous backwaters that, with the added stressor of climate change, appear to be crucial for mussel survival and recruitment within the Thicket and likely provide refuge from both high flow and dewatering events; (2) to document the response of known mussel communities, like those in Village Creek, a recognized mussel sanctuary in need of continuous monitoring (Bordelon and Harrel, 2004; Karatayev and Burlakova, 2007, Tarter et al., 2022), to extreme climactic events; and (3) through the collection and analysis of genetic material, to provide clarification on species status of unionids that cannot be distinguished by external morphology or that lack genetic validation [like the STS *P. amphichaenus* (Texas heelsplitter)]. Identity clarification on STS is critical as recent reports have grossly overestimated the presence of *Fusconaia askewi* (Texas pigtoe) and reported a high abundance of *Pleurobema riddellii* (Louisiana pigtoe). For example, a report Bio-West to the Lower Neches Valley Authority states 275 “Louisiana pigtoes” were found in a LNVA canal (TX Comptroller website, accessed Jun 16, 2022), a location not conducive to the life history strategy of the species. In this survey and in Tarter (2019) genetic samples were taken from individuals with phenotypic expression resembling *P. riddellii.* This will allow for valid presence/absence conformation of the species (2022 results pending).

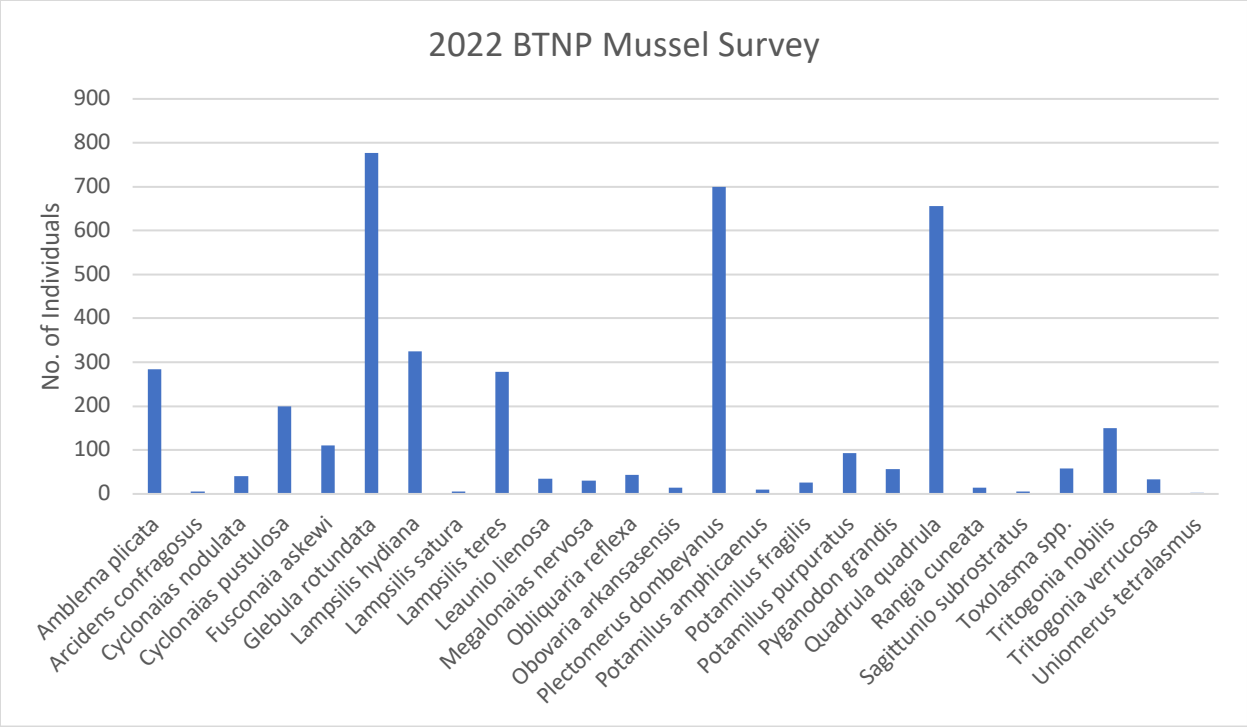


Figure 3. Relative abundance of bivalve species noted in 2022 BTNP mussel survey. *Toxolasma parvum* and *Toxolasma texasiense* were group together for field identification as they share external morphological features (genetic analysis pending).

Results

Among all 19 sites surveyed in 2022 a total search effort of 47 person-hours detected 3953 living individual bivalves (dead individuals were not counted) from approximately 25 species (genetic analysis pending). The mean catch per unit effort (live mussels/person-hour) was ~84 individuals. Genetic material from 19 individuals was collected for species verification. The most abundant species were *Glebula rotundata* (777 individuals observed), *Plectomerus dombeyanus* (699 individuals observed), and *Quadrula quadrula* (656 individuals observed). All regional STS but *P. riddellii* were documented. Genetically validated accounts of *P. riddellii* have not yet occurred in the Thicket.

