Upper Red River Basin Bioassessment

Sarah Robertson, Stephen Curtis, Clinton Robertson, Archis Grubh, Gordon Linam
Texas Parks and Wildlife Department, Inland Fisheries Division

AND

Melissa Casarez
University of Texas at Austin, Biodiversity Collections

River Studies Report No. 29

Inland Fisheries Division
Texas Parks and Wildlife Department
Austin, Texas

June 2019

Cover photo: Salt Fork of the Red River, Collingsworth County, Texas

TABLE OF CONTENTS

ACKNOWLEDGMENTS

This study was a collaborative effort between the Texas Parks and Wildlife Department's Inland Fisheries and Wildlife divisions and the University of Texas with aid from a few other partners. Without the collective effort of these individuals this study would not have been possible.

Texas Parks and Wildlife Department, Inland Fisheries Division: Karim Aziz

Texas Parks and Wildlife Department, Wildlife Division: Matt Poole and Caroline Ellison

University of Texas: Adam Cohen, Dean Hendrickson, Chelsea Jones, Doug Martin, and Chase Shelburne

We also thank Dan Johnson for his help in identifying crayfish collected during this study.

We thank Beth and Britt Sturgeon for river access and assisting us in the field.

We thank Stephan Magnelia, Kevin Mayes, and John Botros for reviewing early drafts of this report.

Partial funding for this project was provided through the State Wildlife Grants Program in corporation with the U.S. Fish and Wildlife Service, Wildlife and Sport Fish Restoration Program.

Upper Red River Basin Bioassessment

EXECUTIVE SUMMARY

One aquatic bioassessment study area encompassing six sites and 34 supplemental collection sites were sampled across 14 counties in the upper Red River Basin of the Texas Panhandle and along the Texas-Oklahoma border during the fall of 2015 and 2016. The bioassessment study area included sampling at six sites on the Middle Fork Pease River within the Matador Wildlife Management Area. Fish were collected from all 40 sites and freshwater mussels and macroinvertebrates were collected from a subset of sites. All crayfish collected were documented.

Overall 43 species of fish were documented from the upper Red River Basin. Fish species richness by site ranged from one to 17 species. Five fishes classified as species of greatest conservation need were documented (Prairie Chub, Red River Shiner, Silverband Shiner, Red River Pupfish, and Orangebelly Darter), but were typically found in low numbers. Federal and state-listed species historically found within this range were not encountered (Blue Sucker and Sharpnose Shiner). Fluvial specialists, including pelagic-broadcast spawning minnows, were found in low numbers and only at a few sites; however, it is possible they are more prevalent in the mainstem Red River which was not sampled in this study.

No live freshwater mussels were collected during this study; however, long-dead shell material representing four species was found at one site on the Wichita River. Three species of crayfish were collected.

Sampling within Matador Wildlife Management Area included data collection on fish, mussels, aquatic benthic macroinvertebrates, and water quality. Twelve species of fish and 24 benthic macroinvertebrate taxa were collected from the Middle Fork Pease River within Matador Wildlife Management Area. Bank searches found no evidence of freshwater mussels and no crayfish were documented from the management area. Fish species collected included several species that offer angling opportunities such as Largemouth Bass, Channel Catfish, and several sunfish species. The Middle Fork Pease River was not flowing during sampling and was a series of isolated pools. For this reason, calculation of indices of biotic integrity for fish or invertebrates were deemed inappropriate and omitted from analysis.

Matador Wildlife Management Area provides public bank fishing access to the Middle Fork Pease River and camping opportunities for a small public lands fee. Outside of the management area, public access for recreational activities such as boating, paddling, and fishing is limited within the upper Red River Basin by low stream flows and fencing of the right-of-way at bridge crossings. Most rivers and streams within the study area have low and inconsistent stream flows limiting kayaking or canoeing opportunities; however, several city and county parks on the Wichita and Salt Fork of the Red River provide public access for bank fishing.

This study updated fish occurrence records for 40 sites across the upper Red River Basin. This information will be used in conservation planning by Texas Parks and Wildlife Department for their Native Fish Conservation Areas initiative (Birdsong et al., 2019). Sport fish species data and recreational access information will also inform the agency's recreational access initiatives such as the Texas Paddling Trails and the River Access and Conservation Areas programs, both of which work with local landowners and partners to increase public access for fishing and paddling.

INTRODUCTION

Study Area

Red River: The Red River flows 2,188 km through Texas, Oklahoma, Arkansas, and Louisiana before joining the Mississippi River at the Louisiana-Mississippi border (Huser 2000). The mainstem originates in Texas where the Prairie Dog Town Fork gives way to the Red River at the eastern edge of the Texas panhandle. The southern shore of the river goes on to form the Texas-Oklahoma border (Huser 2000), followed by the Texas-Arkansas border, before entering Louisiana and eventually joining the Mississippi River (Huser 2000). The watershed drains an area of 169,900 km^2 and spans several Texas ecoregions: Western High Plains, Southwestern Tablelands, Texas Blackland Prairies, Central Oklahoma/Texas Plains, and South Central Plains (Griffith et al. 2004). Major tributaries to the Red River in Texas include several forks (Prairie Dog Town Fork, Salt Fork, and North Fork), the Wichita River, the Pease River, Big Cypress Bayou, and the Sulphur River. Only one major reservoir impounds the Red River within Texas, Lake Texoma (Huser 2000); however, there are impoundments on several tributaries.

Within the upper Red River Basin, the Prairie Dog Town Fork has been recognized by the Nationwide Rivers Inventory for having remarkable cultural, geologic, historic, recreational, and scenic value (National Park Service 2010). Two segments of the Prairie Dog Town Fork have been named as ecologically significant stream segment nominees: Upper Prairie Dog Town Fork Red River (Texas Commission on Environmental Quality (TCEQ) Segment 0229) and Lower Prairie Dog Town Fork Red River (TCEQ segment 0207; TPWD 2018a). The upper segment was recognized as a riparian conservation area (Palo Duro Canyon State Park) and for high water quality, high aesthetic value, and exceptional aquatic life (TPWD 2018a). Both segments of the Prairie Dog Town Fork and two segments of the mainstem Red River (TCEQ segments 0205 and 0206) have been recognized for providing habitat for the federally threatened interior least tern *Sterna antillarum* (TPWD 2018a). Several additional tributaries of the Red River have been nominated, including the Pease (TECQ Segment 0220) and Middle Pease (TCEQ Segment 0221) rivers for their value as riparian conservation areas (Copper Breaks State Park and Matador Wildlife Management Area, respectively; TPWD 2018a).

The geographic bounds for this study include the 13 counties within the Red River Basin upstream of Lake Texoma (Childress, Clay, Collingsworth, Cooke, Cottle, Donley, Gray, Hardeman, Hemphill, Montague, Wheeler, Wichita, and Wilbarger counties) and one county surrounding the reservoir (Grayson County). Only tributary sites, not mainstem Red River, were sampled because the mainstem lies within Oklahoma's jurisdiction and Oklahoma Department of Wildlife Conservation has plans to survey those sites during the time of this study (ODWC, personal communication).

> Matador Wildlife Management Area: Matador Wildlife Management Area (WMA) is located in Cottle County, TX and is comprised of 28,183 acres of rolling plains and shrubland (TPWD 2018b). The Middle Fork Pease River runs through the middle of the WMA; however, it typically only flows for a short duration each year and is usually found as a series of long, disconnected pools. Matador WMA offers many recreational activities including hunting, camping, equestrian, fishing, hiking, and wildlife viewing.

Survey and Management History

Biological Surveys: University of Texas' Fishes of Texas database has historic records for 66 species of freshwater fishes from the upper Red River sub-basin (Hendrickson and Cohen 2015); however, there are many data gaps within the upper basin. Ongoing fish data collection efforts at Matador WMA, beginning in 2004 by West Texas A&M University (WTAMU), have documented 20 fish species (Richard Kazmaier, WTAMU, personal communication).

Basin-wide, 26 species of freshwater mussels have been known to occur in the Red River drainage (TPWD 2008). No recent published mussel assemblage surveys were available within the study area for this project; however, TPWD surveys in the 1990s yielded seven common species from the Wichita River watershed (Howells 1998). No comprehensive crayfish or benthic macroinvertebrate surveys within the study area were found.

Imperiled Species: Historical fish collections from the upper Red River Basin document 11 freshwater species currently identified by TPWD (2012) as species of greatest conservation need (SGCN): Goldeye *Hiodon alosoides*, American Eel *Anguilla rostrata*, Blue Sucker *Cycleptus elongatus*, Prairie Chub *Macrhybopsis australis*, Silver Chub *M. storeiana*, Red River Shiner *Notropis bairdi*, Sharpnose Shiner *N. oxyrhynchus*, Chub Shiner *N. potteri*, Silverband Shiner *N. shumardi*, Red River Pupfish *Cyprinodon rubrofluviatilis*, and Orangebelly Darter *Etheostoma radiosum*, (Hendrickson and Cohen 2015). Blue Sucker is listed as state-threatened and Sharpnose Shiner is listed as federally-endangered. Additionally, the Plains Minnow *Hybognathus placitus*, Shoal Chub *M. hyostoma*, River Shiner *Notropis blennius*, and Suckermouth Minnow *Phenacobius mirabilis* are proposed for inclusion on TPWD's SGCN list (Cohen et al. 2018) and have been reported from the Red River Basin.

Two SGCN mussels have historically occurred in the Red River Basin: Ouachita Rock-pocketbook *Arkansia wheeleri* and Southern Hickorynut *Obovaria jacksoniana* (TPWD 2008). The Ouachita Rock-pocketbook is listed as federally endangered and is not known to occur in Texas. Southern Hickorynut is listed as state-threatened in Texas.

Sport Fish Harvest Regulations: Sport fishes in the upper Red River Basin, above Lake Texoma, are managed under statewide fishing regulations (TPWD 2017).

Fish Stockings: TPWD stocked 200 adult Channel Catfish *Ictalurus punctatus* at two locations in the Middle Fork Pease River at Matador WMA in 2002 (TPWD 2018c). The only other reported riverine stocking in the study area (not including Lake Texoma) is a stocking of 10,823 Spotted Bass *Micropterus punctulatus* fingerlings in the Wichita River in 1998 (TPWD 2018c).

Water Quality: Several stream segments within the study area are listed by TCEQ for water quality impairments: Choctaw Creek (TCEQ segment 0202J), Iron Ore Creek (0202k), Lower Prairie Dog Town Fork Red River (0207), Little Wichita River (0211), Wichita River below Diversion Lake Dam (0214), Salt Fork Red River (0222), McClellan Creek (0224A), and Upper Prairie Dog Town Fork Red River (229; TCEQ 2014a). Each of these streams is listed for presence of elevated bacteria levels, except for the Little Wichita River which is listed for high chlorides, sulfates, total dissolved solids and depressed dissolved oxygen values and the Upper Prairie Dog Town Fork which is listed for pH concerns. In each of these cases TCEQ recommended a review of standards or additional data collection (TCEQ 2014a).

STUDY SITES

The upper Red River Basin bioassessment consisted of sampling at 40 sites across 14 counties in the Texas Panhandle and along the Texas-Oklahoma border (Figures 1 and 2; Tables 1 and 2). Six sites were within Matador WMA and thirty-four supplemental sites were distributed throughout the basin.

TABLE 1.—Upper Red River Basin study site locations and the type of data collected at each during October 2015 and 2016 in Clay, Childress, Collingsworth, Cottle, Cooke, Donley, Gray, Grayson, Hardeman, Hemphill, Montague, Wheeler, Wichita, and Wilbarger counties, TX.