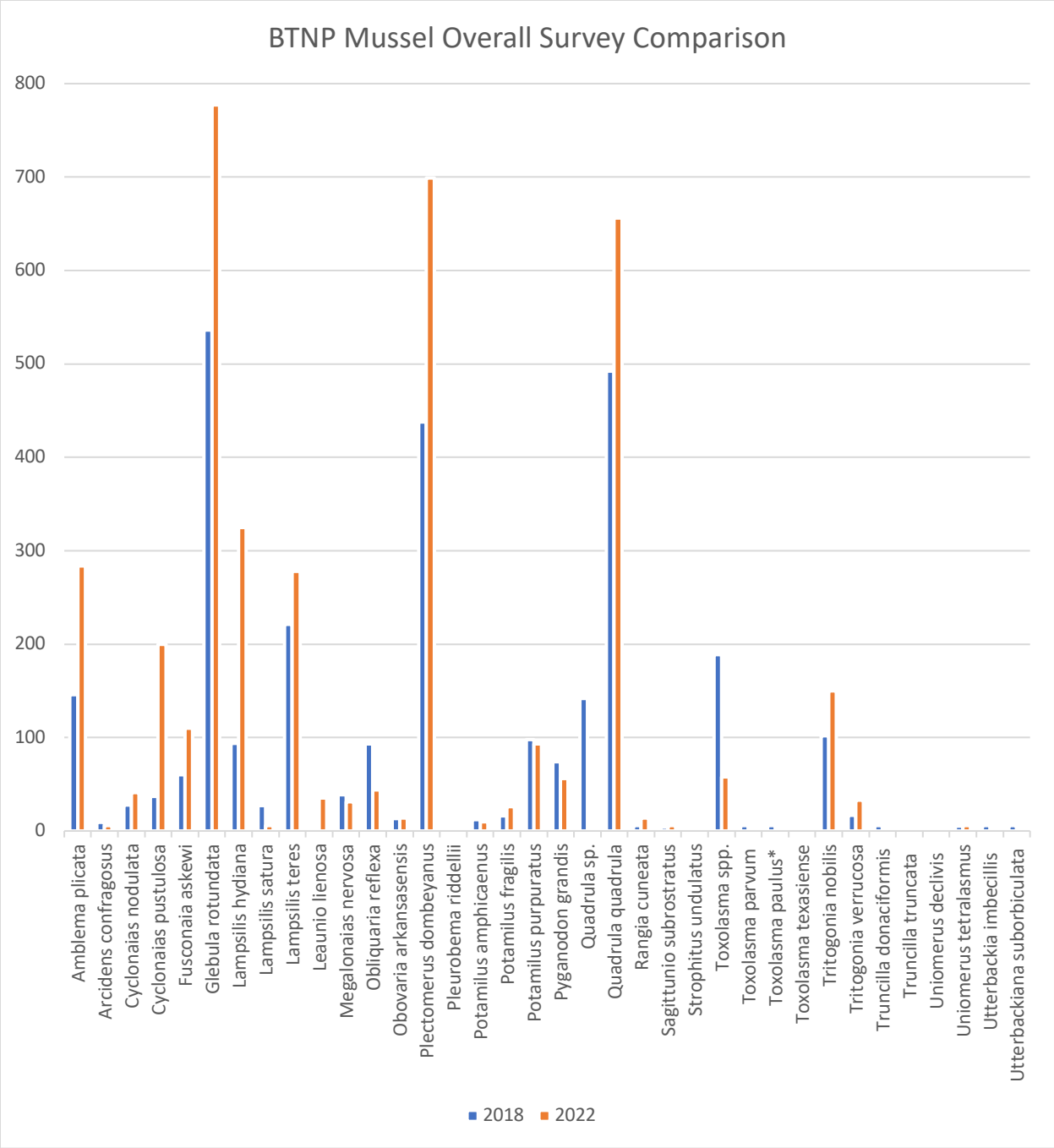


Figure 4. Comparison of species and number of individuals detected in the Big Thicket from surveys in 2018 and 2022

Through analysis of site-specific species richness and catch per unit effort (CPUE) at multiple time scales (2002, 2014, 2018, 2022), both flooding and drought events were found to be damaging to mussel populations in the Thicket. Though drought appeared to have the strongest community-wide negative impact, flooding altered community composition and spatial distribution. The impact was not

uniform throughout the region and varied greatly with floodplain topography, instream structure, and channel slope. Particularly in the upstream reaches of Village Creek where channel slope is high, intensified flow shear stress resulting from elevated discharge during extreme flooding events lead to bank instability and bed scouring. Such conditions are known to dislodge individuals, lead to mortality and/or transport downstream to unsuitable habitat. Accordingly, many of the individuals found in both the 2017 and 2022 surveys were physically damaged (Tarter et al., 2022). Overall species richness (Figure 4) was lower in 2022 than in 2018 (~29 species).