				Fish Sampling Gear						
Site	**Location**	**Coordinates**	**Sampling Date**	**Seine**	**Gill net**	**Trammel**	**Backpack**	**Frame net**	**Dip net**	**Mussels**
A-F	Middle Fork Pease River at Matador WMA		(See Figure 2; Table 2)							
1	Washita River on Ramp Ranch	35.7154, -100.1801	10/6/2015	x	x			x		
2	Washita River at RR 2654	35.7198, -100.1125	10/3/2015	x						
3	Gageby Creek at CR 13	35.6067, -100.3033	10/3/2015						x	
4	Gageby Creek at CR EE	35.6194, -100.2820	10/3/2015					x		
5	Sweetwater Creek at SH 152	35.5174, -100.4665	10/3/2015	x						
6	Sweetwater Creek at FM 592	35.4732, -100.1213	10/3/2015	x						
7	Sweetwater Creek at CR 29	35.4466, -100.0229	10/3/2015	x						
8	McClellan Creek at SH 273	35.3276, -100.6096	10/3/2015	x						
9	North Fork Red River at FM 2473	35.3901, -100.3840	10/3/2015	x						
10	Sand Creek (North) at CR 9	35.2983, -100.3783	10/3/2015	x						
11	Salt Fork Red River at SH 273	34.9906, -100.5881	10/3/2015	x						
12	Salt Fork Red River at SH 203	34.8873, -100.0513	10/2/2015	x						
13	Sand Creek (South) at CR 270	34.8485, -100.0633	10/2/2015	x						
14	Prairie Dog Town Fork at US 83	34.5687, -100.1937	10/2/2015	x						
15	Buck Creek at CR 19	34.6111, -100.1107	10/2/2015	x						
16	North Pease River at US 83	34.2744, -100.2852	10/2/2015	x						
17	Pease River at FM 104	34.2279, -100.0739	10/6/2015	x						
18	Wanderers Creek at US 287	34.2564, -99.5270	10/19/2016	x						
19	Pease River at US 283	34.1792, -99.2781	10/19/2016	x						x
20	Wichita River at SH 25	33.8693, -98.8394	10/21/2016	x						
21	Tenth Cavalry Creek at SH 240	34.0893, -98.7624	10/21/2016	x						
22	Gilbert Creek at US 44	34.0645, -98.5568	10/21/2016	x						
23	Wichita River at FM 171	34.0883, -98.2036	10/18/2016	x						x
24	Little Wichita River at FM 2332	33.8942, -97.9895	10/18/2016	x						x
25	Pecan Creek at FM 2849	33.8907, -97.7635	10/20/2016	x						
26	Panther Creek at Hancock Rd.	33.9234, -97.7443	10/20/2016	x						
27	Broadtree Creek at FM 2953	33.8946, -97.5493	10/20/2016	x	x					
28	Mountain Creek at FM 373	33.8034, -97.4553	10/21/2016	x						
29	North Fish Creek at CR 411	33.7994, -97.3126	10/21/2016	x			x			
30	Hickory Creek at CR 127	33.7942, -97.0563	10/21/2016	x						
31	Rock Creek at CR 106	33.8103, -97.0072	10/21/2016	x						
32	Shawnee Creek at SH 91	33.8069, -96.5630	10/22/2016	x	x	x			x	
33	Iron Ore Creek at US 69	33.7010, -96.4905	10/22/2016	x						
34	Choctaw Creek at SH 56	33.6337, -96.4982	10/22/2016	x						

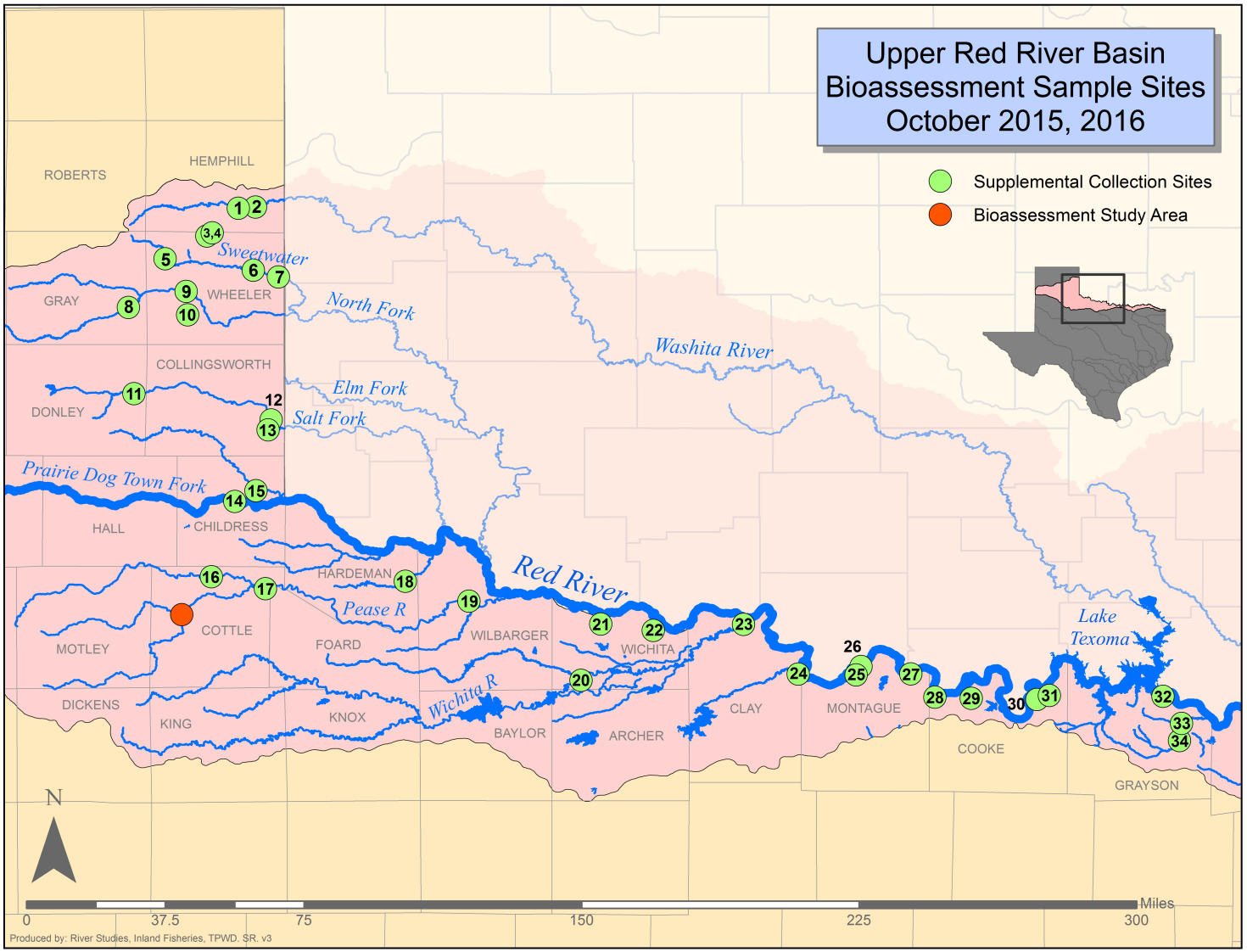

FIGURE 1.—Locations of upper Red River Basin data collection sites in Clay, Childress, Collingsworth, Cottle, Cooke, Donley, Gray, Grayson, Hardeman, Hemphill, Montague, Wheeler, Wichita, and Wilbarger counties, TX in October 2015 and October 2016. See Table 1 for specific site locations.

Matador Wildlife Management Area

Matador WMA was selected as the primary bioassessment study area, meaning it was a site of more intensive data collection than supplemental collection sites. This included collection of water quality, benthic macroinvertebrate, mussel, and fish assemblage data at multiple sites. In total, six study sites were sampled on the Middle Fork Pease River for fish assemblage data (Sites A–F; Figure 2; Table 2). A subset of these sites (Sites B, D, E) were also sampled for aquatic invertebrates and water quality. Bank searches for mussel shells were conducted at all sites within the WMA.

The Middle Fork Pease River at Matador WMA consisted of a series of disconnected pools during the time of this survey (Figure 3). This is typical of the system, which only flows at this location a couple of months each year. Depths ranged from 0.1 to 1.2 m (0.5 to 4 ft) with zero current velocity. Substrates were predominately silt with some gravel at all sites with the exception of Site B, which was a combination of sand and gravel. All sites contained mostly open water, with little instream cover present (0-25%). Site F was the only site that had moderate amounts of cover (50-75%) in the form of aquatic macrophytes and filamentous algae.

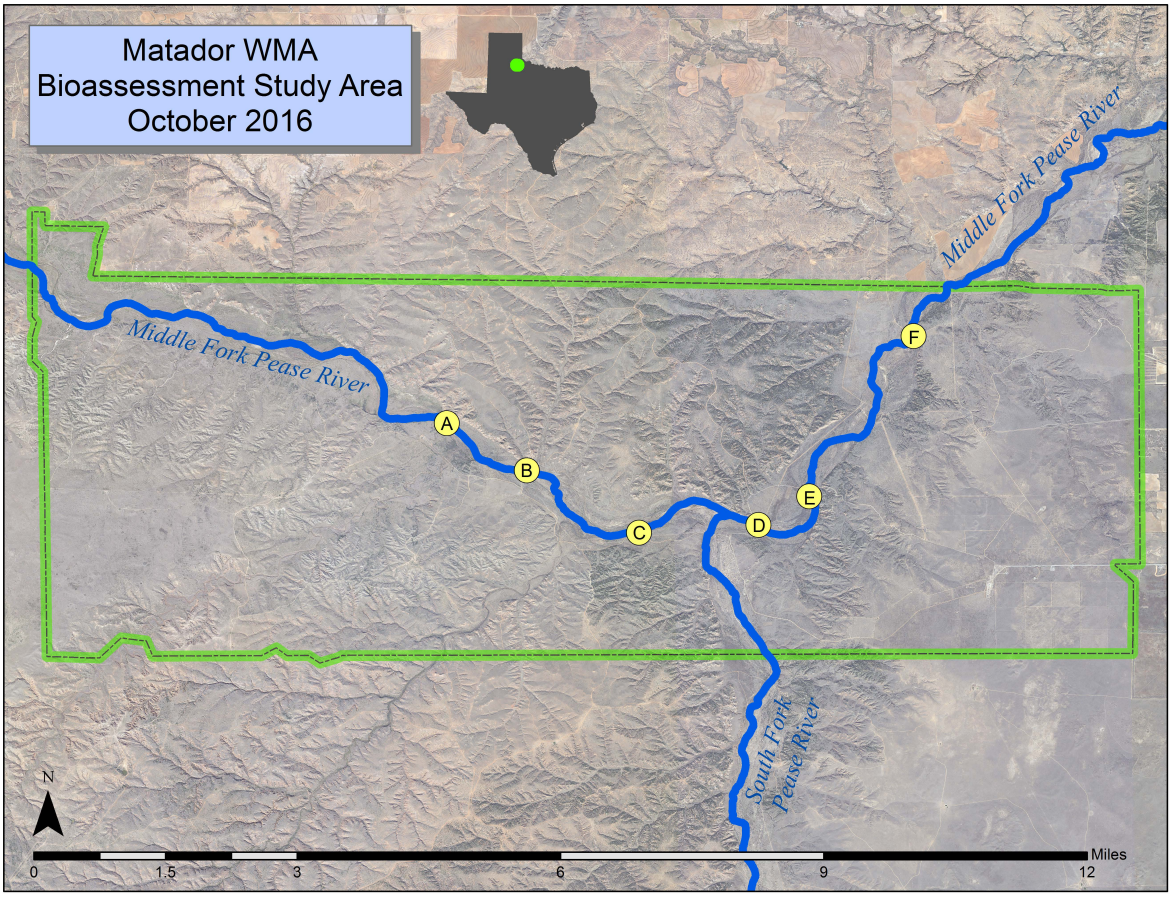

FIGURE 2.—Locations of study sites within the bioassessment study area at Matador Wildlife Management Area, Cottle County, TX. See Table 2 for specific site locations. The green dotted line represents the boundary for Matador Wildlife Management Area.

TABLE 2.—Bioassessment area study site locations and the type of data collected at each from Matador Wildlife Management Area October 20, 2016, in Cottle County, TX.

Site	Location on Middle Fork Pease River	Coordinates	Sampling Date	Seine	Gill net	Mussels	Macro-Invert.	Water Quality
A	Samson Pasture	34.1415, -100.4478	10/20/2016	x	x	x		
B	Lone Canyon Pasture	34.1337, -100.4346	10/20/2016	x		x	x	x
C	South Middle Pasture	34.1234, -100.4161	10/20/2016	x		x		
D	Mouth of River	34.1247, -100.3964	10/20/2016	x		x	x	x
E	Dogleg Pasture	34.1294, -100.3880	10/20/2016	x		x	x	x
F	Shorty Pasture	34.1558, -100.3708	10/20/2016	x		x		

FIGURE 3.—Photos showing representative habitats of sites sampled on the Middle Fork Pease River within Matador Wildlife Management Area in Cottle County, TX on October 20, 2016. Photos are labeled with the corresponding site letters found in Table 2 and Figure 2.

Supplemental Upper Red River Basin Collection Sites

Thirty-four supplemental collection sites were sampled throughout the upper Red River Basin 14 counties in Texas (Sites 1–34; Figure 1; Table 1). These included 34 sites on 27 tributary streams. These sites were sampled to fill gaps or update fish occurence data in the statewide Fishes of Texas Project database (Hendrickson and Cohen 2015). A subset of these sites was selected for mussel sampling (Sites 19, 23, 24). Limited quantitative habitat data was collected from supplemental sites; however, photos of each site are included to provide a reference of conditions at the time of sampling (Figure 4).

FIGURE 4.—Supplemental sites 1-34 sampled in 2015 and 2016 in Clay, Childress, Collingsworth, Cottle, Cooke, Donley, Gray, Grayson, Hardeman, Hemphill, Montague, Wheeler, Wichita, and Wilbarger counties, TX.

FIGURE 4.— Continued.

FIGURE 4.— Continued.

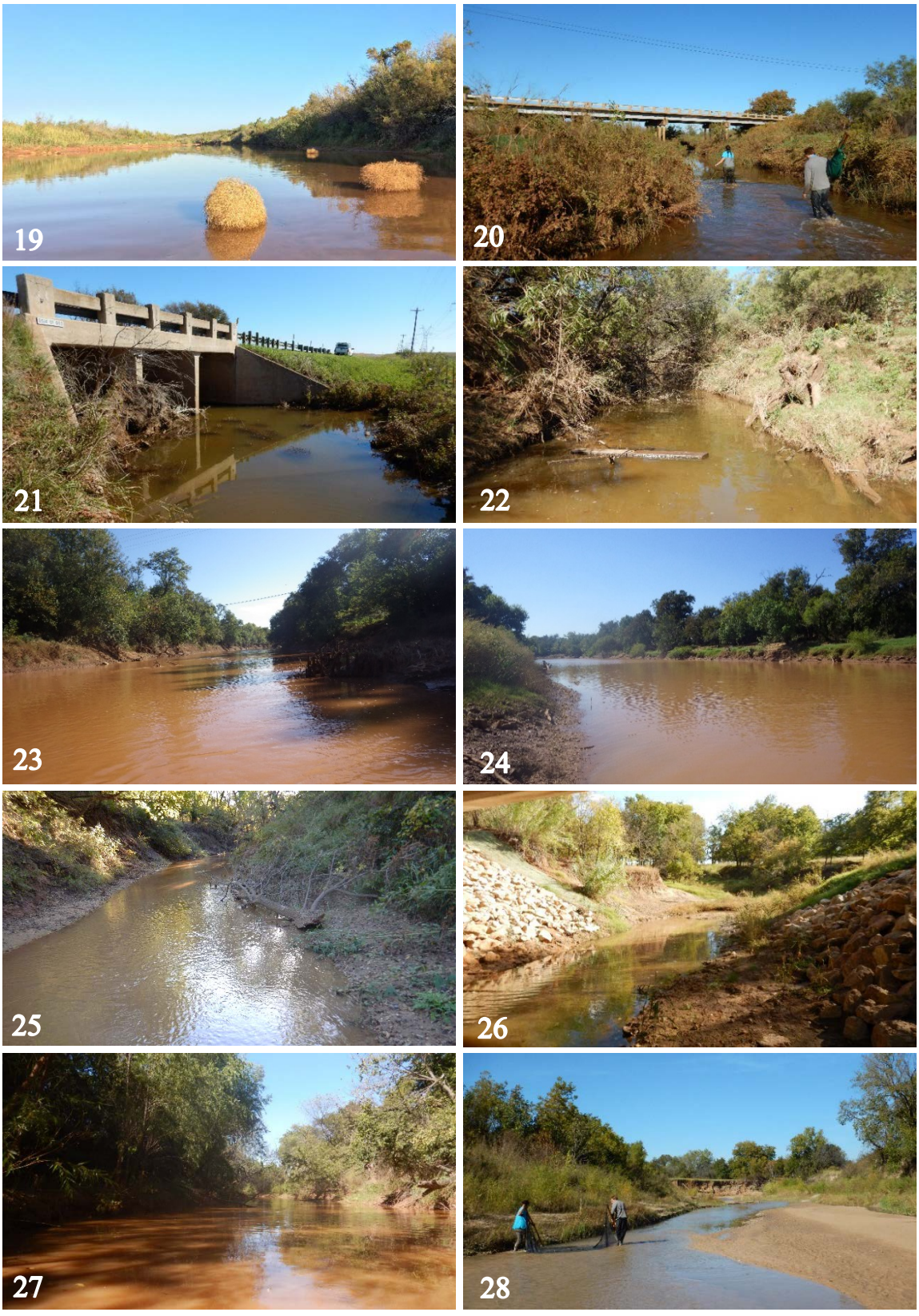

FIGURE 4.— Continued.

WATER QUALITY

Methods: Point measurements for water temperature, specific conductivity, dissolved oxygen, and pH were recorded using a YSI multi-parameter water quality sonde at a subsample of the Matador WMA sites on the Middle Fork Pease River (sites B, D, and E). Total dissolved solids (TDS) concentrations were calculated by multiplying specific conductivity by 0.64 (Atekwana et al. 2004). Data were verified using TCEQ quality assurance procedures (TCEQ 2014b). Point measurements were evaluated in context of the surface water quality standards (TCEQ 2014a). No stream gages occur on the Middle Fork Pease River to evaluate water quantity. No stream discharges were taken due to a lack of suitable stations with flowing water.

Results and Discussion: The Middle Fork Pease River (Segment 0221) has inadequate data for fully assessing designated water quality standards (TCEQ 2014a). Ten assessments are required to fully assess a water segment; however, TCEQ has only reported one assessment between December 1, 2005 and November 30, 2012 (TCEQ 2014a), meaning the standards for this segment have never been fully assessed. That single assessment found all parameters, except bacteria, within established standards.

Water temperature, pH, and dissolved oxygen measurements recorded during this study were within designated water quality standards (Table 3) for segment 0221. While no standard exists for specific conductivity, it can be used as a means of indirectly measuring TDS. Based upon specific conductivity, TDS exceeded the TCEQ standard (Table 3). Though considered perennial for water quality standard purposes (TCEQ 2014b), the river was not flowing at the time of this assessment and had been reduced to a series of isolated pools. The high TDS readings are likely related to the measurements being taken in these isolated pools. Bacteria was not evaluated during this study.

TABLE 3.—Water quality data collected from three sites on the Middle Fork Pease River (all within the boundaries of the Matador Wildlife Management Area) in Cottle County, TX on October 20, 2016. Texas Commission on Environmental Quality (TCEQ) water quality standards for Segment 0221 (Middle Fork Pease River) are reported for comparison (TCEQ 2014b).

Site	**Time** (Hrs)	**Temperature** (°C)	**Specific Conductivity** (µS/cm)	**Total Dissolved Solids** (mg/L)	**Dissolved Oxygen** (mg/L)	**pH**
B	1100	18.8	5594	3580	10.2	7.9
D	1315	20.3	6715	4298	10.5	7.8
E	1345	21.0	6559	4198	12.2	8.4
TCEQ Standard		≤ 32.8	N/A	≤ 2800	Grab min: ≥ 3	6.5 - 9.0

FISH ASSEMBLAGE

Matador Wildlife Management Area (Sites A–F)

Methods: Fish were collected from six sites (A–F) on the Middle Fork Pease River in Matador WMA on October 20, 2016 utilizing 15 ft seines (3/16 in delta weave mesh) to assess fish community composition. Monofilament, experimental mesh gill nets (36 m x 1.8 m) were deployed at Site A to target deep areas in the pool that were difficult to seine. Expanding upon TCEQ sampling protocols (TCEQ 2014b), a minimum sampling effort of 10 seine hauls was utilized at each site; however, additional sampling continued as needed until all habitat types had been effectively sampled and new species were no longer collected. Only four seine hauls were completed at Site C due to silt depths of 2–3 ft that made wading nearly impossible and seining in most of the site ineffective. High conductivities in the Middle Fork Pease River precluded backpack electrofishing.

Once captured, large fish and sport fishes were identified to species, measured, a subset were photographed, and released. Smaller specimens were fixed in a 10% solution of formalin for identification and enumeration in the laboratory. All fish were examined for external deformities, disease, lesions, tumors, and skeletal abnormalities. Vouchered specimens will be permanently housed at the University of Texas at Austin's Biodiversity Collections. Data will be available online through the Fishes of Texas Project database (www.fishesoftexas.org; Hendrickson and Cohen 2015).

Results and Discussion: A total of 2,405 individuals consisting of seven families and 12 species were collected across six sites in Matador WMA (Table 4; Figure 5). Fish abundance for Site C is included in Table 4; however, for discussion purposes, Site C will be excluded since it was not effectively sampled. All sites possessed moderate to high species richness ranging from six species at Site F to nine species at

sites A and B. Species richness was characteristic of other reference streams with high aquatic life use scores within the same ecoregion (Linam et al. 2002).

All species were collected at a minimum of two sites except for Spotted Gar *Lepisosteus oculatus* and Gizzard Shad *Dorosoma cepedianum* which were only collected using a gill net at Site A and Channel Catfish which was only collected at Site E. Western Mosquitofish *Gambusia affinis* was the most abundant species collected at all sites with an overall relative abundance of 44%. Common Carp *Cyprinus carpio* was the only non-native species and was collected at four sites.

TABLE 4.—Abundance of fish by species collected by all gear types by site from the Middle Fork Pease River in Matador WMA, Cottle County, TX on October 20, 2016. Historical fish species occurrences collected from Matador WMA by West Texas A&M University (WTAMU) from 2004 to 2016 using a variety of gear types are denoted with X (Dr. Richard Kazmaier, unpublished data).