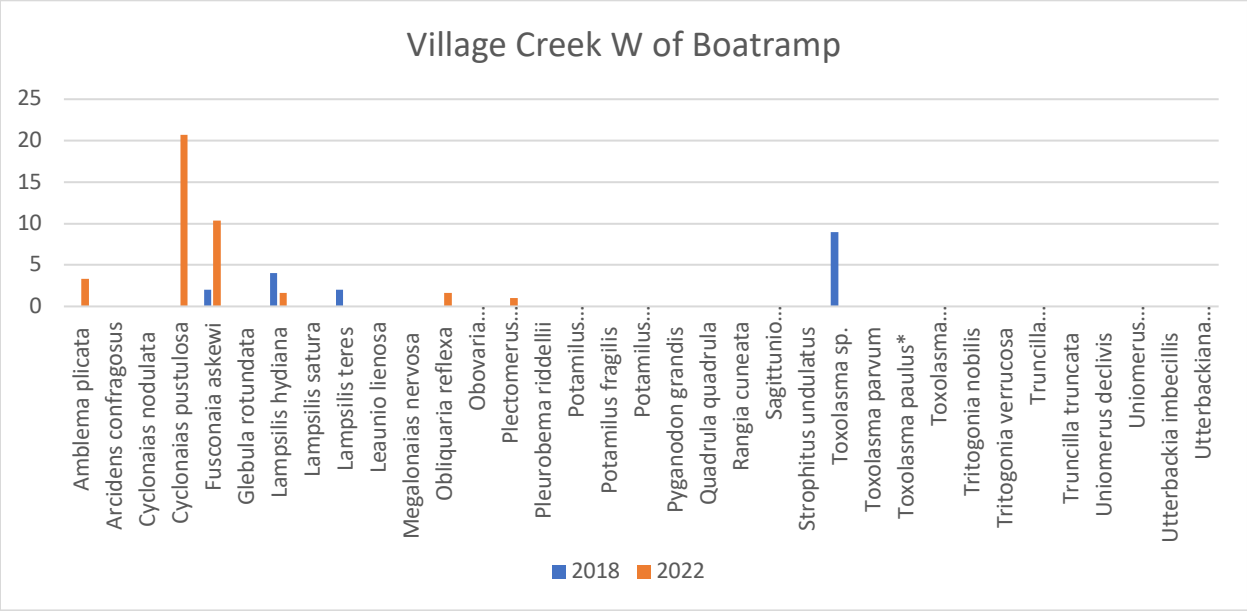


Figure 5. Site S17 2022

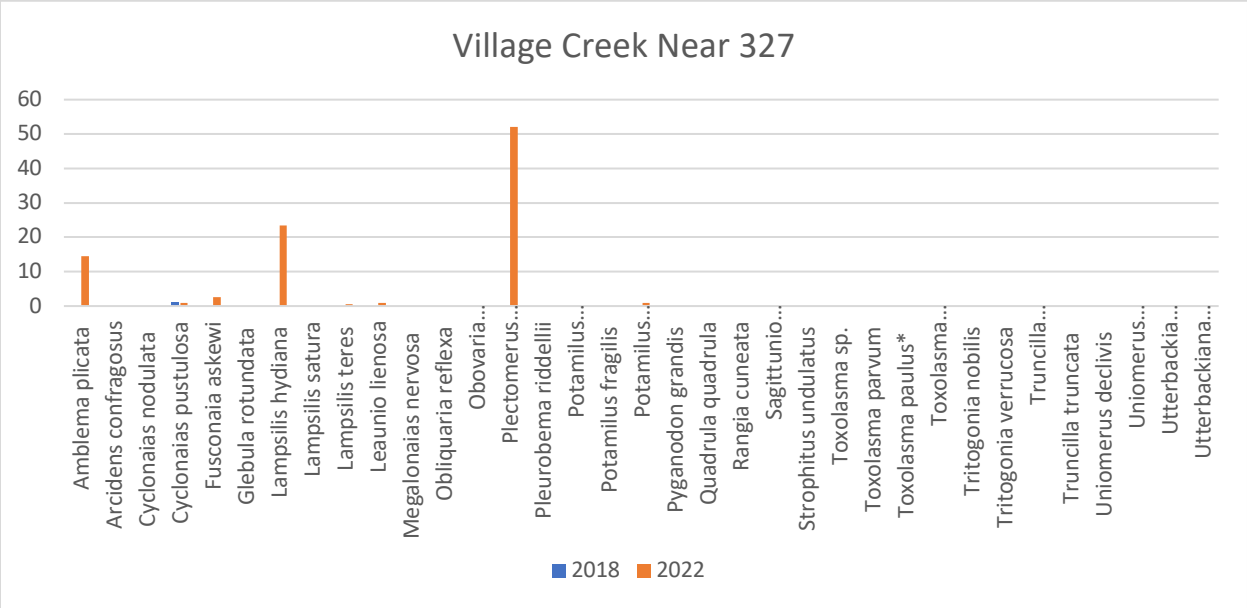


Figure 6. Site S16 2022

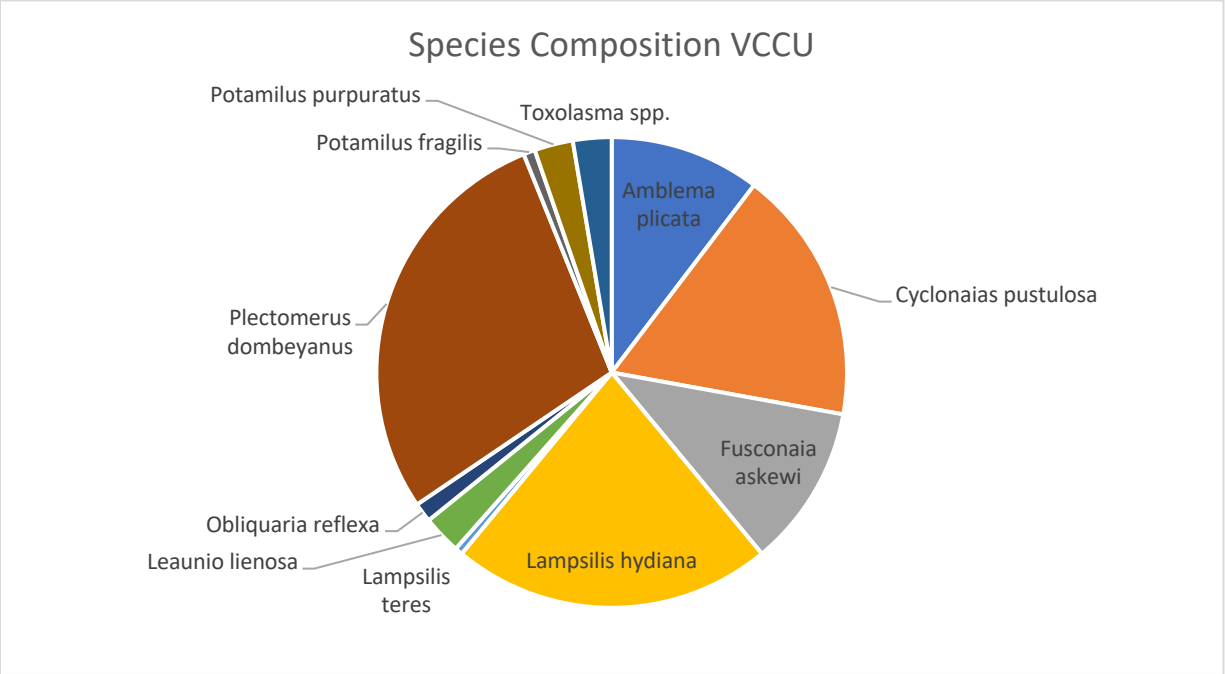
However, improvement in abundance and species diversity were noted at several sites that contained few individuals and/or displayed low species diversity after the 2017 flood event (Figures 5 and 6), indicating the sites are recovering from the record-breaking flood. Further support of ecological recovery from the 2017 high flows was noted through the detection of small (juvenile) *F. askewi*, indicating recent recruitment of the species. No small *F. askewi* were detected in the 2018 study.