Family	Scientific name	Common name	WTAMU	Site A	Site B	Site C	Site D	Site E	Site F
Lepisosteidae	*Lepisosteus oculatus*	Spotted Gar	X	2					
Clupeidae	*Dorosoma cepedianum*	Gizzard Shad	X	21					
Cyprinidae	*Cyprinella lutrensis*	Red Shiner	X	1	44		55	22	
	Cyprinus carpio	Common Carp	X	15	3		15		20
	Hybognathus placitus	Plains Minnow	X						
	Notropis stramineus	Sand Shiner	X						
	Pimephales vigilax	Bullhead Minnow	X						
Catostomidae	*Carpiodes carpio*	River Carpsucker	X						
Ictaluridae	*Ameiurus melas*	Black Bullhead	X		3		4		
	Ictalurus punctatus	Channel Catfish	X					1	
Fundulidae	*Fundulus zebrinus*	Plains Killifish	X		25			1	
Poeciliidae	*Gambusia affinis*	Western Mosquitofish	X	10	564	21	241	149	85
Cyprinodontidae	*Cyprinodon rubrofluviatilis*	Red River Pupfish	X						
Centrarchidae	*Lepomis cyanellus*	Green Sunfish	X	4	2		26	116	27
	Lepomis humilis	Orangespotted Sunfish	X						
	Lepomis macrochirus	Bluegill	X	10	130	5	80	273	67
	Lepomis megalotis	Longear Sunfish	X	17	114		56	45	59
	Lepomis microlophus	Redear Sunfish	X						
	Micropterus salmoides	Largemouth Bass	X	3	26		16	13	14
	Pomoxis nigromaculatus	Black Crappie	X						
	Number of species collected		**20**	**9**	**9**	**2**	**8**	**8**	**6**
	Number of individuals collected			**83**	**911**	**26**	**494**	**619**	**272**

Four centrarchid (sunfish and black bass) species consisting of Bluegill *Lepomis macrochirus*, Longear Sunfish *L. megalotis*, Green Sunfish *L. cyanellus*, and Largemouth Bass *Micropterus salmoides* were collected across all five sites (Table 4). The centrarchid family was the most prevalent comprising 46% of the total number of individuals across all sites. All four of these species were collected in a wide range of sizes suggesting that the centrarchid community in the Matador WMA is healthy.

West Texas A&M University researchers have documented 20 species in Matador WMA between 2004 and 2016 using multiple sampling gears including fyke nets, hoop nets, minnow traps, seines, and backpack electrofishers (Table 4; R. Kazmaier, WTAMU, unpublished data). All species collected during this study were previously documented in these WTAMU surveys. Fishes that were not collected during this study, but previously documented, include Plains Minnow, Sand Shiner *Notropis stramineus*, Bullhead Minnow *Pimephales vigilax*, River Carpsucker *Carpiodes carpio*, Red River Pupfish,

Orangespotted Sunfish *Lepomis humilis*, Redear Sunfish *Lepomis microlophus*, and Black Crappie *Pomoxis nigromaculatus*. Dr. Kazmaier has noted anecdotal declines in catch rates for some of these species over the years, particularly Red River Pupfish and River Carpsucker (personal communication). It is possible that these sites serve as sink populations and these species are only found in the system after prolonged connection events with downstream flowing portions of the river.

The 12 species (Figure 5) making up the composition collected from the Middle Fork Pease River during this study are consistent with what would be expected living within this region in disconnected pool habitats containing fairly dense emergent aquatic vegetation. Prairie stream fishes such as Plains Minnow, Plains Killifish *Fundulus zebrinus* and Red River Pupfish, which are typical of this area have been documented in Matador WMA, but are likely only transient given the intermittently flowing nature of this reach.

FIGURE 5. —All twelve fish species collected from Matador Wildlife Management Area on October 20, 2016, from most to least abundant (starting in the upper left-hand corner and moving left to right by row): Western Mosquitofish, Bluegill, Longear Sunfish, Green Sunfish, Red Shiner, Largemouth Bass, Common Carp, Plains Killifish, Gizzard Shad, Black Bullhead, Spotted Gar, and Channel Catfish.

Supplemental Upper Red River Basin Collection Sites (Sites 1–34)

Methods: Surveys at supplemental sites took place during October of 2015 and 2016. The 2015 survey (October 2–6, sites 1–17; Figure 1; Table 1) focused on the uppermost reaches of the Red River Basin within the Texas Panhandle and the 2016 survey (October 18–22, sites 18–34; Figure 1; Table 1) concentrated on tributaries along the Texas-Oklahoma border. Gear types were selected based on the perceived ability to sample effectively in available habitat types and included seines (10 ft with 1/8 in mesh and 15 ft with 3/16 in mesh), gill nets (36 m x 1.8 m monofilament, experimental mesh), trammel nets (multifilament mesh), backpack electrofisher, frame nets, and dip nets (Table 1). Seines were utilized at all but two sites (sites 3 and 4) and hauls were conducted until all mesohabitat types were effectively sampled and no additional species were collected. Average effort per site was 12 seine hauls. Sites 3 and 4 were on Gageby Creek and at the time of sampling habitats were shallow, narrow, and densely vegetated making seines ineffective. Dip nets and frame nets were utilized instead. When

utilized, gill nets were deployed immediately upon arriving at a site, and retrieved after completion of sampling with other gear types. Gill nets were typically set one to two hours per site.

All or a subset of all individuals were preserved in a buffered 10% formalin solution and taken to the laboratory for identification and enumeration and permanent deposition into the University of Texas at Austin's Biodiversity Collections. Tissues were also taken from select voucher specimens and were deposited in the university's Genetic Resources Collections. All specimens have been fully processed and catalogued into the TNHC database and will be made available for future research through the public Fishes of Texas Project database (Hendrickson and Cohen 2015). Currently, records can be viewed on other online biodiversity data providers, such as GBIF (Hendrickson et al. 2019).

Results: Across the 34 supplemental collection sites, a total of 43 species were collected consisting of 9,725 individuals (tables 5 and 6). Site 32 (Shawnee Creek) was the most species rich with 17 species, including the only record of Orangebelly Darter for the study. Orangebelly Darter is an SGCN with very few historical voucher records for the state (TPWD 2012; Hendrickson and Cohen 2015). Sites with low richness (≤ three species) were characterized by stagnant pools, low flows, or short reaches suitable for sampling.

The most widespread species found during these surveys were Western Mosquitofish (32 sites) and Red Shiner *Cyprinella lutrensis* (23 sites). They were both also the most abundant, with Red Shiner making up over one-third of all individuals collected and Western Mosquitofish one-fourth. Only three other species were found at half or more of the 34 supplemental sites: Green Sunfish (19 sites), Bluegill (17 sites), and Longear Sunfish (17 sites). High abundance of Red Shiner and the high frequency of these common species, with the exception of Bluegill, in the upper Red River Basin are congruent with findings from a previous examination of historical fish records by Wilde et al. (1996). Noted differences in the list of most widespread species from the 1996 report were several native cyprinids, all still present but occurring less frequently. In total 15 cyprinid species were collected. All are native to the basin with the exception of Common Carp, a non-native species to the United States, and Bullhead Minnow which is thought to have been previously introduced in the upper Red River Basin (Hubbs et al. 2008).

One new species, Bigeye Shiner *Notropis boops* (Figure 6), was collected at Site 31 (Rock Creek). The range of Bigeye Shiner includes the Mississippi River Basin from Ohio down to southern Oklahoma; however, there were previously no documented historical occurrences in Texas (Page and Burr 2011; Hendrickson and Cohen 2015). Another notable find within the family Cyprinidae was a single specimen from site 28 (Mountain Creek) identified as Silverband Shiner *Notropis shumardi* (TNHC 62869), a species previously noted as extirpated from the upper Red River (Wilde et al. 1996) and listed as SGCN in Texas.

FIGURE 6. —Bigeye Shiner collected from Site 31 at Rock Creek. This represents the first occurrence record for this species in Texas.

TABLE 5. —Fish species and counts for supplemental collection sites 1—17, Red River Basin, TX: 1. Hemphill County, Washita River at Ramp Ranch (10/06/2015), 2. Hemphill County, Washita River at SH277 (10/03/2015), 3. Wheeler County, Gageby Creek at CR B (10/03/2015), 4. Wheeler/Hemphill County, Gageby Creek at CR EE (10/03/2015), 5. Wheeler County, Sweetwater Creek at SH152 (10/03/2015), 6. Wheeler County, Sweetwater Creek at RR592 (10/03/2015), 7. Wheeler County, Sweetwater Creek at CR29 (10/03/2015), 8. Gray County, McClennan Creek at SH273 (10/03/2015), 9. Wheeler County, N Fork Red River at FM2473 (10/03/2015), 10. Wheeler County, Sand Creek at CR9 (10/03/2015) 11. Donley County, Salt Fork Red River at SH273 (10/03/2015), 12. Collingsworth County, Salt Fork Red River at SH203 (10/02/2015), 13. Collingsworth County, Sand Creek at CR270 (10/02/2015), 14. Childress County, Prairie Dog Town Fork Red River at US83 (10/02/2015), 15. Childress County, Buck Creek at CR19 (10/02/2015), 16. Cottle County, North Pease River at US83 (10/02/2015), 17. Cottle County, North Pease River at CR104 (10/06/2015).

			Site																
Family	**Scientific Name**	**Common Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Lepisosteidae	*Lepisosteus oculatus*	Spotted Gar																	
	Lepisosteus osseus	Longnose Gar																	
	Lepisosteus platostomus	Shortnose Gar																	
Clupeidae	*Dorosoma cepedianum*	Gizzard Shad																	
Cyprinidae	*Campostoma anomalum*	Central Stoneroller																	
	Cyprinella lutrensis	Red Shiner						47	36		121		27	76	461		244	12	
	Cyprinella lutrensis × *C. venusta*	Red Shiner × Blacktail Shiner																	
	Cyprinella venusta	Blacktail Shiner																	
	Cyprinus carpio	Common Carp	1														2		
	Hybognathus placitus	Plains Minnow														1	1	6	39
	Macrhybopsis australis	Prairie Chub																	
	Notropis atherinoides	Emerald Shiner																	
	Notropis bairdi	Red River Shiner														2	3	138	36
	Notropis boops	Bigeye Shiner																	
	Notropis buchanani	Ghost Shiner																	
	Notropis shumardi	Silverband Shiner																	
	Notropis stramineus	Sand Shiner						36	6		25		6	6					
	Phenacobius mirabilis	Suckermouth Minnow							11					1	7				
	Pimephales promelas	Fathead Minnow													40		53	1	
	Pimephales vigilax	Bullhead Minnow													10				
Catostomidae	*Carpiodes carpio*	River Carpsucker																	
	Ictiobus bubalus	Smallmouth Buffalo																	
Ictaluridae	*Ameiurus melas*	Black Bullhead																	
	Ameiurus natalis	Yellow Bullhead		1		1		3	5		1						2		
	Ictalurus punctatus	Channel Catfish							1										
	Pylodictis olivaris	Flathead Catfish																	
Fundulidae	*Fundulus grandis*	Gulf Killifish																	
	Fundulus olivaceus	Blackspotted Topminnow																	
	Fundulus zebrinus	Plains Killifish						8	3		12		160	6		9	14	40	77
Poeciliidae	*Gambusia affinis*	Western Mosquitofish	25	256	38	15	1	78	11	2	2	293	232	5	567		39	18	2

TABLE 5. —Continued

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Cyprinodontidae	*Cyprinodon rubrofluviatilis*	Red River Pupfish									1		23	12		22	1	60	27
Centrarchidae	*Lepomis cyanellus*	Green Sunfish	2			2	2	2			3				39		13		
	Lepomis cyanellus × *L. humilis*	Green Sunfish × Orangespotted Sunfish																	
	Lepomis gulosus	Warmouth					1												
	Lepomis humilis	Orangespotted Sunfish													5				
	Lepomis macrochirus	Bluegill	9				12		1						13				
	Lepomis megalotis	Longear Sunfish					3		1	2					16				
	Lepomis microlophus	Redear Sunfish					1												
	Lepomis sp. (juvenile)	unidentified juvenile sunfish	24				6												
	Lepomis sp. (hybrid)	unidentified suspected hybrid sunfish																	
	Micropterus salmoides	Largemouth Bass	4				3		1	4					1				
	Pomoxis annularis	White Crappie																	
Percidae	*Etheostoma pulchellum*																		
	Etheostoma radiosum	Orangebelly Darter																	
	Percina caprodes	Logperch																	
	Percina sciera	Dusky Darter																	
Sciaenidae	*Aplodinotus grunniens*	Freshwater Drum																	
	Number of individuals collected		**65**	**257**	**38**	**18**	**29**	**174**	**76**	**8**	**165**	**293**	**448**	**106**	**1159**	**34**	**372**	**275**	**181**
	Number of species collected		**6**	**2**	**1**	**3**	**8**	**6**	**10**	**3**	**7**	**1**	**5**	**6**	**10**	**4**	**10**	**7**	**5**

TABLE 6. —Fish species and counts for supplemental collection sites 18—34, Red River Basin, TX: 18. Hardeman County, Wanderers Creek at US287 (10/19/2016), 19. Wilbarger County, Pease River at US283 (10/19/2016), 20. Wichita County, Wichita River at SH25 (10/21/2016), 21. Wichita County, Tenth Cavalry Creek at SH240 (10/21/2016), 22. Wichita County, Gilbert Creek at I-44 (10/21/2016), 23. Clay County, Wichita River at West FM171 (10/18/2016), 24. Clay County, Little Wichita River at FM2332 (10/18/2016), 25. Montague County, Pecan Creek at FM2849 (10/20/2016), 26. Montague County, Panther Creek at Hancock Rd. (10/20/2016), 27. Montague County, Broadtree Creek at FM2953 (10/20/2016) 28. Cooke County, Mountain Creek at FM373 (10/21/2016), 29. Cooke County, N Fish Creek at CR411 (10/21/2016), 30. Cooke County, Hickory Creek at CR127 (10/21/2016), 31. Cooke County, Rock Creek at CR106 (10/21/2016), 32. Grayson County, Shawnee Creek at SH91 (10/22/2016), 33. Grayson County, Iron Ore Creek at US69 (10/22/2016), 34. Grayson County, Choctaw Creek at SH56 (10/22/2016)

			Site															
Family	**Scientific Name**	**Common Name**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**
Lepisosteidae	*Lepisosteus oculatus*	Spotted Gar					3										1		
	Lepisosteus osseus	Longnose Gar						1									1		
	Lepisosteus platostomus	Shortnose Gar						1											
Clupeidae	*Dorosoma cepedianum*	Gizzard Shad	3		5		9					5			1				
Cyprinidae	*Campostoma anomalum*	Central Stoneroller												99		23	2	24	1
	Cyprinella lutrensis	Red Shiner	506	207	693	7		155	15	412	56	1	32		81	9	11	366	87
	Cyprinella lutrensis × *C. venusta*	Red Shiner × Blacktail Shiner																	14
	Cyprinella venusta	Blacktail Shiner								5					4	41		17	58
	Cyprinus carpio	Common Carp					2			1									
	Hybognathus placitus	Plains Minnow		26				2					56						
	Macrhybopsis australis	Prairie Chub		89				19											
	Notropis atherinoides	Emerald Shiner						3					12					29	
	Notropis bairdi	Red River Shiner		276									15						
	Notropis boops	Bigeye Shiner														8			
	Notropis buchanani	Ghost Shiner						16	225	2									
	Notropis shumardi	Silverband Shiner											1						
	Notropis stramineus	Sand Shiner									4						47	25	
	Phenacobius mirabilis	Suckermouth Minnow			5					2							2	5	
	Pimephales promelas	Fathead Minnow	15		5		8												
	Pimephales vigilax	Bullhead Minnow	9		57		6	124	5	31						6	33	155	30
Catostomidae	*Carpiodes carpio*	River Carpsucker					1					2							
	Ictiobus bubalus	Smallmouth Buffalo										2							
Ictaluridae	*Ameiurus melas*	Black Bullhead	6			3	2			1									
	Ameiurus natalis	Yellow Bullhead										1		8					
	Ictalurus punctatus	Channel Catfish					2	10				2					1	6	1
	Pylodictis olivaris	Flathead Catfish						1											
Fundulidae	*Fundulus grandis*	Gulf Killifish			9														
	Fundulus olivaceus	Blackspotted Topminnow												10	26		21	16	
	Fundulus zebrinus	Plains Killifish		56									93	120					
Poeciliidae	*Gambusia affinis*	Western Mosquitofish	44	62	173	55	13	21	10	281	33	13	5		46	9	34	41	26

TABLE 6. —Continued

			18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Cyprinodontidae	*Cyprinodon rubrofluviatilis*	Red River Pupfish		6									1						
Centrarchidae	*Lepomis cyanellus*	Green Sunfish	1		6	2	1			11	1	2	4	18	8	11	1		
	Lepomis cyanellus × *L. humilis*	Green Sunfish× Orangespotted Sunfish	1																
	Lepomis gulosus	Warmouth										5							
	Lepomis humilis	Orangespotted Sunfish	14		1	1	2		4	1		3					20		
	Lepomis macrochirus	Bluegill	9		1		4	1	4	6	5	20	1		9	5	9	1	
	Lepomis megalotis	Longear Sunfish	13			1	1	2	6	28	10	8		5	11		13	1	3
	Lepomis microlophus	Redear Sunfish													3				
	Lepomis sp. (juvenile)	unidentified juvenile sunfish					17					13					13		
	Lepomis sp. (hybrid)	unidentified hybrid sunfish														2			
	Micropterus salmoides	Largemouth Bass	1						2	2	1	1			3		1		
	Pomoxis annularis	White Crappie	1				4		5			9							
Percidae	*Etheostoma pulchellum*													39		15			
	Etheostoma radiosum	Orangebelly Darter															5		
	Percina caprodes	Logperch								2									
	Percina sciera	Dusky Darter																1	4
Sciaenidae	*Aplodinotus grunniens*	Freshwater Drum						1	2										
	Number of individuals collected		**623**	**722**	**955**	**69**	**75**	**357**	**278**	**785**	**110**	**87**	**220**	**299**	**192**	**129**	**215**	**687**	**224**
	Number of species collected		**13**	**7**	**10**	**6**	**15**	**14**	**10**	**14**	**7**	**15**	**10**	**7**	**10**	**10**	**17**	**13**	**9**

Another notable find is Blackspotted Topminnow *Fundulus olivaceus* which was found at four sites near Lake Texoma in Cooke and Grayson counties. Blackspotted Topminnow are commonly confused with Blackstripe Topminnow *Fundulus notatus* since there is a lack of strong distinguishing characters. Due to their similarity, all specimens from this study originally identified as Blackspotted Topminnow were re-examined and confirmed by multiple staff.

Summary of Fish Data Collection

A total of 12,130 individuals consisting of 43 fishes were collected during this assessment. Historically, Hendrickson and Cohen (2015) report 66 species from the upper Red River Basin, from the headwaters downstream to Grayson County. Overall, three species were added to this checklist: Bigeye Shiner, Shortnose Gar, and Blackspotted Topminnow. Additionally, this study has provided TPWD and the Biodiversity Collections with updated records and vouchers for 40 sites, all of which will be made available to the public through the Fishes of Texas Project website (www.fishesoftexas.org/).

MUSSEL ASSEMBLAGE

Methods: Mussels were surveyed by two methods depending on site condition and accessibility. A select number of sites (sites 19, 23, and 24) were surveyed for a minimum of one person-hours using tactile searches in all available mesohabitat types (Strayer and Smith 2003). If live or dead mussels were detected, photograph vouchers were taken and a subsample of shells were sent to Texas A&M–Institute of Renewable and Natural Resources for species identification verification. Additionally, visual shoreline assessments were conducted at all sites within Matador WMA (Sites A-F).

Results and Discussion: No live mussels were found at any sites. Long-dead shell material from Pink Papershell *Potamilus ohiensis*, Yellow Sandshell *Lampsilis teres*, Bleufer *Potamilus purpuratus*, and Southern Mapleleaf *Quadrula apiculata* was observed at Site 23 on the Wichita River (Figure 7). No shell material was found at sites sampled Matador WMA on the Middle Fork Pease River or sites 19 and 24 on the Pease and Little Wichita rivers, respectively.

FIGURE 7. —Freshwater mussel shells found in the Wichita River at W FM 171 (Site 23) on October 18, 2016, Clay County, TX from left to right: Pink Papershell, Southern Mapleleaf, Bluefer, and Yellow Sandshell. No live mussels were found at this site or during this study.

Red River Basin mussel surveys by TPWD in the 1990s yielded few live mussels. Those surveys documented Giant Floater *Pyganodon grandis*, Paper Pondshell *Utterbackia imbecillis*, Fragile Papershell *Leptodea fragilis*, Pondhorn *Uniomerus tetralasmus*, Southern Mapleleaf, Pink Papershell, and Yellow Sandshell within the Wichita River watershed and no live mussels or shell material within the Pease River watershed (Howells 1996, 1998). Although it is difficult to assess the current status of freshwater mussels within the upper Red River Basin given this limited sampling effort, previous studies have

documented declines in freshwater mussels within the Red River Basin, which has been attributed to habitat degradation affecting both mussels and host fish (Vaughn 2000).

Within the entire Red River Basin in Texas, 26 species of mussels are known to historically occur (TPWD 2008); however, the lower portion of the basin (downstream of Lake Texoma) is known for higher mussel species richness than the upper Red River Basin. A contributing factor to low number of mussel species in the upper basin may be the naturally occurring high levels of salinity (Red River Authority 1996), which has been shown to harm glochidia of some freshwater mussels (Gillis 2011).

BENTHIC MACROINVERTEBRATE ASSEMBLAGE

Methods: Aquatic macroinvertebrates were collected from the Middle Fork Pease River at three sites within Matador WMA (sites B, D, and E) using a D-frame kicknet. All collections were preserved in 100% ethanol and returned to the laboratory for identification and enumeration. Due to the fragmented condition of the Middle Fork Pease River during sampling, calculation of a benthic index of biotic integrity (BIBI) was deemed inappropriate; however, some of the indices used in developing BIBI were summarized as a means to describe the assemblage.

Results and Discussion: The benthic macroinvertebrates collected from the Middle Fork Pease River were represented by seven orders, 17 families, and 24 genera, with a total of 784 individuals (Table 7). Site D had the highest taxa richness (16 genera) and Site E had the lowest (nine genera). Of the 24 taxa collected, 19 belonged to the predator functional feeding guild; however, the collector gatherer/scraper guilds were represented by the most individuals. Across all combined sites the ratio of EPT individuals (orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)) to total individuals collected was fairly high (57%). A high EPT ratio is typically a sign of good water quality, seeing as these taxa are typically intolerant to water quality impairments such as pollution. However, EPT taxa collected during this study were unbalanced as no Plecoptera nor Trichoptera were collected. Additionally, the most abundant EPT taxa collected was *Caenis* (mayfly), which is typically found in stagnant waters and has covered gills which allow them to survive in water with high sediment loads (Waters 1995).

Water quality and habitat are affected by natural and anthropogenic induced fragmentation in streams. This fragmentation can have dramatic effects on aquatic biota by disrupting nutrient cycling, sediment transport, and inhibiting fish and invertebrate movement (Dynesius and Nilsson 1994; Fuller et al. 2015). Two TCEQ monitoring sites within the Pease River watershed (Pease River at US 283 and Pease River at US 287; TCEQ 2018) were periodically sampled for benthic macroinvertebrates between 1978 and 1993 in portions of the river that are consistently flowing and connected. In comparison to the fragmented stream reach sampled during this study, the TCEQ data set documented 13 unique taxa, including two which are typically characterized as flow-sensitive (*Baetis* and *Hydropsyche*; Extence et al. 1999; TCEQ 2018).

No flow sensitive taxa were collected during the current study; however, the current study produced 17 unique taxa that were not collected in the TCEQ dataset. Most of the unique taxa (*Hydrochus, Hydrocanthus, Notomicrus, Chaoborus, Trichocorixa, Trepobates, Enallagma, Erythemis, Perithemis, Tramea,* and *Didymops*) in the current study fall in the slow to standing water categories (Extence et al.1999), except for the gomphids (*Dromogomphus* and *Stylurus*) and the baetids (*Paracloeodes*) that are typically found in flowing waters. Despite fragmented habitat conditions, the bioassessment study sites at Matador WMA produced an overall higher species richness than sites sampled within flowing reaches of the Pease River; however, it should be noted that collection methods varied (Surber samplers were used in the TCEQ dataset) and invertebrate assemblages can be highly variable depending on season.