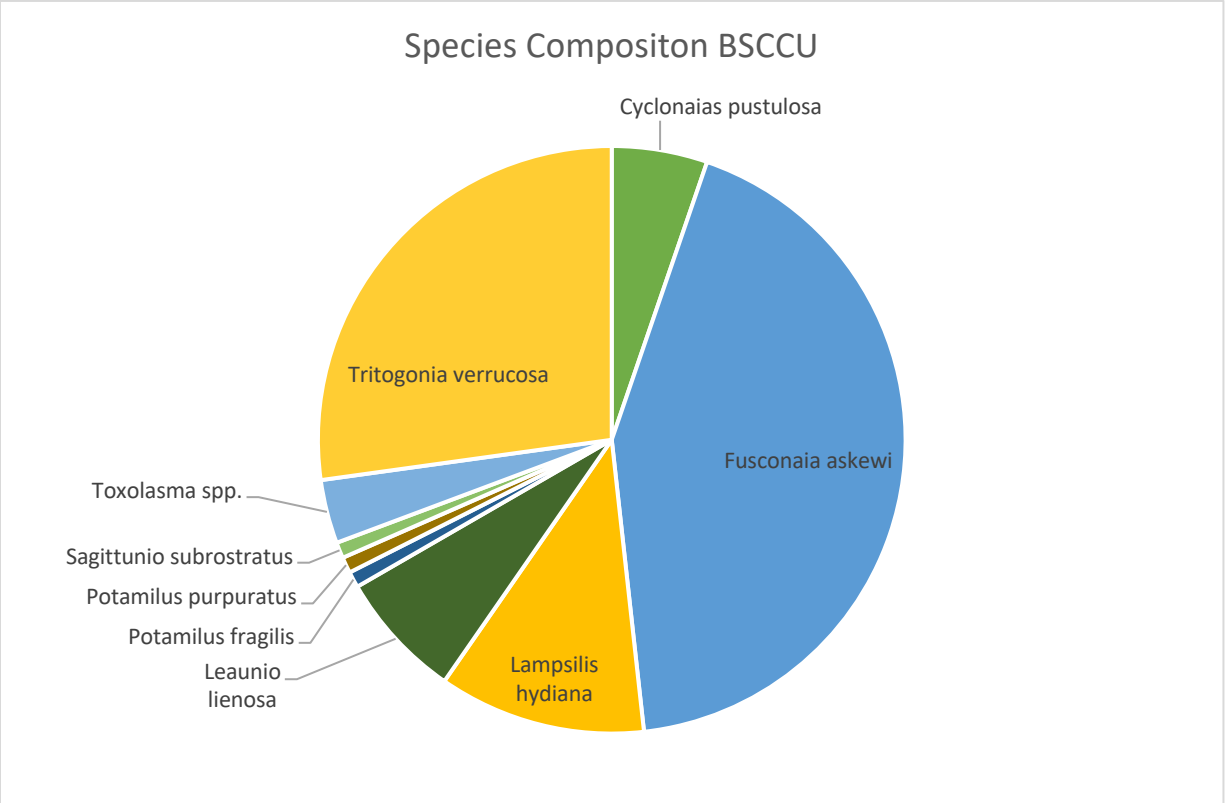
Conclusion

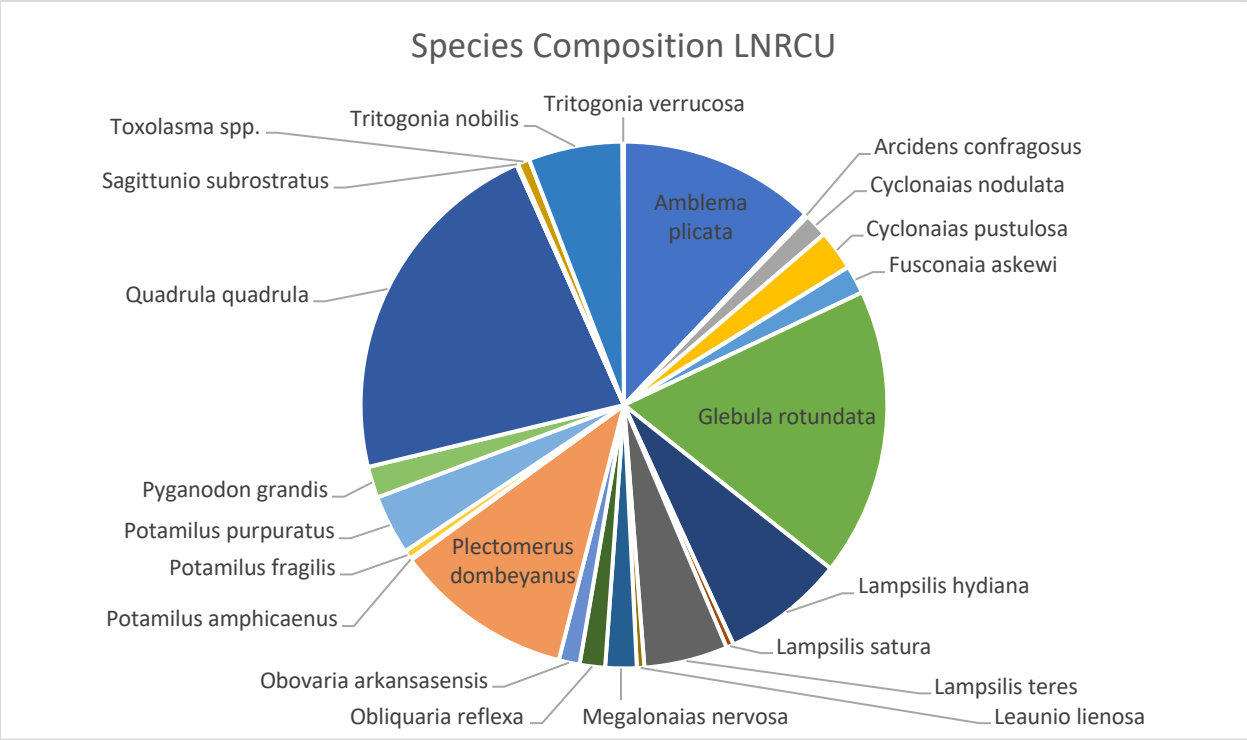
Intensive surveys were performed in April, May, and June 2022. Rare and/or STS were found in the waters of all BTNP units surveyed with the exception of the Beech Creek unit. The lack of such species in Beech Creek was consistent with the 2018 project findings, supporting the hypothesis that both dewatering during drought conditions and high shear stress during extreme precipitation event have left the far upstream, high slope narrow channel reaches unable to support the life history requirements of rare and STS. Species richness was highest in the Lower Neches River Corridor (23 species) and in the Beaumont (19 species) units, followed by the Upper Neches River Corridor (12 species), Village Creek Corridor (11 species), and Big