TABLE 7.—Benthic macroinvertebrates with their associated abundances, trophic guilds (CG= collector gatherer, FC= filtering collector, P= predator, SCR= scraper, SHR= shredder) and life stages (A= adult, L= larval) collected from sites B, D, and E on the Middle Fork Pease River at Matador Wildlife Management Area on October 20, 2016.

Order	Family	Genus	Life stage	Trophic	Site B	Site D	Site E
Amphipoda	Hyalellidae	*Hyalella*		CG/SHR	1	1	
Coleoptera	Hydrochidae	*Hydrochus*	A	SHR		2	
		Hydrophilus	A	SHR			1
	Hydrophilidae	*Berosus*	A	CG	2		
			L	P	11	30	
	Noteridae	*Hydrocanthus*	A	P		1	
		Notomicrus	A	P	18	6	
Diptera	Chaoboridae	*Chaoborus*		P	5		
	Chironomidae			P/CG/FC	26	112	1
	Tabanidae			P	1	8	
Ephemeroptera	Baetidae	*Paracloeodes*		SCR/CG	2	2	
	Caenidae	*Caenis*		CG/SCR	291	157	
Hemiptera	Belostomatidae	*Belostoma*		P			2
	Corixidae	*Trichocorixa*		P/CG			
	Gerridae	*Rheumatobates*		P		5	
		Trepobates		P		1	1
Lepidoptera	Crambidae	*Oxyelophila*		SHR		1	
Odonata	Coenagrionidae	*Argia*		P	8	11	
		Enallagma		P	32	8	1
	Gomphidae	*Dromogomphus*		P	4		
		Stylurus		P	11		1
	Libellulidae	*Erythemis*		P	2		3
		Perithemis		P		1	7
		Tramea		P			5
	Macromiidae	*Didymops*		P	1		
		Number of individuals collected			**416**	**346**	**22**
		Number of taxa collected			**14**	**14**	**9**

CRAYFISH

Methods: Crayfish were not specifically targeted during this assessment; however, all crayfish collected were photographed and released. Photo vouchers and locality information were placed on the website iNaturalist (http://www.inaturalist.org/) for species identification and verification.

Results and Discussion: Three species of crayfish were collected from nine sites during this study (Figure 8; Table 8). Water Nymph Crayfish *Orconectes nais* was the most common species collected and was found at 5 sites. All three crayfish have a NatureServe conservation status of G5, meaning the species are secure due to a large geographic range and common occurrence throughout that range (NatureServe 2017).

TABLE 8.—Species of crayfish encountered during fish sampling in October 2015 and 2016 as part of the upper Red River Basin bioassessment and the waterbodies and sites each species were found at. See Table 1 for site information.

Scientific Name	Common Name	Waterbody	Site
Orconectes nais	Water Nymph Crayfish	Sweetwater Creek	6
		McClellan Creek	8
		Pecan Creek	25
		Broadtree Creek	27
		Rock Creek	31
Orconectes virilis	Virile Crayfish	Shawnee Creek	32
Procambarus simulans	Southern Plains Crayfish	Sweetwater Creek	7
		Salt Fork Red River	12
		Gilbert Creek	22
Number of species encountered		**3 species**	

FIGURE 8.—Photos documenting each species collected during the upper Red River bioassessment in October 2015 and 2016, from left to right: Water Nymph Crayfish, Virile Crayfish, and Southern Plains Crayfish.

IMPERILED SPECIES

Five species of fishes classified as SGCN were collected across 16 sites during this study: Prairie Chub (NatureServe Global Conservation Status: G3-vulnerable; NatureServe 2017), Red River Shiner (G4-apparently secure), Silverband Shiner (G5-secure), Red River Pupfish (G5), and Orangebelly Darter (G5; tables 5 and 6; Figure 9). Additionally, two species currently proposed for inclusion in the Texas Conservation Action Plan as SGCN (Cohen et al. 2018) were collected: Plains Minnow (G4) and Suckermouth Minnow (G5). Of these species, Silverband Shiner, Orangebelly Darter, and Prairie Chub had very limited distributions (tables 5 and 6). The remaining species were moderately widespread throughout the study area, occurring at six to nine sites.

All but one of these species, Red River Pupfish, are classified as or hypothesized to be fluvial specialists, meaning some portion of their life history is dependent on the presence of a natural flow regime. Prairie Chub, Red River Shiner, Silverband Shiner, and Plains Minnow are all hypothesized to belong to the pelagic-broadcast-spawning reproductive guild (Taylor and Miller 1990; Winston et al. 1991; Perkin and Gido 2011). Members of this guild broadcast semi-buoyant ova. Flowing water along long, unfragmented reaches of river is required for eggs and larva to drift and stay suspended, preventing settlement and suffocation in sediments (Perkin and Gido 2011). These species primarily occur and reproduce in large prairie rivers with broad, sandy, shallow channels and may move into smaller tributaries depending on environmental conditions and connectivity. These species have had reported declines (Wilde et al. 1996) and even extirpations within the Red River Basin attributed to stream fragmentation and flow regime alteration (Winston et al. 1991; Taylor 2010).

FIGURE 9. —Species of greatest conservation need (SGCN) collected during the supplemental sampling for the upper Red River Basin bioassessment from left to right on the top row are: Red River Pupfish, Red River Shiner, Orangebelly Darter, and Prairie Chub (Silverband Shiner not pictured). The bottom row shows species that have been suggested for inclusion in the Texas Conservation Action Plan as SGCN from left to righ: Plains Minnow and Suckermouth Minnow.

During this study, Plains Minnow, and Red River Shiner were collected at the same six sites (Pease River, North Fork Pease River, Mountain Creek, Red River, and Buck Creek), with Plains Minnow occurring at one additional site on the Wichita River. This is consistent with historical fish occurrence data and suggests these reaches provide adequate continuous habitat and instream flows to support life history requirements or they provide access to reaches of the mainstem Red River which supports recruitment. While the Red River likely provides adequate undammed stream distances (Perkin and Gido 2011), successful reproduction can still be hindered by reduced instream flows that fragment connectivity and the lack of sufficient flow pulses to trigger spawning and transport eggs downstream.

Prairie Chub was collected from two sites during this study (Pease River and Wichita River). Historical collections contain numerous records of this species from the Salt Fork and North Fork of the Red River in Oklahoma, but not Texas. This is possibly due to increased fragmentation or declining instream flows in upper stream reaches in Texas.

Silverband Shiner was noted as extirpated from the upper Red River (Wilde et al. 1996). One Silverband Shiner was collected during this study (Site 28, Mountain Creek). This species is thought to be more

common in large rivers (Robison and Buchanan 1988). This is supported by historical fish collection records from the Red River Basin where they are almost entirely found in the mainstem (Hendrickson and Cohen 2015).

Orangebelly Darter utilizes gravel substrates in areas of moderate current velocity for spawning (Scalet 1973). During this study it was only collected at one locality (Shawnee Creek) downstream of Lake Texoma. The range for this species occurs primarily downstream of Lake Texoma (NatureServe 2017), which was not the focus for this study. The Suckermouth Minnow utilizes similar habitats for spawning and was collected from seven sites, but was not locally abundant at any location. It was recommended for inclusion as a SGCN due to habitat fragmentation and flow regime alteration (Cohen et al. 2018).

Red River Pupfish, while not a fluvial specialist, is facing the threats of hybridization with introduced non-native Sheepshead Minnow *Cyprinodon variegatus* (Becher and Gumm 2017). Dispersal of Sheepshead Minnow, native to the Texas Coast, and hybridization between these species has been documented in the nearby Brazos River Basin (Wilde 2015). While collected from nine sites during this study, the genetic purity of these specimens was not evaluated.

Native Fish Conservation Areas are watersheds which have been prioritized to preserve fish diversity in Texas. Fishes classified as SGCN were found throughout the Upper Red River NFCA in Texas and portions of the Lower Red-Sabine NFCA (Birdsong et al. 2019) that were sampled (Figure 10).

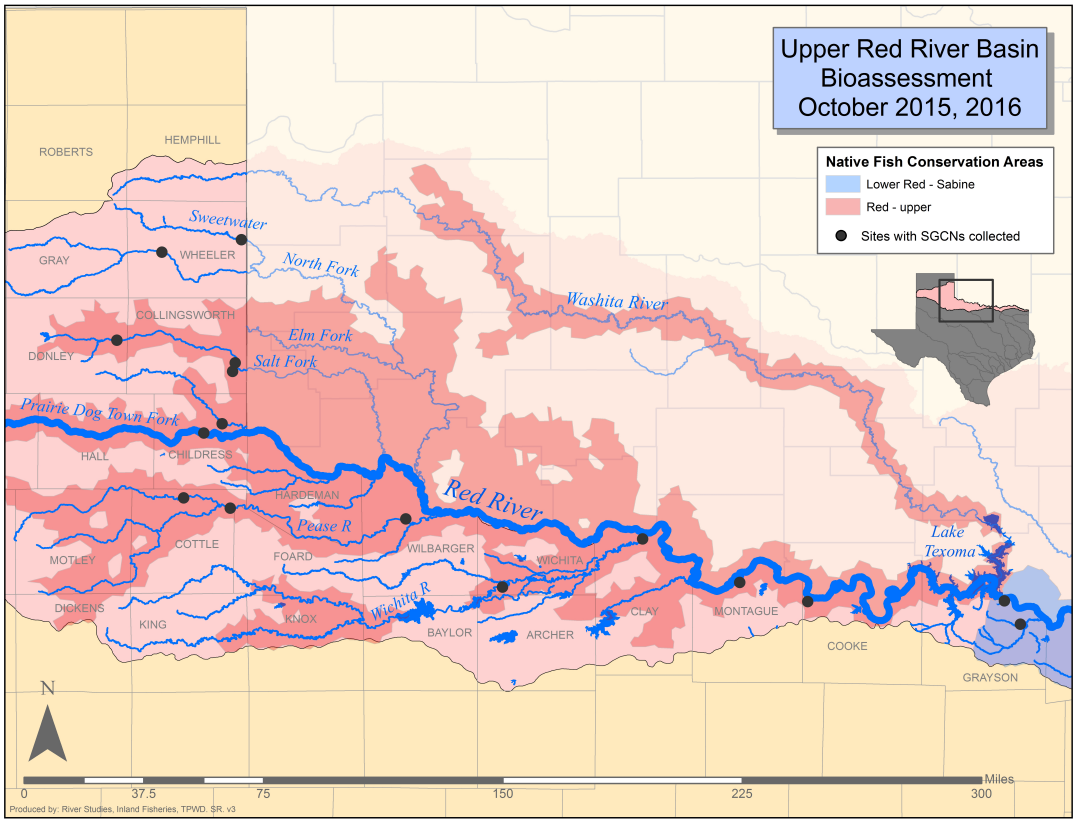

FIGURE 10. —Locations where current or proposed species of greatest conservation need (SGCN; Cohen et al. 2018) were collected during the upper Red River Basin bioassessment in October 2015, 2016. Bounds of the Upper Red River and Lower Red, Sabine River Native Fish Conservation Areas are highlighted (Birdsong et al. 2019).

Current or proposed SGCN fishes were collected from two tributaries outside current NFCA bounds: Sweetwater Creek (site 7) and North Fork Red River (Site 9). Eleven Suckermouth Minnows were collected from Sweetwater Creek and one Red River Pupfish from the North Fork Red River. The Upper Red River NFCA should be evaluated using these data and criteria laid out in Birdsong et al. (2019) to determine if the NFCA should be expanded to include these tributaries.

RECREATIONAL ACCESS

Public recreational access to rivers and streams in the upper Red River Basin is largely limited to road crossings; however, of the available public road crossings many do not provide suitable public access due to stream dewatering and fencing of the right-of-way at bridges. There is typically little bank fishing, canoeing, and kayaking in the upper watershed due to limited access and low flows (Robert Mauk, TPWD, personal communication). Several county and city parks offer access to the Wichita River and Salt Fork of the Red River (Table 9), but none are suitable for motorized boat launches. Few sunfish and no bass were collected from these rivers during our surveys suggesting limited fishing potential; however, Channel Catfish were collected from the most downstream site on the Wichita River near the confluence with the Red River.

TABLE 9.—List of upper Red River Basin public river access locations.

Site Name	Location	Access Fee	Use	Controlling Authority	Comments
Wichita River					
Lucy Park	33.918211, -98.576939	free		City of Wichita Falls	unimproved dirt ramp
Burnett Park	33.897973, -98.706970	free		Wichita County	no ramp, kayak launchable from bank
Salt Fork Red River					
Pioneer's Park	34.9571, -100.2231	free		Collingsworth County	no ramp, kayak launchable from bank
Middle Fork Pease River					
Matador Wildlife Management Area	34.1234, -100.4161	$12/year*		Collingsworth County	

Camping Bank fishing access Kayak/Canoe launch

*Purchase of an annual Limited Public Use permit is required prior to visiting.

SPORT FISHING OPPORTUNITIES

Methods: For all sites within Matador WMA (Sites A–F) game fish and adult sunfish were measured for total length and released. Additionally, up to 50 juvenile sunfish retained for identification in the laboratory were measured for total length and pooled with released fish lengths. Length frequency histograms were created for Largemouth Bass and all measured sunfish to assess length distributions for species that provide angling opportunity within Matador WMA. Length class designations for stock,

quality, preferred, and, memorable categories (Anderson and Neumann 1996) are displayed on each histogram. These length class distributions were created based on percentage classes of world record lengths for each respective species. Stock lengths relate to the minimum size at which anglers will likely first catch the species, length the species reaches sexual maturity, and length that the species is effectively sampled using traditional sampling gear (Anderson and Neumann 1996; Flickinger et al. 1999). Individuals of quality length and larger are considered a desirable size that anglers like to catch.

Results and Discussion: Two species of game fish were collected from the Middle Fork Pease River at Matador WMA: Channel Catfish and Largemouth Bass (Figure 11). Largemouth Bass (n = 72) were collected at all five sites with the highest abundances at sites B and D (Table 4). Total lengths for Largemouth Bass ranged from 63 to 450 mm (2.5 to 18 in) with almost 80% of catch measuring less than 200 mm in length (Figure 12). Stock size or larger fish comprised 21% (n = 15) of the catch, quality size or larger comprised 7.0% (n = 5), and preferred size or larger comprised 2.8% (n = 2). Four Largemouth Bass of harvestable size (> 356 mm) ranging from 357 to 450 mm (14 to 18 in) were collected from sites B, D, E and F.

FIGURE 11. – Two species of game fish that offer angling potential within Matador Wildlife Management Area include Channel Catfish (left) and Largemouth Bass (right).

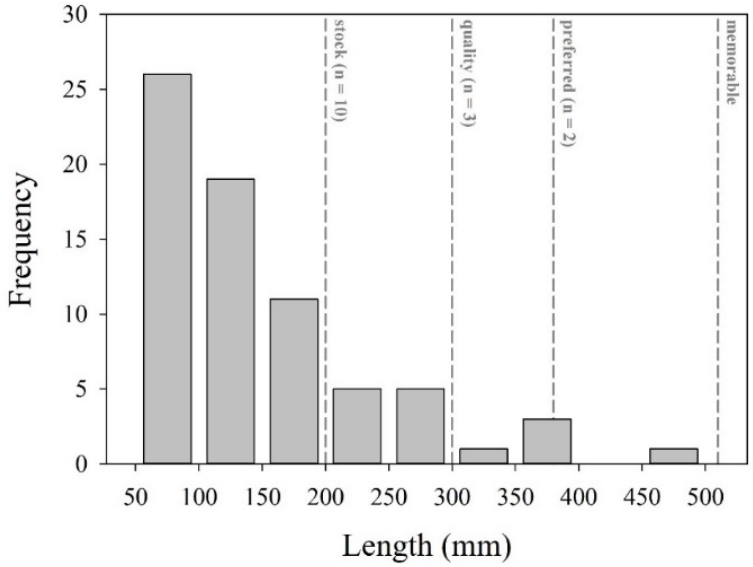

FIGURE 12. – Length frequency histogram for Largemouth Bass (n = 71; one fish was released without measuring) collected in Matador Wildlife Management Area on October 20, 2016, from all gear types with length class designations for stock (200 mm; 8 in), quality (300 mm; 12 in), preferred (380 mm; 15 in) and memorable (510 mm; 20 in) lengths (Anderson and Neumann 1996).

In addition to these two species, three species of sunfish were collected at Matador WMA which offer additional angling opportunities (Figure 13). Bluegill (n = 565), Longear Sunfish (n = 291) and Green Sunfish (n = 175) were collected at all five sites with the highest collective abundances at sites B and E (Table 4). Of the 397 sunfish measured, total lengths ranged from 17 to 138 mm (0.7 to 5.4 in) with 3.3% (n = 13) of the catch comprising fish of stock length or larger (Figure 14). Smaller individuals (< 80 mm; i.e., juveniles) were collected across all five sites. Sampling occurred in the fall following sunfish spawning, which typically spans early spring to late summer depending on the species (Thomas et al. 2007). A higher proportion of larger individuals would likely be collected in the spring or summer prior to and during spawning season.

FIGURE 13. – Non-game classified sport fish that offer angling potential within Matador Wildlife Management Area include from left to right Bluegill, Longear Sunfish, and Green Sunfish.

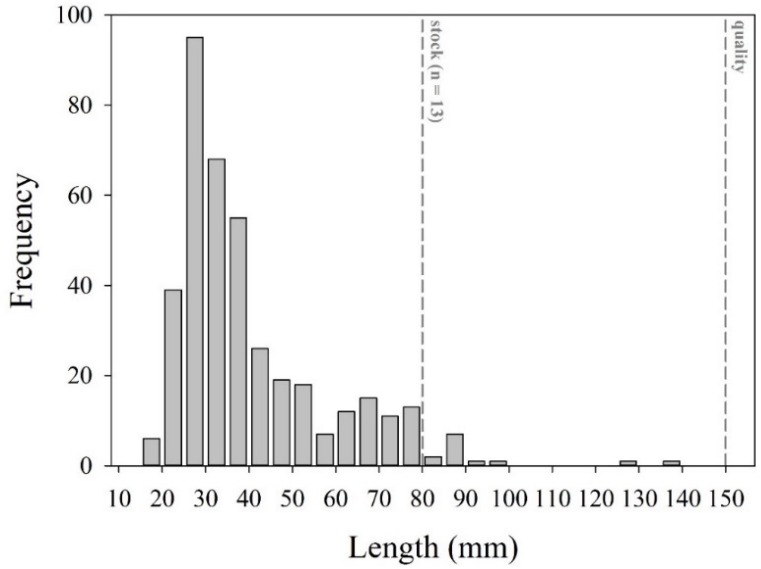

FIGURE 14. – Length frequency histogram for sunfish (n = 397) collected at Matador Wildlife Management Area on October 20, 2016, with size class designations for stock (80 mm; 3 in) and quality (150 mm; 6 in) lengths (Anderson and Neumann 1996).

Considering size of individuals and overall fish assemblage, sites B, D, E, and F all provide some quality fish and angling opportunity. All four sites had abundant sunfish and quality or better category Largemouth Bass. Site E also had juvenile Channel Catfish, indicating successful reproduction for this species.

SUMMARY AND RECOMMENDATIONS

Upper Red River Basin

Fish assemblage sampling occurred at 40 tributary sites throughout the upper Red River Basin in Texas yielding a total of 43 fish species. These collections included five fish species of SGCN status (Prairie Chub, Red River Shiner, Silverband Shiner, Red River Pupfish, and Orangebelly Darter), although these species were found in relatively low abundance at a few sites.

No live freshwater mussels were collected from the nine sites searched. Long dead shells representing four species previously documented from the upper Red River Basin were collected on the Wichita River. Three common species of crayfish were collected.

Due to low river flows and fencing of the right-of-way at bridge crossings, there are limited public recreational access opportunities within the study area. Additionally, low numbers of sport fish and sunfish collected indicate low angling potential from waters surveyed. There are three county and city parks along the Wichita River and Salt Fork of the Red River which allow access for kayak launch depending on river flow and bank fishing.

Matador Wildlife Management Area

Twelve fish species and 24 aquatic macroinvertebrate taxa were documented from the Middle Fork Pease River at Matador WMA. The fragmented nature of the river during sampling made calculation of indices of biotic integrity for fish and invertebrates inappropriate. No freshwater mussel shells or crayfish were encountered during sampling within the WMA.

Several species collected from Matador WMA provide angling opportunities including Largemouth Bass, Channel Catfish, and several sunfish species. Largemouth Bass at several sites provide quality angling opportunities with relatively high abundances and 2.8% of total catch falling in the preferred size class (greater than 380 mm or 15 in).

Point water quality measurements taken at three sites within Matador WMA fell within established water quality standards. No riparian or stream health metrics were assessed due to the fragmented nature of the Middle Fork Pease River during the study.

Recommendations

The only notable fish assemblage deficiencies observed were low abundances of cyprinids classified as fluvial specialists, particularly pelagic-broadcast spawning species such as Prairie Chub, Red River Shiner, Silverband Shiner, and Plains Minnow. Mirroring historical collections (Hendrickson and Cohen 2015), species from this group were only collected in larger tributaries (Pease River, Wichita River, and Prairie Dog Town Fork) and sites in close proximity to the mainstem Red River (Buck Creek and Mountain Creek). It is possible that other tributary sites sampled during this study do not provide adequate lengths of connected habitats or flows for successful recruitment of these species. Given suitable flow regimes, the mainstem Red River from the Prairie Dog Town Fork to Lake Texoma may

provide adequate length for successful recruitment of these species. Therefore, to evaluate the status of these populations in the upper Red River Basin, mainstem Red River samples should be evaluated in combination with results from this study.

Future evaluations of NFCA bounds should consider data collected during this study and potentially expand the Upper Red River NFCA to include the North Fork Red River in Wheeler County and Sweetwater Creek, given the presence of SGCNs in those localities.

Matador WMA provides anglers a good opportunity to fish for game fish such as Channel Catfish and Largemouth Bass as well as a variety of sunfish species. The public uses several road crossings on the Middle Fork Pease River to access these pools, primarily targeting Largemouth Bass and sunfish (C. Ellison, TPWD, personal communication). A volunteer creel survey could be implemented to obtain angling pressure and harvest data. If justified, WMA staff could consult with TPWD district fisheries management biologists on active management of select pools within the WMA to maintain and enhance sport fish populations and support the needs of anglers who visit the property for recreational purposes.

Given that the Middle Fork Pease River in Matador WMA typically consists of isolated pools, stock density indices such as Proportional Stock Density (PSD) could be calculated on length-frequency data to provide insight into fish assemblage structure for species that provide visitors with angling opportunities (Anderson and Neumann 1996; Ney 1999). For this study, PSDs for Largemouth Bass and sunfish species were not calculated due to small sample sizes for both groups within each site (Gustafson 1988; Miranda 2007). The ideal approach would be to increase sample sizes and calculate PSD's specific to each site, since interaction is limited between the pools. It is important to remember that these methods were created for management of small impoundments that support traditional Largemouth Bass-Bluegill fisheries, not riverine systems (Ney 1999). Provided that the Middle Fork Pease River maintains its current lentic state, this simple assessment using stock density indices could be incorporated for continued monitoring of Largemouth Bass and sunfish populations in each of the pools on the Matador WMA.