Sandy Creek Corridor (9 species) units. The Beech Creek Unit displayed both the lowest number of species and lowest relative abundance of individuals. Relative abundance was highest in the Beaumont (177), Lower Neches River Corridor (146), and Upper Neches River Corridor (103) units.

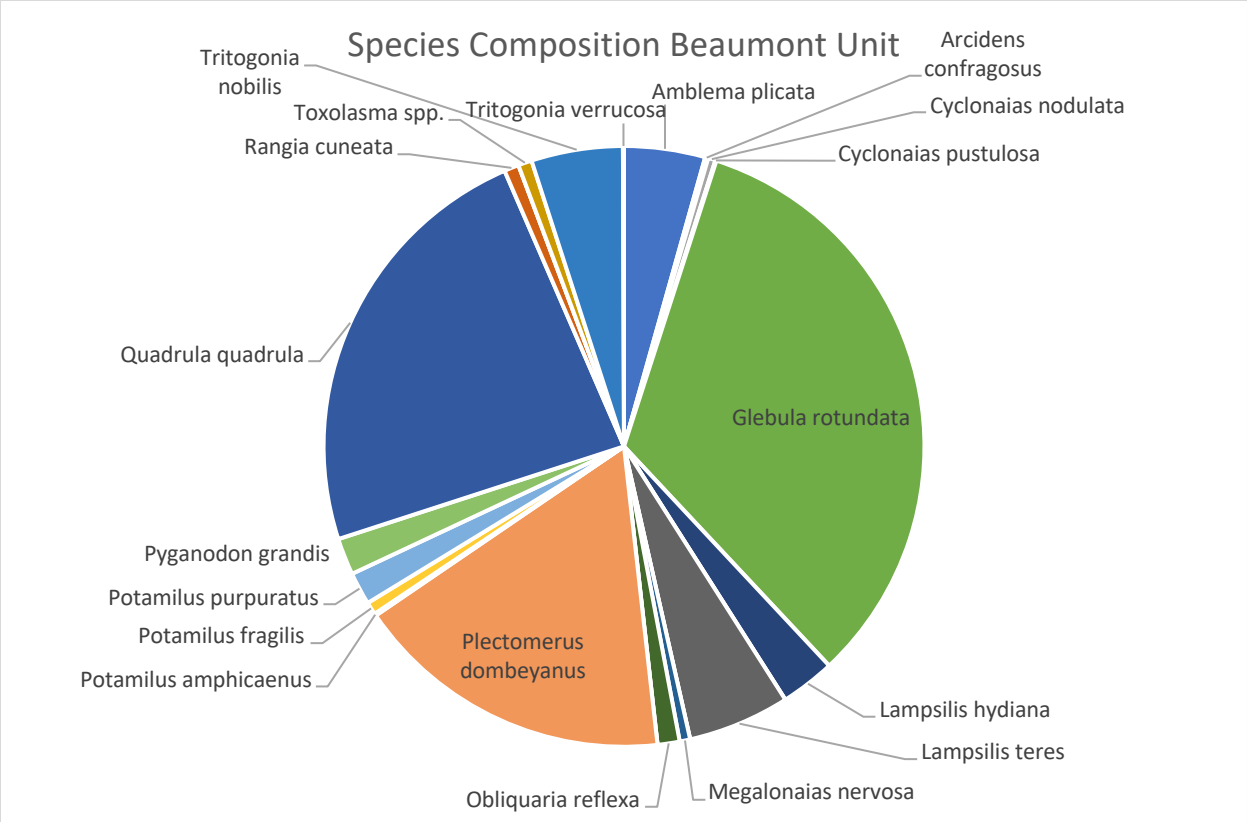
The 2011/2012 drought and 2017 flood still appeared to have significantly impacted regional freshwater mussel density and community composition, populations in stream reaches with both low bank and floodplain slope continue to support dense and speciose mussel populations at a level unsurpassed by any region of the state. The protection provided to riparian habitat within the Big Thicket National Preserve is a clear example of the resilience of nature and hard work of those who seek to protect it.

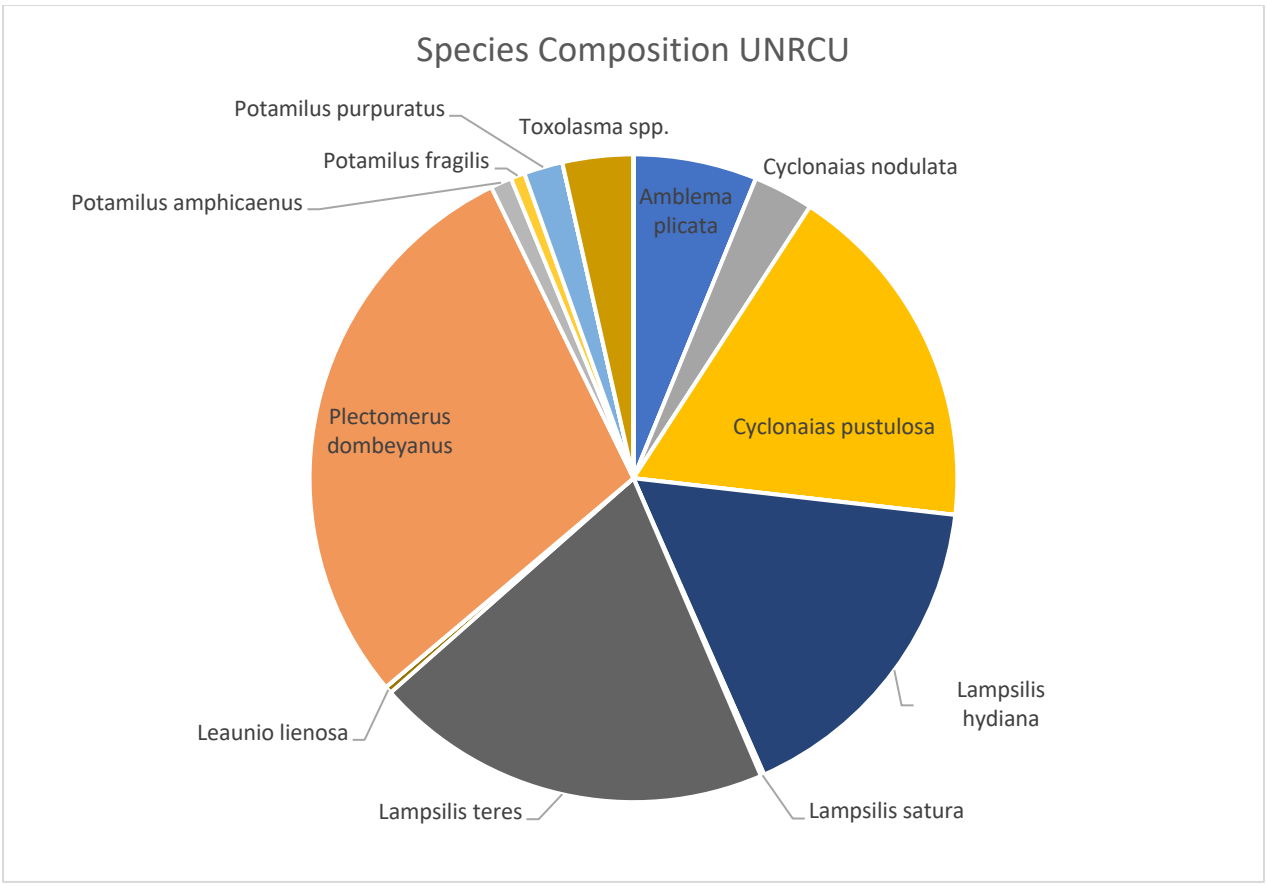
Appendix 1. Species composition by preserve unit 2022