Further sampling of freshwater mussels is recommended throughout the upper Red River Basin, focusing on sites near the Red River mainstem which have the highest likelihood of mussel occurrence. This data could be combined with mussel survey data from Oklahoma universities and Oklahoma Department of Wildlife Conservation to provide a more complete picture of the status of freshwater mussels in the upper Red River Basin. Additional mussel sampling in the Wichita River is also recommended to determine if live mussels still persist there, as only long-dead shells were collected. This is of special concern due to the operation of a reverse osmosis plant that discharges brine reject in to the Wichita River, potentially leading to increases in salinity in the river (Grubh et al. 2014) which can harm mussels, their larvae, and fish hosts. Further, as recommended in Grubh et al. (2014), it would be valuable to repeat biological and water quality assessment at all of their study sites on the Wichita River given that several years have passed since that study was performed and brine reject discharges have continued.

Public river access is limited in the upper Red River Basin due to inconsistent river flows and a lack of sport fish and habitats. It is not recommended at this time that TPWD pursue development of paddling trails or leased river access sites within the study area.

The greatest concerns facing streams in the upper Red River Basin from both an ecological and recreational standpoint are water availability, water quality, and habitat connectivity. To address these

concerns, it is important to bring together datasets from Texas and Oklahoma so a holistic assessment can be used in development and implementation of conservation or management strategies that could increase base flows and decrease fragmentation.

LITERATURE CITED

Anderson, R.O., and R.M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 *in* B.R. Murphy and D.W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Atekwana, E.A., R.S. Roew, E. Atekwana, D.D. Werkema, Jr., and F.D. Legall. 2004. The relationship of total dissolved solids measurements to bulk electrical conductivity in an aquifer contaminated with hydrocarbon. Journal of Applied Geophysics 56:281–294.

Becher, C., and J.M. Gumm. 2017. The roles of inter- and intra-sexual selection in behavioral isolation between native and invasive pupfishes. Current Zoology 64:135-144.

Birdsong, T.W., G.P. Garrett, B.J. Labay, M.G. Bean, P.T. Bean, J.B. Botros, M.J. Casarez, A.E. Cohen, T.G. Heger, A. Kalmbach, D.A. Hendrickson, S. Magnelia, K. Mayes, M. McGarrity, R. McGillicuddy, M.M. Parker, and S. Robertson. 2019. Texas native fish conservation area network: strategic investments in restoration and preservation of freshwater fish diversity. Pages XXX–XXX *in* T.W. Birdsong, D.C. Dauwalter, and G.P. Garrett, editors. Multispecies and Watershed Approaches to Freshwater Fish Conservation: Science, Planning, and Implementation. American Fisheries Society, Symposium XXX, Bethesda, Maryland.

Cohen, A.E., G.P. Garrett, M.J. Casarez, D.A. Hendrickson, B.J. Labay, T. Urban, J. Gentle, D. Wylie, and D. Walling. 2018. Conserving Texas biodiversity: status, trends, and conservation planning or fishes of greatest conservation need. University of Texas-Austin.

Dynesius, M., and C. Nilsson. 1994. Fragmentation and flow regulation of river systems in the northern third of the world. Science 266:753-762.

Extence, C.A., D.M. Balbi, and R.P. Chadd. 1999. River flow indexing using British benthic macroinvertebrates: a framework for setting hydroecological objectives. Regulated rivers: research and management 15:543-574.

Flickinger, S.A., F.J. Bulow, and D.W. Willis. 1999. Small impoundments. Pages 561-587 *in* C.C. Kohler and W.A. Hubert, editors. Inland fisheries management in North America, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Fuller, M.R., M.W. Doyle, and D.L. Strayer. 2015. Causes and consequences of habitat fragmentation in river networks. Annals of the New York Academy of Sciences 1355:31-51.

Gillis, P.L. 2011. Assessing the toxicity of sodium chloride to the glochidia of freshwater mussels: implications for salinization of surface waters. Environmental Pollution 159:1702-1708.

Griffith, G.E., S.A. Bryce, J.M. Omernik, J.A. Comstock, A.C. Rogers, B. Harrison, S.L. Hatch, and D. Bezanson. 2004. Ecoregions of Texas. U.S. Environmental Protection Agency, Corvallis, Oregon.

Grubh, A.R., C.R. Robertson, K. Aziz, L.J. Kleinsasser, R.J. Mauk, and M.H. Howell. 2014. Response of water quality and the aquatic community to a reverse osmosis unit discharge into the Wichita River, Texas. River Studies Report No. 21. Texas Parks and Wildlife Department, Austin, Texas. Available: https://tpwd.texas.gov/publications/pwdpubs/media/pwd_rp_t3200_1792.pdf. (September 2017).

Gustafson, K.A. 1988. Management briefs: approximating confidence intervals for indices of fish population size structure. North American Journal of Fisheries Management 8:139-141.

Hendrickson, D.A., and A.E. Cohen. 2015. Fishes of Texas Project Database. Version 2.0. Available: doi:10.17603/C3WC70.

Hendrickson, D.A., A.E. Cohen, and M.J. Casarez. 2019. University of Texas, Biodversity Center, Ichthyology Center, Ichthyology Collection (TNHCi). Version 5.33. University of Texas at Austin, Austin, Texas. Available: https://doi.org/10.15468/h8gxdr accessed via GBIF.org on 2019-05-01.

Howells, R.G. 1996. Distributional surveys of freshwater bivalves in Texas: progress report for 1994. Management Data Series No. 120. Texas Parks and Wildlife Department, Austin, Texas.

Howells, R.G. 1998. Distributional surveys of freshwater bivalves in Texas: progress report for 1997. Management Data Series No. 147. Texas Parks and Wildlife Department, Austin, Texas.

Hubbs, C., R.J. Edwards, and G.P. Garrett. 2008. An annotated checklist of the freshwater fishes of Texas, with keys to identification of species, 2nd edition. Texas Journal of Science Supplement 43.

Huser, V. 2000. Rivers of Texas. Texas A&M University Press. College Station, Texas.

Linam, G.W., L.J. Kleinsasser, and K.B. Mayes. 2002. Regionalization of the index of biotic integrity for Texas streams. River Studies Report No. 17. Texas Parks and Wildlife Department, Austin, Texas. Available: http://tpwd.texas.gov/publications/pwdpubs/media/pwd_rp_t3200_1086.pdf. (September 2017).

Miranda, L.E. 2007. Approximate sample sizes required to estimate length distributions. Transactions of the American Fisheries Society 136:409-415.

NatureServe. 2017. NatureServe Explorer. An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Available: http://explorer.natureserve.org. (January 2018).

Ney, J.J. 1999. Practical use of biological statistics. Pages 167-191 *in* C.C. Kohler and W.A. Hubert, editors. Inland fisheries management in North America, 2nd edition. American Fisheries Society, Bethesda, Maryland.

National Park Service. 2010. The nationwide rivers inventory. United States Department of the Interior, Washington, D.C. Available: https://www.nps.gov/ncrc/programs/rtca/nri/index.html. (September 2018).

Page, L.M., and B.M. Burr. 2011. A field guide to freshwater fishes of North America, north of Mexico. 2nd ed. Houghton Mifflin Company, Boston, Massachusetts. 276 pp.

Perkin, J.S. and K.B. Gido. 2011. Stream fragmentation thresholds for a reproductive guild of Great Plains fishes. Fisheries 36: 371-383.

Red River Authority . 1996. Red River basin chloride control project: environmental issues summary report. Red River Authority of Texas. Available: http://www.rra.texas.gov/

Robison, H.W. and T.N. Buchanan. 1988. Fishes of Arkansas. The University of Arkansas Press, Fayetteville, Arkansas.

Scalet, C.G. 1973. Reproduction of the orangebelly darter, *Etheostoma radiosum cyanorum* (Osteichthyes: Percidae). American Midland Naturalist 89:156-165.

Strayer, D.L., and D.R. Smith. 2003. A guide to sampling freshwater mussel populations. American Fisheries Society, Bethesda, Maryland.

Taylor, C.M. 2010. Covariation among plains stream fish assemblages, flow regimes, and patterns of water use. Pages 447-459 *in* K.B. Gido and D.A. Jackson, editors. Community ecology of stream fishes: concepts, approaches, and techniques. American Fisheries Society Symposium 73. American Fisheries Society, Bethesda, Maryland.

Taylor, C.M., and R.J. Miller. 1990. Reproductive ecology and population structure of the Plains Minnow, *Hybognathus placitus* (Pisces: Cyprinidae), in central Oklahoma. American Midland Naturalist 123:32–39.

TCEQ (Texas Commission on Environmental Quality). 2014a. 2014 Texas integrated report for the Clean Water Act sections 305(b) and 303(d). Texas Commission on Environmental Quality, Austin, Texas. Available: https://www.tceq.texas.gov/waterquality/assessment/14twqi/14basinlist. (November 2016).

TCEQ (Texas Commission on Environmental Quality). 2014b. Surface water quality monitoring procedures, volume 2: methods for collecting and analyzing biological assemblage and habitat data. Texas Commission on Environmental Quality, Austin, Texas. Available: https://www.tceq.texas.gov/publications/rg/rg-415. (September 2017).

TCEQ (Texas Commission on Environmental Quality). 2018. Surface water quality monitoring information system (SWQMIS). Texas Commission on Environmental Quality, Austin, Texas. Available: https://www80.tceq.texas.gov/SwqmisPublic/public/default.htm

Thomas, C., T.H. Bonner, and B.G. Whiteside. 2007. Freshwater fishes of Texas: a field guide. Texas A&M University Press, College Station, Texas.

TPWD (Texas Parks and Wildlife Department). 2008. Texas mussel watch: freshwater mussels of Texas distribution chart. Texas Parks and Wildlife Department, Austin, Texas.

TPWD (Texas Parks and Wildlife Department). 2012. Texas conservation action plan: species of greatest conservation need list and rare communities lists. Texas Parks and Wildlife Department, Austin, Texas. Available: http://www.tpwd.state.tx.us/landwater/land/tcap/sgcn.phtml. (September 2018).

TPWD (Texas Parks and Wildlife Department). 2017. 2017–2018 Outdoor annual. Texas Parks and Wildlife Department, Austin, Texas.

TPWD (Texas Parks and Wildlife Department). 2018a. Ecologically significant stream segments. Texas Parks and Wildlife Department, Austin, Texas. Available: http://tpwd.texas.gov/landwater/water/conservation/water_resources/water_quantity/sigsegs/index.phtml. (July 2018).

TPWD (Texas Parks and Wildlife Department). 2018b. Matador WMA. Texas Parks and Wildlife Department, Austin, Texas. Available: https://tpwd.texas.gov/huntwild/hunt/wma/find_a_wma/list/?id=15. (July 2018).

TPWD (Texas Parks and Wildlife Department). 2018c. GoFish internal server. Texas Parks and Wildlife Department, Austin, Texas. (July 2018).

Vaughn, C.C. 2000. Changes in the mussel fauna of the middle Red River drainage: 1910 – present. Pages 225-232 *in* R.A. Tankersley, D.I. Warmolts, G.T. Watters, B.J. Armitage, P.D. Johnson, and R.S. Butler, editors. Proceedings of the first Freshwater Mollusk Conservation Society symposium. Ohio Biological Survey.

Waters, T.F. 1995. Sediment in streams. Sources, biological effects and control. American Fisheries Society Monograph 7. American Fisheries Society, Bethesda, Maryland.

Wilde, G.R. 2015. Reproductive ecology and population dynamics of fishes in the upper Brazos River. Texas Tech University, Lubbock, Texas.

Wilde, G.R., R.R. Weller, C.D. Smith, and R. Jimenez, Jr. 1996. Review and synthesis of existing fish collection records for the Upper Red River Basin upstream from Lake Texoma. Report submitted to U.S. Army Corps of Engineers, Tulsa District. Texas Tech University, Lubbock, Texas.

Winston, M.R., C.M. Taylor, and J. Pigg. 1991. Upstream extirpation of four minnow species due to damming of a prairie stream. Transactions of the American Fisheries Society 120: 98-105.

4200 Smith School Road ▪ Austin, Texas 78744
www.tpwd.texas.gov