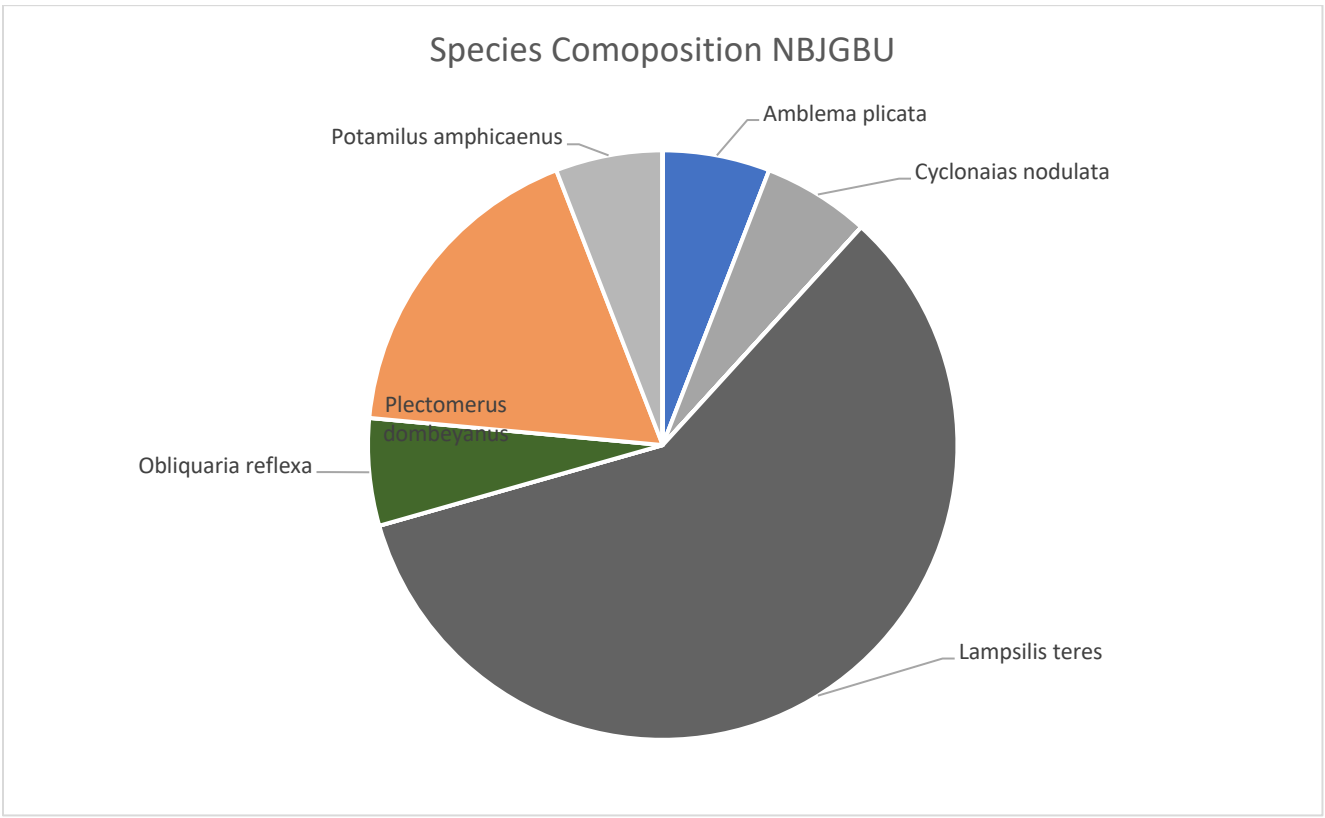


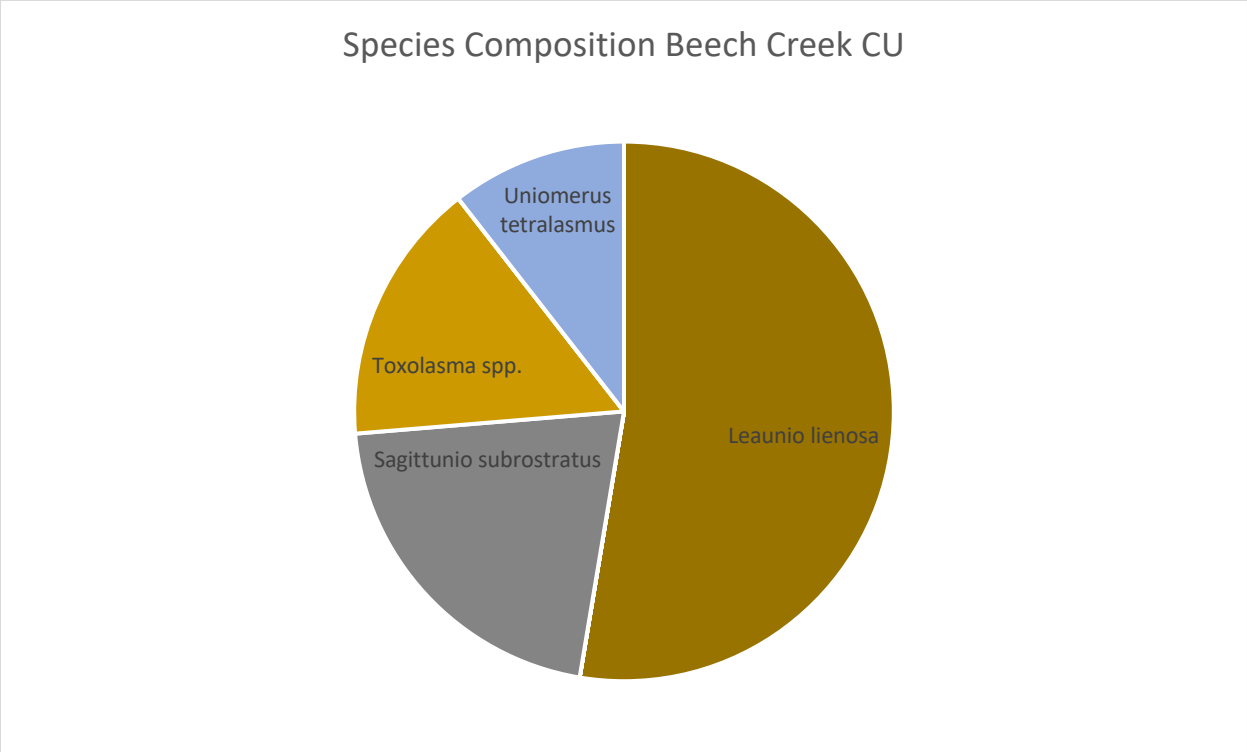



Species Composition LNRCU
Tritogonia verrucosa
Tritogonia nobilis
Toxolasma spp.
Sagittunio subrostratus
Quadrula quadrula
Pyganodon grandis
Potamilus purpuratus
Potamilus fragilis
Potamilus amphicaenus
Obovaria arkansasensis
Obliquaria reflexa
Megalonaias nervosa
Leaunio lienosa
Lampsilis teres
Lampsilis satura
Lampsilis hydiana
Glebula rotundata
Fusconaia askewi
Cyclonaias pustulosa
Cyclonaias nodulata
Arcidens confragosus
Amblema plicata
Plectomerus dombeyanus


Species Composition Beaumont Unit
Tritogonia nobilis
Toxolasma spp.
Rangia cuneata
Tritogonia verrucosa
Amblema plicata
Arcidens confragosus
Cyclonaias nodulata
Cyclonaias pustulosa
Quadrula quadrula
Glebula rotundata
Pyganodon grandis
Potamilus purpuratus
Potamilus fragilis
Potamilus amphicaenus
Plectomerus dombeyanus
Lampsilis hydiana
Lampsilis teres
Megalonaias nervosa
Obliquaria reflexa


Species Composition UNRCU
Potamilus purpuratus
Toxolasma spp.
Potamilus fragilis
Cyclonaias nodulata
Potamilus amphicaenus
Amblema plicata
Plectomerus dombeyanus
Cyclonaias pustulosa
Lampsilis hydiana
Leaunio lienosa
Lampsilis teres
Lampsilis satura


Species Comoposition NBJGBU
Potamilus amphicaenus
Amblema plicata
Cyclonaias nodulata
Plectomerus dombeyanus
Obliquaria reflexa
Lampsilis teres


Species Composition Beech Creek CU
Uniomerus tetralasmus
Toxolasma spp.
Leaunio lienosa
Sagittunio subrostratus

Appendix 2. Freshwater mussels scientific name update list

Scientific Name as of 2021 FMCS list	Former name	Common Name (Williams et al., 2017. A Revised List of the Freshwater Mussels)	Found in Tarter et al (2022)	Found in Tarter (2019)	notes	**
Amblema plicata		Threeridge	Y	y		
Arcidens confragosus		Rock Pocketbook	Y	y		
Cyclonaias pustulosa	*Q. pustulosa*	Pimpleback	y	y	Now includes *Q. mortoni*	
Cyclonaias nodulata	*Quadrula nodulata*	Wartyback	y	y	Reassigned to Cyclonaias	
Fusconaia askewi	includes *F. lananensis*	Texas pigtoe	Y	y	**State Threatened Species** *F. lananensis* is now part of *F. askewi*	
Glebula rotundata		Round pearl shell	Y	y		
Lampsilis hydiana		Louisiana Fatmucket	y	y		
Lampsilis satura		Sandbank Pocketbook	y	y	**State Threatened Species**	
Lampsilis teres		Yellow Sandshell	y	y		
Potamilus fragilis	*Leptodea fragilis*	Fragile Papershell	y	y		
Sagittunio subrostratus	*Ligumia subrostrata*	Pondmussel	Y	y		
Megalonaias nervosa		Washboard	y	y		
Obliquaria reflexa		Threehorn Wartyback	y	y		
Obovaria arkansasensis	*O. jacksoniana*	Southern Hickorynut	y	y	**State Threatened Species**	
Plectomerus dombeyanus		Bankclimber	y	y		
Pleurobema riddellii		Louisiana Pigtoe	N*	n	**State Threatened Species** *genetic analysis pending 2022	
Potamilus amphichaenus		Texas Heelsplitter	y	y	**State Threatened Species**	
Potamilus pupuratus		Bleufer	y	y		
Pyganodon grandis		Giant floater	y	y	*Pyganodon grandis*	
Quadrula quadrula	*Quadrula apiculata*	Southern Mapleleaf	y	y	*Q. apiculata* now considered *Q. quadrula*	
Tritogonia nobilis	*Quadrula nobilis*	Gulf Mapleleaf	Y	y		
Strophitus undulatus		Creeper	n	n		
Toxolasma parvum	*T. parvus*	Lilliput	Y	*	Spelling correction to *T. parvum*	
Toxolasma texasiense		Texas Lilliput	Y	*		
Tritogonia verrucosa	*Quadrula verrucosa*	Pistolgrip	Y	y	*Q. verrucosa* is now *T.verrucosa*	
Truncilla donaciformis		Fawnsfoot	n	y		
Uniomerus declivis		Tapered Pondhorn	n	n		
Uniomerus tetralasmus		Pondhorn	Y	y		
Utterbackia imbecillis		Paper Pondshell	Y	y		
Utterbackiana suborbiculata	*A.suborbiculata*	Flat floater	Y	y	Was *Anodonta suborbiculata*	
Leaunio lienosus	*Villosa lienosa*	Little Spectaclecase	Y	***	****Toxolasma parvum, T. texasiense*, and *V. lienosa* were all considered *Toxolasma* sp. in Tarter (2019)	
Fusconaia flava		Wabash Pigtoe	n	n		
*Corbicula fluminea***		Asian clam**	Y	y	**non-unionid bivalve - invasive	
*Rangia cuneata***		Marsh clam**	Y	y	**non-unionid bivalve - native	

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